revista de investigación marina

3

XI International Symposium on Oceanography of the Bay of Biscay

2-4 April, 2008. Donostia-San Sebastián (Spain)

azti
tecnalia

Several authors, 2008. XI International Symposium on Oceanography of the Bay of Biscay. *'Revista de Investigación Marina'* 3: 289 pp.

La serie *'Revista de Investigación Marina'*, editada por la Unidad de Investigación Marina de Tecnalia, cuenta con el siguiente Comité Editorial:

La '*Revista de Investigación Marina'* de Tecnalia edita y publica investigaciones y datos originales resultado de la Unidad de Investigación Marina de Tecnalia. Las propuestas de publicación deben ser enviadas al siguiente correo electrónico aborja@pas.azti.es. Un comité de selección revisará las propuestas y sugerirá los cambios pertinentes antes de su aceptación definitiva.

Edición: 1.ª Abril 2008

Unidad de Investigación Marina
Internet: www.azti.es
Edita: Unidad de Investigación Marina de Tecnalia
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20010 Pasaia
Foto portada: © Alex Iturrate

Agradecemos la colaboración de las siguientes entidades en la realización de este "XI International Symposium on Oceanography of the Bay of Biscay":

XI International Symposium on Oceanography of the Bay of Biscay
XI Simposio Internacional de Oceanografía del Golfo de Vizcaya
XI Colloque International d'Océanographie du Golfe de Gascogne

Introduction

Twenty-two years later we have arrived at the *XI International Symposium on Oceanography of the Bay of Biscay*, this time in San Sebastián. This is not simply another edition of our symposium. This year we celebrate 100 years of the Oceanographic Society of Gipuzkoa, the second oldest oceanographic society in the world (founded in 1908), after that of Monaco. This is explained by the title of the symposium: "*100 years of research, within the Bay of Biscay*". This will be highlighted through two conferences: (a) a broad overview of the investigation undertaken in this embayment, over the last centuries; and (b) another providing a vision of our next challenges, as marine researchers.

Hence, this is an ideal occasion to meet marine investigators, coming from all the research centres of the Bay of Biscay, and especially to meet those friends coming, symposium after symposium, to this event. Likewise, to extend our congratulations to the Aquarium of San Sebastián, as headquarters of the Society.

Our initial idea was to organise the symposium in the Aquarium, but your response surpassed our previous expectations: 150 contributions, to the both oral and poster sessions. Our venue is now the Kursaal Conferences Centre, but the continuously-renowned Aquarium is present in the Symposium, with parallel activities, e.g. registration, visits and a public lecture. This is a new contribution of the symposium, trying to extend marine knowledge to the society.

As in previous symposia, the contributions submitted are adapting to the new areas of research that, 22 years ago, we did not consider: the management of our coasts and offshore waters; integration of the assessment; the relationships between dynamics and biology; the new challenges of fisheries; global change; biodiversity; habitat mapping; modelling; and many others.

One of the great 'added values' of this symposium is the possibility to observe the advances in topics of the oceanography, within the Bay of Biscay, as a whole. This gives us a global view, allowing a better understanding of this ecosystem in an integrated way. This will permit us, in the future, to adapt to the requirements of the European Marine Strategy, for which the ecosystem-based approach management is needed.

To celebrate these "*100 years of research, within the Bay of Biscay*", we have the opportunity to present all this knowledge to the scientific community, in a special issue of *Continental Shelf Research*. Contributions integrating several disciplines and broad-scale studies are welcome, together with studies permitting an understanding of scientific topics of the functioning of this ecosystem.

We hope that you enjoy your stay in San Sebastián!

Dr Angel Borja, AZTI-Tecnalia
Conference Chairman

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PROGRAMME

Tuesday, 1st April

Meeting of the ***Joint Programme Board (JPB) of the European Master in Marine Environment and Resources (MER)*** at the **AQUARIUM**

Programme

17:00 Master MER 2007-2008: updating.

18:00 Planification of activities of the Master MER during 2008-2009

19:00 Course RIMER organization – July 2008

16:00 - 20:00 Registration in the Aquarium and free visit to the facilities

20:00 Welcome Reception & Refreshments at the Aquarium

Wednesday, 2nd April

ORAL SESSION

08:30 - 09:15	Registration			
09:15	Opening words			
9:30 - 10:15	Aperture talk: Overview of historical research within the Bay of Biscay (Orestes Cendrero, IEO)			
10:15 - 10:45	Coffee break			**Presentation of the of the European Master in Marine Environment and Resources (Ionan Marigómez**, UPV)
10:45	New developments of in situ monitoring of oyster behaviour to detect water quality change in the Bay of Arcachon, France	JC. Massabuau	**Chemistry & Pollutants** *Chairs of the session: Ionan Marigómez (University of the Basque Country) and Ricardo Riso (University of Brest)*	
11:05	A 16-year monitoring programme of shellfishing water quality: metals in molluscs	Oihana Solaun		
11:25	Spatial and temporal variability of CO2 fluxes at the sediment-water, sediment-air and air-sea interfaces in the Arcachon lagoon (France)	Gérard Thouzeau		
11:45	Dissolved and particulate lead in the Corcubión Sound (NW Iberian Peninsula). Comparison with contamination trend in the Galician Rias	Ricardo Prego		
12:05	Determination of metal background values in estuarine and coastal waters of the Basque Country	Itziar Tueros		
12:25	Biogeochemical inter-tidal processes and fluxes of organomercury and organotin compounds in the Arcachon Bay (France)	Pablo Rodríguez-González		
12:45	Fate of mercury and butyltin compounds in the turbid plume of the Adour estuary: reactivity and dispersion along the Basque Coast	Mathilde Monperrus		
13:05	Baseline survey of imposex and TBT concentrations in Nassarius reticulatus and N. nitidus in the ports of Pasaia and Bilbao, Basque Country	J. Germán Rodríguez		
13:25 - 15:00	Lunch			

15:00	Long-term morphological and stratigraphical evolutions of estuaries: Comparison between the Marennes-Oléron bay and the Arcachon lagoon	Eric Chaumillon	**Geology & Sediments**	
15:20	A high marsh transfer function for sea-level reconstructions in the southern Bay of Biscay	Alejandro Cearreta	*Chairs of the session: Michael Collins (University of Southampton) and Jean-Marie Jouanneau (University of Bordeaux)*	
15:40	Late Quaternary (MIS 1-3) environmental change in the S Bay of Biscay evidenced by benthic microfaunas of the basque shelf	J. Rodríguez-Lázaro		
16:00	Facies, granulometry, morphoscopy and exoscopy of south armorican continental shelf sediments (inner shelf)	Guilhem Estournès		
16:20 - 16:40	Coffee break			**POSTER SESSION 16:20 to 18:30**
16:40	Changes in intertidal benthic assemblages after the relocation of an industrial sludge discharges to a submarine outfall	Silvia Otero	**Benthic communities**	Circulation
17:00	Recolonization process by macrobenthic fauna in the new intertidal areas created after restoration of farm lands in the Bidasoa estuary (SE Bay of Biscay)	Mikel A. Marquiegui	*Chairs of the session: Ángel Borja (AZTI-Tecnalia) and Jean-Claude Sorbe (CNRS)*	Physical oceananography
17:20	Changes in the marine sublittoral vegetation at the western Basque Coast between 1982 and 2007: a consequence of the climate change?	José María Gorostiaga		Plankton
17:40	Assessing LIDAR data for coastal habitat discrimination	Guillem Chust		Integrative assessment
18:00	Seafloor cartography and habitat mapping of the Basque inner continental shelf	Ibon Galparsoro		
18:20	Facies, biocoenoses and fishery impacts on Le Danois Bank deep-sea benthic ecosystem (El Cachucho) using photogrammetry	Francisco Sánchez		
18:40	End of the day			
20:00	Public conference: Cómo las tecnologías marinas pueden hacernos la vida más sostenible: de la fantasía a la realidad. Organization: Fundación ZERI (Zero Emissions Research & Initiatives) Web: www.zeri.org Venue: Aquarium of San Sebastián	Gunter Pauli		

Thursday, 3rd April

ORAL SESSION

09:00	Presentation of the Bay of Biscay and English Channel operational model. Validation of hydrology on the shelf	Pascal Lazure	**Circulation & transport**
09:20	Variability of circulation off N and NW Iberia: insights from a forecast model	Manuel Ruiz Villarreal	*Chairs of the session: Moncho Gómez-Gesteira (University of Vigo) and Pascal Lazure (Ifremer)*
09:40	Analysis of Ekman transport patterns along the Bay of Biscay from FROM 1967 to 2005	Inés Álvarez	
10:00	Physical processes governing water circulation in the southeastern limit of the Bay of Biscay	Almudena Fontán	
10:20	Sedimentation patterns by river plumes in the southern margin of the Bay of Biscay: modelling and observations	Manuel González	
10:40	Comparison of lagoon hydrodynamics using synthetic descriptors	Martin Plus	

11:00 - 11:30	Coffee break			
11:30	SST warming trend along the continental coast of the Atlantic Arc (1985 – 2005)	Moncho Gómez-Gesteira	**Physical oceanography** *Chairs of the session: Pablo Otero (IEO-A Coruña) and Bernard Le Cann (University of Brest)*	
11:50	Temperature variability in the Bay of Biscay during the past 30 years, from an in situ analysis and a 3D regional simulation	Sylvain Michel		
12:10	T/S relationships for Eastern North Atlantic Central Water in the Basque coast (N Spain). Recent changes induced by climate anomalies	Victoriano Valencia		
12:30	Warm and saline upper Ocean intrusions north of Spain in 2006	Bernard Le Cann		
12:50	Estimating turbidity indicators and total suspended matter in the Bay of Biscay using MODIS 250-m imagery	Caroline Petus		
13:10	Interannual variability of river plumes in the southern Bay of Biscay during spring	Gonzalo González-Nuevo		
13:30 - 15:00	Lunch			
15:00	Spring and Summer Blooms of Phytoplankton (SeaWiFS/MODIS) along a Ferry line in the Bay of Biscay and W English Channel	Carlos García-Soto	**Plankton & nutrients** *Chairs of the session: Xabier Irigoien (AZTI-Tecnalia) and Christine Dupuy (University of La Rochelle)*	
15:20	Real-time ecological modelling of nutrients and phytoplankton on the Bay of Biscay French shelf	Alain Ménesguen		
15:40	Nitrogen uptake by size-fractionated plankton in the North Biscay Bay during spring	Jean-François Maguer		
16:00	Characterisation of hydrodynamical conditions on the Aquitan shelf prior to Dinophysis events in the Arcachon Basin	François Batifoulier		
16:20 - 16:45	Coffee break			**POSTER SESSION 16:20 to 18:30**
16:45	Vertical distribution of living planktic foraminifera in the Northern part of the Plateau des Landes (Bay of Biscay)	Sophie Retailleau		Chemistry
17:05	Temporal pattern of surface ichthyoplankton in southern bay of Biscay (W. Atlantic)	Jean d'Elbée		Geology
17:25	The RNA/DNA optimal value: a complement to the RNA/DNA starvation value to determine the overall status of fish larvae populations	Estíbaliz Díaz		Benthos
17:45	Integrating Multiple Ecosystem Elements in Assessing Ecological Quality in the Basque Country: application to the Marine Strategy	Ángel Borja	**Special Topic** *Chairs of the session: Javier Franco (AZTI-Tecnalia) and Verena Trenkel (Ifremer) (to be confirmed)*	Fisheries
18:05	Integrative assessment of the ecological status of Cantabrian (N. Spain) coastal water bodies.	Xabier Guinda		
18:25	An integrated assessment of the ecological and economical status of French fisheries in the Bay of Biscay	Fabienne Daurès		
18:45	End of the day			
20:00	Official dinner in a cider restaurant			

Friday, 4th April

ORAL SESSION

09:15 - 10:00	Closing talk: Future of the marine research Maurice Héral (Ifremer)		
10:15	Short-finned Squid fishery based in commercial landings on Northern Iberian Peninsula (NE Atlantic)	Isabel Bruno	**Fisheries**
10:35	Les flottilles des Pertuis charentais vues du ciel	Jean-Pierre Léauté	*Chairs of the session: Ignacio Olaso (IEO-Santander) and Maurice Héral (Ifremer) (to be confirmed)*
10:55 - 11:15	Coffee break		
11:15	JUVENA series review of the spatial distribution of anchovy juveniles in the Bay of Biscay	Guillermo Boyra	**Fisheries**
11:35	Growth of early juvenile European anchovy, Engraulis encrasicolus, in the Bay of Biscay based on otolith microstructure analyisis	Naroa Aldanondo	
11:55	Is the global functioning of the pelagic ecosystem over the continental shelf of the Bay of Biscay (NE Atlantic) mainly driven by rates of rivers discharge? A comparison of two contrasting years with special reference to anchovy (Engraulis encrasicolus L.) nutritional state	Jean-Pierre Bergeron	
12:15	Does Le Danois Bank (El Cachucho) influence albacore catches in the Cantabrian Sea?	Cristina Rodríguez-Cabello	
12:35	Robustness of European Hake Management Strategy to stock recruitment relationship in the context of alternative indices of stock reproductive potential	Hilario Murua	
12:55	Management Strategy Evaluation of Northern Hake and associated fisheries: TAC versus Effort based Management	Dorleta García	
13:15	Spanish bottom trawl surveys in Cantabrian Sea and Galician waters (North of Spain). Overview of horse mackerel historical series	Francisco Velasco	
13:35	Effects of trawl exclusion in a set of indicators in the Cantabrian Sea inner shelf (Southern Bay of Biscay)	Alberto Serrano	
13:55	Placing Bay of Biscay key trophic compartments in their fisheries context	Jérémy Lobry	
14:15	Closing ceremony		

New developments of *in situ* monitoring of oyster behaviour to detect water quality change in the Bay of Arcachon, France.

Damien Tran*[a], Gilles Durrieu[a], Pierre Ciret[a], Mohamedou Sow[a] and Jean-Charles Massabuau[a]

Introduction

Now more than ever, protection of the environment is a top priority. This is particularly true for aquatic environments and especially so for coastal waters such as the Bay of Biscay. A current estimate is that 40% of the world's population lives within 60 km of a coastline, and it is thought that this will increase to more than 80% by 2050. The ability of oysters or other mollusk bivalves to 'taste' their environment is one of the possible ways to monitor the quality of our coastal waters. Monitoring their natural opening/closing activity is yet another way to put a 'thermometer' in our waters and read, throughout the year, the health of both the bivalves and their environment. With the technological advances in internet and mobile telephone networks in recent years, we can now continuously survey and record the behaviour of animals everywhere in the earth. A multidisciplinary team of biologists, electronics specialists and mathematicians from the Marine Biological Station of Arcachon, University Bordeaux 1, & CNRS (France) recently performed new developments of this system (Tran et al. 2003, 2004, 2007) to gain more insigths into bivalve ecophysiology and to aid in the on-line monitoring of water quality.

In the Bay of Arcachon, the objective is to study oyster comportment and behavioral changes that could be associated with the presence of toxic algae, which is an important problem for the local oyster farming and human health. With our biosensor we planned to describe the behavioral valve activity of the oyster *in situ*, with and without toxic alga. A final goal is to detect toxic algae as soon as they enter in the Bay and to provide on line informations, both to public and to scientific people.

Methods

Valve activity measurement

Our monitoring site is in the front of the Marine Biological Station of Arcachon in France. We record the valve activity of 16 oysters (permanently submersed) equipped with two light electrodes glued to the shells of freely behaving bivalves. With these electrodes that have been designed to minimise animal disturbance, we can measure the amount of shell opening and closing (Fig.1).

Mathematical treatment

By GSM, we receive 1700000 data per day from the activity of the oysters. These data are analysed and allow the calculation of several parameters such as individual recording valve activity. Especially, to model the variety of bivalve behaviours, we have developed a non-parametric and robust regression analysis based on kernel estimators (Briollais et al. 2007, Tran et al. 2003) that allow us to investigate deeper the behaviour of *C. gigas in situ*.

Figure 1. Detail of an oyster equipped with light electrodes glued on each valve that allows permanent record of valve activity.

Results and Discussion

In situ recording site

The first experimental set-up has been running from february to november 2006 (Fig. 2) without any human intervention in the field. A second set-up has been similarly working a full year (december 2006-2007). This demonstrates the efficiency of our present technology at sea.

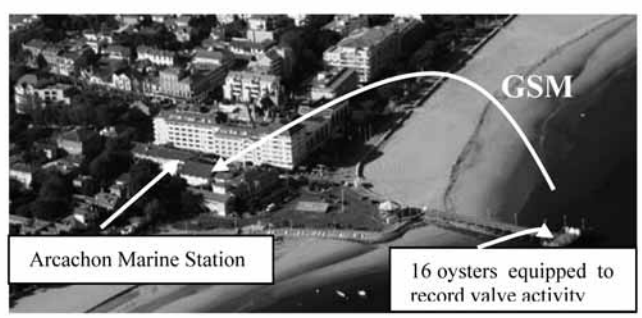

Figure 2. Experimental location of the 16 oysters equipped nearby the Marine station of Arcachon. The data are sent by mobile telephone technology (GSM).

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Web site diffusion

After mathematical analysis, the record of row individuals oyster valve activity and some analysis is freely available dailyt:http://www.domino.u-bordeaux.fr/molluscan_eye. Fig.3

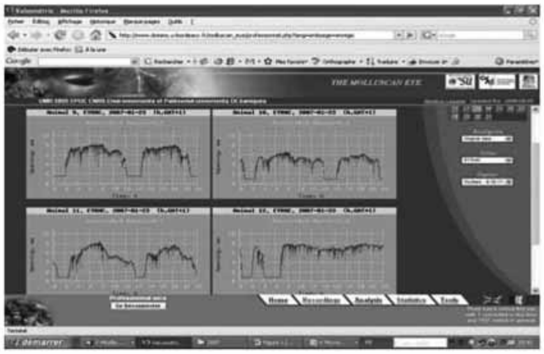

Figure 3. Website portal http://www.domino.u-bordeaux.fr/molluscan_eye. of *Crassostrea gigas* valve activity in the Bay of Arcachon, France. On this page, there is the daily record of 4 individual oysters.

Figure 4 presents the change of valve opening duration recorded in April 2006. The mean value ranges from 15-22 h/day. This is likely the first demonstration showing that submerged oysters do not remain fully open when immersed. Interestingly also, a spontaneous rhythm of opening duration clearly occurred. It was obviously closely correlated to the tide amplitude (Fig. 5). We finally observed that under our experimental *in-situ* conditions, the valve closure happens mostly at the beginning of the flow of the tide whereas it rarely or never happens at the ebb of the tide. This full data set represents then a first description of the natural oyster behavior in the Bay of Arcachon. Now, it remains to understand why the physical parameters synchronize the biological behaviour of *C. gigas*. An hypothesis that remains to be demonstrated is that tide could be linked to the food availability and play a key role in the nutrition and digestion process. Comparisons with natural

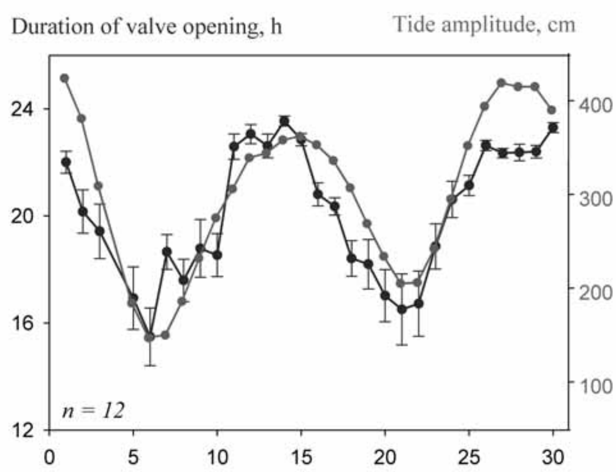

Figure 4. Daily valve opening duration (mean ± SE, n = 12) of *Crassostrea gigas* in Arcachon bay and tide amplitude in April 2006.

activity during crisis periods (periods during which selling oysters is prohibited) are in progress to see if the oyster's behaviour can be altered by the presence of some identified, or non identified, material present in the water column. Behavioral changes of C. Gigas actvity was recently reported during infestation by the parasite worm *Polydora sp*. (Chambon et al. 2007)

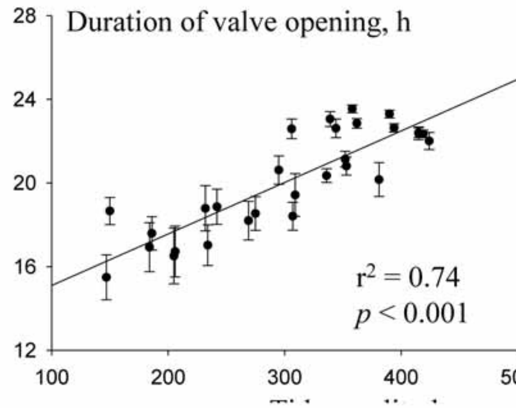

Figure 5. Relationship between daily valve opening duration (mean ± ES, n = 12) of *Crassostrea gigas* in the Bay of Arcachon and tide amplitude.

Conclusions

We have developped a new system for field study of bivalve behaviour. Data are partly available on the web. Up to now we characterized some new aspects of natural biological rhythms in oysters. They were strongly linked to tide parameters. We are presently studying other aspects of these behaviour in presence of toxic algae.

Acknowledgements

This work was partly granted by the Région Aquitaine, Aquitaine valo and the Southern Province of New Caledonia.

References

Briollais, L., G. Durrieu, R. Upathilake, 2007. New approach for genome scan meta-analysis of rheumatoid arthritis : A kernel-based estimation procedure. *BMC genetic*. (in press)

Chambon, C., Legeay, A., Durrieu, G., Gonzalez, P., Ciret, P. JC Massabuau 2007. Influence of the parasite worm Polydora sp. On the behavior of the oyster C. gigas: a study of the respiratory impact and associated oxidative stress. Mar. Biol. 152: 329-338

Tran, D., Ciret, P., Ciutat, A., Durrieu, G., Massabuau, J.-C. 2003. Estimation of potential and limits of bivalve closure response to detect contaminants: application to cadmium. Environmetal Toxicololy and Chemistry. 22, 116-122.

Tran D., Fournier E., Durrieu G. and Massabuau J-C. 2004. Copper detection in the asiatic clam *Corbicula fluminea*: optimum valve closure response. *Aquatic Toxicology* 65(3): 317-327.

Tran D., Fournier E., Durrieu G. and Massabuau J-C. 2007. *Corbicula fluminea* valve closure response as sensitivity threshold to inorganic mercury contamination. *Environmental Toxicology and Chemistry.* 26(7).

A 16-year monitoring programme of shellfishing water quality: metals in molluscs

Oihana Solaun,*[a] Ángel Borja[a] and J. Germán Rodríguez[a]

Introduction

Shell fishing, farming and trading are regulated in EU countries through the 22/2001/ECC, 852/2004/EEC, 853/2004/EEC, 854/2004/EEC, 10/2005/ECC 2073/2005/EEC and 113/2006/EEC directives. In Spain, these activities are also regulated by the 375/1993, 466/2001 and 640/2006 Royal Orders. In the application of these legislative measures, water quality and concentration of bacteria and pollutants (organic compounds and heavy metals) must be measured in areas of shellfising production.

In the Basque Country (Northern Spain) water quality and contaminants in molluscs haven been controlled since 1990. Initially the control was made in five areas previously established for shellfish production. Since 2002, taking into account the recommendations made by the Commission, only three of these five areas are considered for shellfish production: Hondarribia, Mundaka and Plentzia (Figure 1).

The results from the survillance made in these three areas since 1990 can be used to determine the main patterns and temporal trends of water quality and pollutants in molluscs. This contribution aims to determine metal concentration evolution in bivalve molluscs (both *Mytilus galloprovincialis* and *Crassostrea sp*.).

Methods

The mehodology used in this study is included in the above mentioned legislation. As these documets do not unequivocally specify all the methodological aspects for the control of the diferent parametres, sampling and analytical methods used were those taken in the Technical Commision of JACUMAR (*Junta Asesora Nacional de Cultivos Marinos*) to obtain homogeneus and comparable data from different Spanish shellfish production areas.

The sampling frequency was twice a year from 1990 to 2002, and every three months since 2002.

An homogeneized fraction (5 g) of the mollusc flesh was used for metale (Cd, Cu, Zn, Pb, Cr, Ni, Hg, As, Ag) analyses. After acid treatment, the analysis of metals in the extracts was carried out using Atomic Absorption Spectrometry AAS. Cd, Cu, Pb, Ni, Cr, and Zn were determined by THGA graphite furnace, using Zeeman background correction; As and Hg were determined by quartz furnace AAS, after hydride and cold vapour generation, respectively, of the sample in a FIA system.

Statistical tests followed Zar (1984) and were performed using STATGRAPHICS © software.

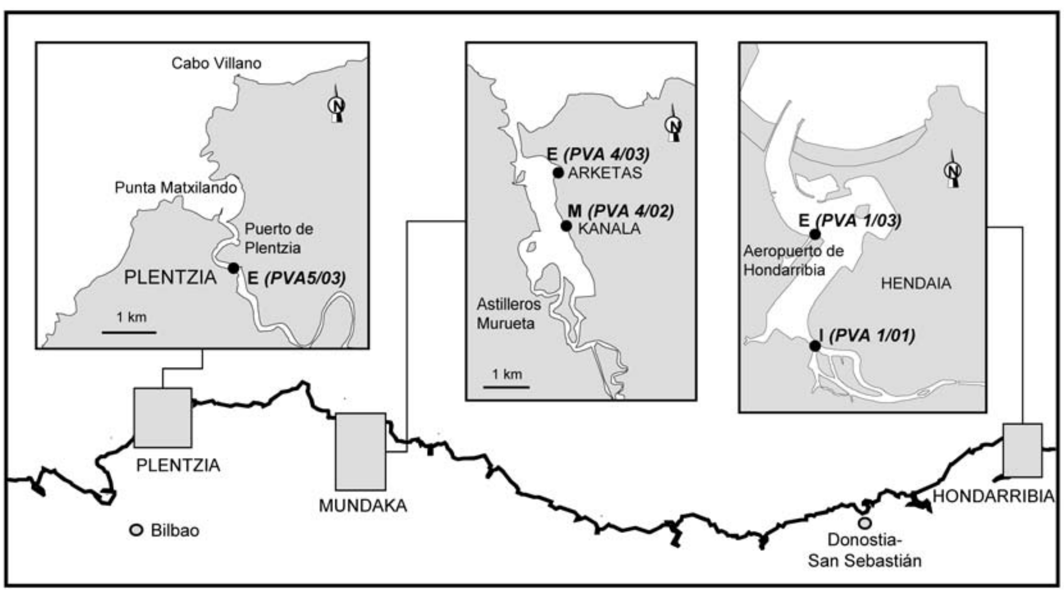

Figure 1 Shellfishing areas declared in the Basque Country, including the sampling stations.

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Results and Discussion

The results show that the moluscs from the Basque Coast follow a normal pattern of heavy metal content variability, related to differences between seasons and species. The metal concentrations mesaured reflect a clear influence of anthropogenic activities. However, few statistically significant temporal trends have been observed (11 of 58 studied cases, p<0.05), whilst three of them are within random variablity (Table 1). Some of the decreasing trends are related to the water treatment in the estuarine systems in recent years.

When the results are compared with legal limits it is observed that, in general, the percentage of cases below legal limits was higher in the last years (period 2001-2006) than in the period 1990-2000 (Figure 2).

Conclusions

In view of the results, and considering that sometimes metal concentrations in molluscs have been above legal limits, it can be concluded that not always have been optimal metal conditions for shellfishing in the Basque coast shellfish production areas. However, these results are used as complemetary to those obtained in bacterial content analysis and the other parameters included in the legislation. Therefore, at this moment three subareas are declared as Zone B (molluscs from these areas can be collected, but only placed on the market for te human consumption after treatment in a purification center) and two subareas as zone C (mollusc from these areas can be collected but placed on the market only after relaying over a long period, wheter or not combined with purification).

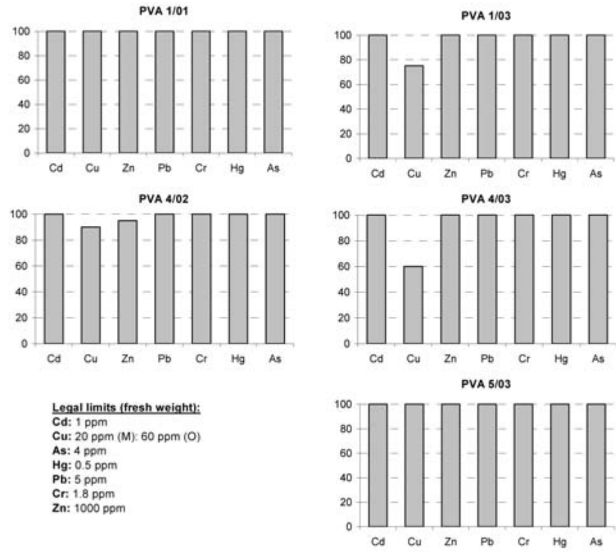

Figure 2 Sample percentage under legal limits, between 2001 and 2006.

Acknowledgements

The Department of Agriculture, Fisheries and Food, of the Basque government has funded this study.

References

Zar, J.H., 1984. Bioestatistical analysis. Prentice-Hall, New Jersey, 718 pp.

Table 1 Spearman test results showing correlation coefficients between metal concentration and time (1990-2006). Bold values are significant at p<0.05, and underlined at p<0.01. As differences were significant between species for Cu, Zn, Pb, Ni, Hg and Ag, values for mussels (M) and oysters (O) are presented separately.

		Nº	Cd	Cu	Zn	Pb	Cr	Ni	Hg	As	Ag
PVA 1/01	M	23	**0.350**	-0.321	**-0.474**	0.176	**-0.425**	-0.173	-0.197	**0.329**	0.170
	O	16		**0.585**	0.453	-0.059		-0.295	**0.610**		**0.635**
PVA 1/03	M	24	0.234	0.022	-0.080	0.058	-0.246	-0.091	-0.314	0.213	0.052
	O	14		0.037	0.099	**-0.620**		-0.284	-0.359		0.521
PVA 4/02	M	2	0.017	-	-	-	-0.067	-	-	**0.518**	-
	O	37		-0.181	0.020	0.146		-0.151	-0.251		0.110
PVA 4/03	M	15	0.233	-0.207	0.275	0.029	-0.204	-0.052	0.024	**0.495**	0.018
	O	24		-0.259	0.295	0.197		-0.233	0.116		**0.453**
PVA 5/03	M	35	0.093	**-0.554**	**-0.333**	-0.237	-0.254	-0.282	-0.218	**0.476**	**0.436**
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Spatial and temporal variability of CO_2 fluxes at the sediment-water, sediment-air and air-sea interfaces in the Arcachon lagoon (France)

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Introduction

The overall objectives of the French research project 'EC2CO-PNEC Chantier Littoral Atlantique' are to characterize the physical, biogeochemical and biological processes which regulate the functioning of littoral ecosystems, and to define the interactions of the latter with the watersheds and the coastal ocean. The Arcachon lagoon (44°40'N, 01°10'W) is one of the two littoral areas studied in this project; this semi-enclosed ecosystem (180 km^2) is the only macrotidal lagoon of the French Atlantic coast. The intertidal zone (115 km^2) of the lagoon is colonized by the largest seagrass bed in Europe (mainly *Zostera noltii*). Besides its ecological interest as a reproduction or rearing area for numerous marine fish and invertebrate species, the lagoon is of noticeable importance due to oyster (*Crassostrea gigas*) cultivation. Oyster production reaches ca. 12,000 tons annually (10% of the French seashell production and 50-70% of the french oyster spat). This protected area is facing increasing anthropogenic perturbations mainly due to increasing riverine population and tourism. This study is the first one ever designed to estimate CO_2 fluxes at the 3 interfaces (sediment-water, sediment-air and air-sea) in the intertidal and subtidal zones of the Arcachon lagoon.

Methods

Flux measurements and study sites

Measurements of CO_2 fluxes at the sediment-water interface were performed using large-sized benthic chambers (Martin *et al.*, 2007; Thouzeau *et al.*, 2007). Three replicate acrylic tubes (0.196 m^2) were gently pushed by SCUBA divers into the sediment, separated from each other by a distance of ca. 2 m. Acrylic hemispheres were secured to each base to trap a known volume of bottom water, varying from 36 to 50 l according to base insertion into the substrate. Clear chambers were used to assess net community production in daylight and opaque chambers to estimate respiration in dark conditions. A series of incubations, centered on high tide, were carried out for ca. 2h30. Homogenisation of water inside the enclosure was provided by adjustable submersible pumps connected to waterproof batteries. As metabolic responses depend on hydrodynamics (Patterson *et al.*, 1991; Forja & Gomez-Parra, 1998), water flow in each enclosure was adjusted to the minimum value allowing stable measurements to be recorded by the probes. O_2 concentrations, salinity, temperature and depth were recorded every minute inside the chambers with YSI 6920 probes. Water samples were collected in the enclo-sures for pH and total alkalinity using 450 ml polyethylene syringes at the beginning and end of the incubations. A Li-Cor quantum sensor (LI-192SA) was deployed near one of the clear hemispheres to record the amount of actual photo-synthetically active radiation (PAR in µmol photons.m^{-2}.s^{-1}, 400-700 nm) available for the enclosed photosynthetic organisms. Irradiance was averaged every minute. At the end of the experiments, the benthic fauna was sampled by cores placed randomly in each chamber (3-5 replicates / chamber).

CO_2 fluxes at the sediment-air interface were measured according to the method described in Migné *et al.* (2002), using three benthic chambers (each covering a 0.071 m^2 area). Changes in CO_2 mole fraction (ppm) in air were measured with an infrared CO_2 gas analyser (Li-Cor Li-800). CO_2 fluxes were then calculated from recorded data using the slope of CO_2 concentration (µmol$_{CO2}$.mol$_{air}^{-1}$) against time (min). Results were expressed in mmolC·m^{-2}·h^{-1} assuming a molar volume of 22.4 L·mol^{-1} at standard temperature and pressure. Measurements were performed under natural light and in darkness in order to assess net primary production and respiration of the benthic community, respectively. The PAR were continuously measured at the sediment surface using a quantum sensor (Li-Cor SA-190). Three sediment cores (sample unit 1.9 cm^2, 10 mm depth) were randomly taken inside each chamber at the end of the experiments to estimate microphytobenthos biomass from the analysis of chlorophyll a (Lorenzen, 1967).

CO_2 fluxes at the air-sea interface were measured with a floating chamber as described in Frankignoulle (1988). The pCO_2 in the water was also monitored continuously during 25h, using an equilibrator, from a small research vessel anchored in a subtidal channel.

The field work was carried out in the southeastern part of the Arcachon lagoon, near Cassy, in 4 study sites represen-tative of the main benthic biota of the lagoon, in March 2005, May 2006 and late September-early October 2007. Station S1 was located in the upper intertidal sandy area. Station S2 was representative of the intertidal muddy bottoms with a microphytobenthic cover. Station S3, also intertidal, was located in -and quite representative of- the extensive seagrass beds. Station S4 (5 m depth) was located in a subtidal channel; sediments of this area (silty sand with shell debris) were less silty than the sediments of S2 and S3.

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Results

Mean respiration rates at the sediment-water interface were in the range 1.6-13.6 mmol DIC m^{-2} h^{-1}. When measured, mean production rates ranged from -0.6 to -5.7 mmol m^{-2} h^{-1} at stations S2 and S3. Near-bottom lighting at S4 was not sufficient to support net production, whatever the season. Hypoxic conditions occurred at the sediment-water interface in May 2006 and respiration was dominant in all 3 stations. The low CPQ (CPQ= $|\Delta O_2/\Delta DIC|$) value in May (0.13) would partly result from higher carbonate dissolution in the sediments when compared to March and October.

Table 1. Mean CO_2 (SA) or DIC (SW) fluxes (darkness/natural light; mmol m^{-2} h^{-1}) measured at the two interfaces in the 4 study sites. nd: no data.

Interface[a]-Date	S1	S2	S3	S4
SA-Mar	0.1 / -0.3	0.2 / -1.9	0.9 / -1.6	
SA-May	1.2 / -1.5	1.6 / -5.6	5.1 / -0.6	
SA-Sept	0.6 / -1.1	1.0 / -5.5	1.5 / -2.7	
SW-Mar		4.0 / -2.1	1.6 / 0.7	nd
SW-May		8.5 / nd	7.6 / -2.2	13.6 / 3.2
SW-Oct		3.6 / -0.6	12.2 / -5.7	2.5 / 4.3

[a] SA: sediment-air, SW: sediment-water.

Mean respiration rates at the sediment-air interface were in the range 0.1-5.1 mmol C m^{-2} h^{-1} while mean production rates ranged from -0.3 to -5.6 mmol m^{-2} h^{-1}. The benthic community respiration rate under emersion was higher in May and lower in March in all stations. The seagrass station presented the highest respiration rates whatever the season was. The net primary production rate showed the same seasonal trend (i.e. maximal rate in May and minimal rate in March) on the sandy and the muddy station. On the seagrass station, it was lower in May and higher in September. The muddy station presented the highest net production rates whatever the season was. Gross primary production and productivity (i.e. gross production standardized on chlorophyll biomass) were higher on the seagrass station in March and on the muddy station in May and September.

Mean CO_2 fluxes at the air-sea interface were close to 0 in March versus 4.8 to 6.6 mmol m^{-2} h^{-1} in May and 0.5 mmol m^{-2} h^{-1} in October. The record of pCO_2 in the water during two tidal cycles gives important insight on carbon benthic-pelagic coupling in a tidal flat dominated system as the Arcachon lagoon. At high tide, water shows slide oversaturation (~700ppmv) with respect to the atmospheric equilibrium (380ppmv). During the first phase of the ebb, when the tidal flats are still immerged, salinity decreases and pCO_2 increases drastically up to 1300ppmv. Such rapid increase in pCO_2 reveals the supply of carbon from the sediment to the water column, either as CO_2 from benthic respiration or as labile organic carbon that is rapidly respired in the water column. When ebb continues, the tidal flats get emerged and disconnected from the channel water, and pCO_2 decreases rapidly to ~800ppmv. Simultaneously, salinity decreases, which reveals the influence of continental waters flowing at low tide in the channel.

Discussion

This study highlighted high spatial and temporal variability of CO_2 fluxes in the Arcachon lagoon; in particular, spatial and/or temporal trends were not always reproduced between stations or interfaces. It allows determining factors regulating CO_2 exchanges and benthic photosynthetic processes in this shallow-water macrotidal ecosystem. Microphytobenthos seemed to account for a major part of the primary production of the seagrass community under emersed condition. This was shown by the temporal variability of production observed at the beginning of the emersion period under stable light and temperature conditions and explained by the upward migration of cells.

The analysis of CO_2 fluxes over the annual cycle provided a basis for describing spatial and temporal variations of the dynamics of sediment-water, sediment-air and air-sea exchanges in the Arcachon lagoon. The results obtained will help understanding the functionning of semi-enclosed ecosystems of the Atlantic coast and calculating carbon budgets in the Arcachon lagoon.

Acknowledgements

This study was funded by the EC2CO-PNEC Chantier Littoral Atlantique. The authors acknowledge the city of Cassy for providing logistical support during the field work.

References

Forja J.M., A. Gomez-Parra, 1998. Measuring nutrient fluxes across the sediment-water interface using benthic chambers. *Marine Ecology progress Series* 164: 95-105.

Frankignoulle M., 1988. Field measurements of CO_2 air-sea exchange. *Limnology and Oceanography* 33: 315-322.

Lorenzen C.J., 1967. Determination of chlorophyll and phaeopigments: spectrophotometric equations. *Limnol. Oceanography* 12:343-346.

Martin S., G. Thouzeau, M. Richard, L. Chauvaud, F. Jean, J. Clavier, 2007. Benthic community respiration in areas impacted by the invasive mollusk, *Crepidula fornicata* L. *Marine Ecology Progress series* 347: 51-60.

Migné A., D. Davoult, N. Spilmont, D. Menu, G. Boucher, J.-P. Gattuso, H. Rybarczyk, 2002. A closed-chamber CO_2-flux method for estimating intertidal primary production and respiration under emersed conditions. *Marine Biology* 140:865-869.

Migné A., N. Spilmont, D. Davoult, 2004. In situ measurements of benthic primary production during emersion: seasonal variations and annual production in the Bay of Somme (eastern English Channel, France). *Continental Shelf Research* 24:1437-1449.

Patterson D.M., K.P. Sebens, R.R. Olson, 1991. In situ measurements of flow effects on primary production and dark respiration in reef corals. *Limnology and Oceanography* 36: 936-948.

Spilmont N., D. Davoult, A. Migné, 2006. Benthic primary production during emersion: in situ measurements and potential primary production in the Seine Estuary (English Channel, France). *Marine Pollution Bulletin* 53:49-55.

Thouzeau G., J. Grall, J. Clavier, L. Chauvaud, F. Jean, A. Leynaert, S. ni Longphuirt, E. Amice, D. Amouroux, 2007. Spatial and temporal variability in benthic biogeochemical fluxes in the Thau lagoon associated with macrophytic and macrofaunal distribution. *Estuarine Coastal Shelf Science*, 72(3): 432-447.

Dissolved and particulate lead in the Corcubión Sound (NW Iberian Peninsula). Comparison with contamination trend in the Galician Rias

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Introduction

Lead is not an essential element from a biological point of view but its research is a question of general interest because its toxicity. Lead concentration is not very high in the environment with the exception of anthropogenicaly influenced areas as it is the case of the estuaries and coastal zones with important population and/or industry (Ewers and Schlipköter, 1991).

There are some studies about dissolved and particulate lead levels in the Galician Rias: mainly in the Ferrol (Cobelo-García et al., 2005) and Vigo (Prego et al., 2006) Rias. Current information from the rias suggests that they are not contaminated although there is some evidence of isolates enrichments of lead in the surface sediments of the most human-disturbed rias, i.e. Ferrol, Coruña, Arousa, Pontevedra and Vigo (Prego and Cobelo-García, 2003). However, there is poor information about the small rias and coastal zones of the Galician Shelf as is the case of the Corcubión Sound.

The Corcubion Sound takes up and area of 90 km^2 bordered on the southern littoral of the Finisterre Cape, the Carnota Beach and the Pindo Hills (Fig.1). Sound is an 8 km arm of the sea forming a 90-50 m depth channel with a shallower inner zone (<30 m depth) that is made up of the small Cee and Xallas estuaries (Fig.1). The sound bathimetry, the damming of the main freshwater flow, the Xallas River, and the low flow of the Cee water stream place this coastal system under the ocean control and its hydrography is different to the own neighbouring rias. Therefore, the biogeochemical trend of lead as a contaminant trace metal in the only sound of Galician coast is researched and compared with the metal pattern observed for the rias.

Material and Methods

To achieve the above mentioned objective three seasonal cruises (winter, spring and summer) have been carried out in the survey area on board the R/V Lura. During each cruise lead concentrations in the water column were measured at 0, 10, 40, 80 m of depth in three stations (A, B and C in Fig.1) besides the Xallas River, Cee water stream and Cee sewage treatment plant (STP):

(1a) Dissolved lead (DPb) using differential pulse anodic stripping voltammetry;

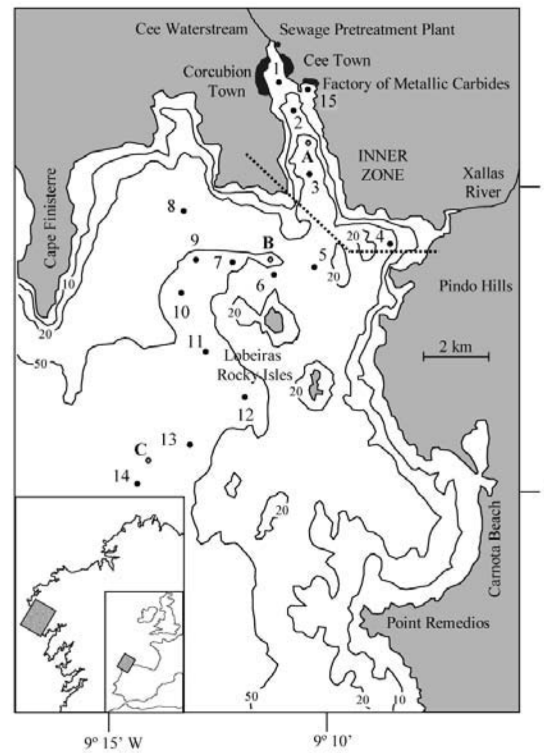

Figure 1. Bathymetric map of the study area. Open circles (A, B and C) represent water samples and full circles sediment samples (1-15).

(2) Particulate lead (PPb) in the suspended particulate matter (SPM) was analysed, after seawater filtration on policarbonate inside a laminar flow cabinet (class 100) and microwave digestion, by graphite camera atomic absorption spectrometry (GCAAS);

(3a) Aluminium and lead concentrations were also measured, after microwave digestion according to 3052 EPA procedure, in 15 surface sediment samples (SAl and SPb) taken along the sound axe; and (3b) one core using flame atomic absorption spectrometry (FAAS) and GCAAS.

The use of trace metals clean techniques was used during all the sampling procedure to avoid any contamination. The analytical procedure and results were checked with certificate reference material for water (CASS-4) and sediment (PACS-2) samples obtaining good agreement with the certified values.

Results and Discussion

Values of 0.1-0.9 nM of dissolved lead in seawater (0.2-0.8 nM in the rivers and 6-8 nM in the STP), 0.04-1.10 nM of particulate lead in seawater (0.6-8.3 nM in the rivers and 1-17

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nM in the STP) for SPM and 12-145 mg·kg^{-1} in the sediment were found in this study to the Corcubión Sound area.

Due to the different oceanic (outer) and continental (inner) influence, a division between both zones in the sound and rias is made for a better discussion of the results. Levels of dissolved, particulate and sedimentary lead are lower in the outer zone (Table 1) of the Corcubión Sound indicating the continental lead inputs to the coastal environment. High lead concentrations were measured in the freshwater contributions, and the spill from the sewage pre-treatment plant of Cee. A possible impact from the factory of metallic carbides is also likely.

Lead concentrations in the inner Sound zone are, in general, similar or lower than those found in two industrialized rias (Ferrol and Vigo) of the Galician coast. On the other hand, lead concentrations in dissolved, particulate and sediments of the outer Corcubión Sound are in the order of those reported for open waters off Galicia (Prego and Cobelo-García, 2004) and lower to the ones reported for other contaminated Galician Rias (Table 1).

In the case of sediments, the values found in Corcubión inner zone are similar to the measured for other Galician marine sediments (Carballeira et al., 2000). Therefore, the horizontal distribution of lead reflects inputs of anthropogenic origins, with higher concentrations at locations close to contaminant sewage outflows. A good example is the influence of industry and the harbour activities of the city of Vigo on the southern margin (>150 mg·kg^{-1}; Besada et al., 1997) and its head (San Simon inlet: from 84 to 394 mg·kg^{-1}, Belzunce-Segarra et al., 1997; Evans et al., 2003).

Lead presence in the sediments of the outer Corcubión zone is similar to the background levels by Al-Pb normalisation like the natural world sediment concentrations (5-60 mg·kg^{-1} of Pb) proposed by Wedepohl (1991).

Table 1. Comparison of lead concentrations in different Galician coastal environments of sound and rias (inner corresponds to the estuarine part).

lead	zone	Corcubión Sound [1]	Ferrol Ria [2]	Vigo Ria [3]
dissolved	inner	0.13-0.88	0.45-1.55	0.68-0.77
(DPb in nM)	outer	0.08-0.55	0.12-0.74	0.49-0.57
particulate	inner	0.04-1.10	0.02-0.08	2.3
(PPb in nM)	outer	0.01-0.09	0.01-0.10	0.79-0.90
sedimentary	inner	44-145	36-127	116-1610
(SPb in mg·kg^{-1})	outer	12-31	13-159	18-36

1 This article
2 Cobelo-García and Prego (2004); Cobelo-García et al. (2004); Cobelo-García et al. (2005)
3 Marcet et al. (1997); Carballeira et al. (2000); Prego et al. (2006)

Conclusions

Respect to lead concentrations, the Corcubion Sound may be considered as a quasi pristine area and possible contamination was only observed in the innermost shallow zone. This coastal system is, in general, low-contaminated in comparison with the next anthropogenicaly disturbed Rias.

In addition to this metal (Pb), the behaviour and levels of another six elements (Cd, Co, Cu, Ni, V and Zn) in this area will be discussed during the congress presentation.

Acknowledgements

We acknowledge to the crew of R/V Lura for their kind cooperation in the sampling. Santos-Echeandía thanks the Basque Government for financial support (pre-doctoral grant). This work is a contribution to the LOICZ-Spain program and it was supported by the Xunta de Galicia PGIDIT06RMA6040IPR project.

References

Belzunce-Segarra, M.J., Bacon, J.R., Prego, R., Wilson, M.J., 1997a. Chemical forms of heavy metals in surface sediments of the San Simon inlet, Ria de Vigo, Galicia. *Journal of Environmental Science and Health,* A32 (5): 1271–1292.

Besada, V., Schultze, F., Viñas, L., 1997a. Distribución de metales pesados en sedimentos superficiales de la Ria de Vigo. In: *Procesos Biogeoquímicos en sistemas costeros Hispano-Lusos* (Ed. by R. Prego & J.M. Fernández Alvarez). Diputación de Pontavedra, pp. 79–83.

Carballeira, A., Carral, E., Puente, X., Villares, R., 2000. Regional scale monitoring of coastal contamination. Nutrients and heavy metals in estuarine sediments and organisms on the coast of Galicia (northwest Spain). *International Journal of Environment and Pollution,* 13: 534–572.

Cobelo-García, A., Prego, R., 2004. Behaviuor of dissolved Cd, Cu, Pb and Zn in the estuarine zone of de Ferrol ria (Galicia; NW Iberian Peninsula). *Fresenius*, 13 (8): 753- 759.

Cobelo-García, A., Prego R., Labandeira, A., 2004. Lands imputs of trace metals, major elements, particulate organic carbon abd suspended solids to an industrial coastal bay of the NE Atlantic. *Water Research*, 38: 1753-1764.

Cobelo-García, A., Prego, R., deCastro, M., 2005. Metal distribution and their fluxes at the coastal boundary of a semi-enclosed ria. *Marine Chemistry*, 97: 277-292.

Evans, G., Howarth, R.J., Nombela, M.A., 2003. Metals in the sediments of Ensenada de San Simón (inner Ría de Vigo), Galicia, NW Spain. *Applied Geochemistry*, 18: 973-996.

Ewers, U. and Schlipköter, H.W. 1991. Lead. In: Metal and their compounds in the environment (Ed. by E. Merian), pp. 971-1014. VCH.

Marcet, P., Andrade, M.L., Montero, M.J., 1997. Contenido y enriquecimiento de metales en sedimentos de la ria de Vigo (España). *Talasas*, 13: 87–97.

Prego, R., Cobelo-García, A., 2003. 20th Centrury overview of Heavy Metals in the Galician Rias (NW Iberian Peninsula). *Environmental Pollution*, 121: 425-452.

Prego, R., Cobelo-García, A., 2004. Cadmium, copper and lead contamination of the seawater column on the Prestige shipwreck (Northeastern Atlantic Ocean). *Analytica Chimica Acta*, 524: 23-26.

Prego, R., Cotté, M.-H., Cobelo-García, A., Martin, J.-M., 2006. Trace metals in the water column of the Vigo Ria: Offshore exchange in mid-winter conditions. *Estuarine, Coastal and Shelf Science,* 68: 289-296.

Wedepohl, K.H., 1991. The composition of the upper earth's crust and the natural cycles of select metals. In: Metals and their Compounds in the Environment (Ed. by E. Merian), Part I, pp 3–17. VCH.

Determination of metal background values in estuarine and coastal waters of the Basque Country.

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Introduction

Some of the European Directives, such as the European Water Framework Directive (WFD) (Directive 2000/60/EC) or the "Revised proposal for a list of priority substances in the context of the water framework directive" (COMMPS Procedure, 98/788/3040/DEB/E1 final report) , have, as ultimate aim, to reduce concentrations of hazardous substances in the marine environment, near to background values. Hence, he determination of natural background levels of heavy metals to distinguish between natural element concentrations and anthropogenically-influenced concentrations is higly relevant (Fowler, 1999; and Carballeira *et al*., 2000; and Borja *et al*., 2005). Due to the geological variety of the different regions, later studies showed the convenience to derive local background levels, especially if they are necessary for environmental assessment (Reimann and Garrett, 2005). Nevertheless, although there exist some studies on background levels in sediments, in the Basque Country (Rodríguez *et al.,* 2006), there are no previous studies in this region concerning metal background values in sea water.

There is not a standard procedure to determine local background vaules in waters, neither a general agreement on the statistical methodologies to be applied (for detailed discussions on this topic in sediments see Carballeira *et al*., 2000; Matschullat *et al*., 2000; and Rodríguez *et al*., 2006). Among them, that proposed by Reimann et al. (2005) permits the definition of upper limits for the background with a defined statistical reliability. This methodology requires a high number of data.

The main objective of this contribution is to estimate the background levels of heavy metals in the estuarine and coastal waters, within the Basque Country, using statistical tools based on the heuristic procedure proposed by Reimann *et al.* (2005).

Methods

A total of 1,594 surface water samples were obtained from 32 estuarine and 19 coastal locations (Figure 1), twice a year, during summer and winter, from 1995 to 2006. Water samples were collected by means of Niskin bottles, at low tide and high tide for estuarine locations. Total dissolved metals were analised. As was determined directly by quartz furnace AAS, after hydride generation of the sample in a FIA system. Cu, Mn, Ni, Pb and Zn content by graphite furnace AAS with Zeeman background correction, previous preconcentration with chelex-100 ion-exchange resin (Pohl and Prusisz, 2004).

Cluster analyses were carried out on data before the background values calculation in order to evaluate differences between estuarine and coastal locations, season of the year, or tide. Graphical inspection of the empirical data distribution, using statistical and geographical displays is necessary. Therefore, the study of cumulative probability plot (CDF diagram) must be done prior to defining background ranges (Reimann *et al*., 2002; Rodríguez *et al.,* 2006)), Tukey boxplot fences and whiskers, and [median ± 2MAD] were estimated for assisting in the estimation of background range.

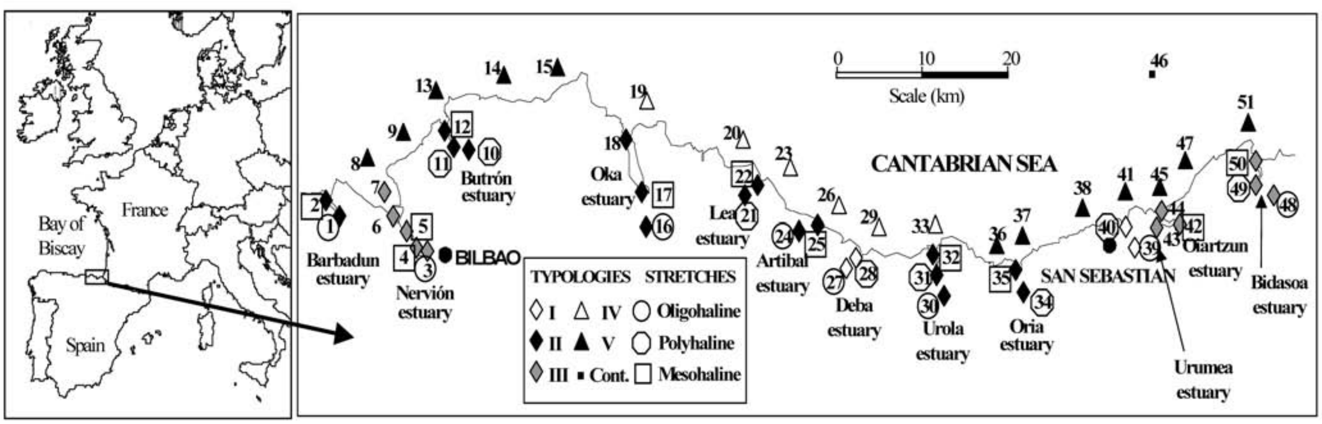

Figure 1 Location of estuarine and coastal sampling sites in the Basque Country. Roman numbers are the typologies defined by Borja *et al.* (2004) for the Water Framework Directive, in this region.

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Results and discussion

Some differences between estuarine and coastal samples were found, therefore, in order to estimate background values, data set was classified using the salinity gradient acording to the Venice Symposium definitions (Anon., 1959). For each metal, six groups of salinity were defined: Freshwater (USP≤0.5), Oligohaline (0.5-5 PSU), Mesohaline (5-18 PSU), Polyhaline (18-30 PSU), Euhaline Estuary (PSU>30 in estuarine locations), Euhaline Littoral (PSU>30 in coastal locations). For each metal, river catchments with more than 10% of outliers in any salinity group were removed. Background ranges calculated as lower-upper inner fences or Median 2MAD (see Rodríguez *et al.,* 2006, for details) are represented in Table 1.

	Median	Median ± 2 MAD	Lower - upper whisker
As Freshwater	0.6	0.33 - 1.1	0.30 - 1.2
As Oligohaline	0.8	0.51 - 1.3	0.40 - 1.6
As Mesohaline	1.0	0.51 - 2.0	0.30 - 2.4
As Polyhaline	1.2	0.68 - 2.1	0.40 - 2.9
As Euhaline estuary	1.4	0.86 - 2.3	0.60 - 2.4
As Euhaline litoral	1.4	0.86 - 2.3	0.60 - 3.6
Cu Freshwater	1.8	0.56 - 5.8	0.30 - 9.9
Cu Oligohaline	1.8	0.74 - 4.4	0.30 - 7.7
Cu Mesohaline	1.8	0.67 - 4.8	0.30 - 11
Cu Polyhaline	1.6	0.68 - 3.8	0.30 - 8.0
Cu Euhaline estuary	1.5	0.64 - 3.5	0.30 - 7.7
Cu Euhaline litoral	1.1	0.45 - 2.7	0.30 - 5.9
Mn Freshwater	1.0	0.30 -4.2	0.30 - 9.0
Mn Oligohaline	2.3	0.30 - 20	0.30 - 97
Mn Mesohaline	5.2	0.49 - 56	0.30 - 257
Mn Polyhaline	5.8	0.49 - 69	0.3 - 161
Mn Euhaline estuary	2.1	0.39 - 11	0.30 - 56
Mn Euhaline litoral	1.0	0.30 - 4.0	0.30 - 15
Ni Freshwater	1.5	0.33 - 6.9	0.30 - 29
Ni Oligohaline	1.9	0.41 - 9.1	0.30 - 23
Ni Mesohaline	1.9	0.47 - 7.6	0.30 - 30
Ni Polyhaline	1.5	0.43 - 5.3	0.30 - 17
Ni Euhaline estuary	1.2	0.30 - 4.8	0.30 - 16
Ni Euhaline litoral	0.8	0.30 - 4.5	0.30 - 8.5
Pb Freshwater	0.8	0.30 - 2.1	0.30 - 9.4
Pb Oligohaline	1.2	0.42 - 3.4	0.30 - 5.9
Pb Mesohaline	1.3	0.49 - 3.4	0.30 - 11
Pb Polyhaline	1.2	0.41 - 3.5	0.30 - 8.5
Pb Euhaline estuary	1.2	0.43 - 3.3	0.30 - 9.1
Pb Euhaline litoral	1.0	0.30 - 3.6	0.30 - 11
Zn Freshwater	15	5.9 - 38	3.0 - 52
Zn Oligohaline	19	5.93 - 61	3.0 - 101
Zn Mesohaline	22	8.7 - 56	4.0 - 124
Zn Polyhaline	21	8.0 - 55	3.0 - 136
Zn Euhaline estuary	19	7.6 - 47	4.0 - 106
Zn Euhaline litoral	11	4.4 - 27	3.0 - 70

Table 1: Results (in ug^{l-1}) for background ranges for each metal and salinity group.

The obtained metal background ranges are higher than those reported by other sources, including data from oceanic waters (OSPAR, HELCOM). Comparing to other estuaries or coastal waters of the world, the Basque Country coast present high background concentrations in Zn. Concentrations in As, Cu and Pb increased as salinity rised, while for Ni the pattern was the opposite.

Conclusions

The heuristic method proposed by Reimann et al. (2005), is useful in determining the regional background metal levels, with an unimodal empirical data distribution. Such methodology can provide assistance to other regions and countries, in establishing background levels and accomplishing (within the requirements of the WFD) a further assessment of the chemical status.

Acknowledgements

Data used in this contribution were obtained from the monitoring network of the Basque coast, undertaken by AZTI-Tecnalia for the *Departamento de Medio Ambiente y Ordenación del Territorio* (Basque Government).

References

Borja, A., 2005. The European Water Framework Directive: a challenge for nearshore, coastal and continental shelf research. Continental Shelf Research, 25(14): 1768-1783.

Carballeira A, Carral E, Puente X, Villares R., 2000. Regional-scale monitoring of coastal contamination. Nutrients and heavy metals in estuarine sediments and organisms on the coast of Galicia (northwest Spain). Int J Environ Pollut 2000; 13: 534-572.

Fowler, SW., 1990. Critical review of selected heavy metal and chlorinated hydrocarbon concentrations in the marine environment. Mar Environ Res; 29: 1-64.

Pohl, P., B. Prusisz, 2004. Pre-concentration of Cd, Co, Cu, Ni and Zn using different off-line ion exchange procedures followed by the inductively coupled plasma atomic emission spectrometric detection. Analytica Chimica Acta 502(1): 83-90.

Reimann, C., P. Filzmoser, Garret, P. Robert, G.(2002). "Factor analysis applied to regional geochemical data: problems and possibilities." Applied Geochemistry 17(3): 185-206.

Reimann, C., R. G. Garrett, 2005. Geochemical background--concept and reality. Science of The Total Environment, 350(1-3): 12-27.

Rodríguez, J.G., I. Tueros, A. Borja, M.J. Belzunce, J. Franco, O. Solaun, V. Valencia, A. Zuazo, 2006. Maximum likelihood mixture estimation to determine metal background values in estuarine and coastal sediments within the European Water Framework Directive. The Science of the Total Environment, 370(2-3): 278-293.

Biogeochemical inter-tidal processes and fluxes of organomercury and organotin compounds in the Arcachon Bay (France)

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Introduction

Trace metals can be present in the environment in different chemical forms which at the same time present different physicohemical properties and specific biogeochemical pathways. An important case of study is the widespread release of Hg and Sn compounds into the environment and the subsequent environmental concern about the toxicity and effects of these pollutants. Unravelling the biogeochemical cycle of such metallic and organometallic species still remains an unexplored task and needs to be evaluated through an interdisciplinary research in which the analytical and the environmental chemistry must collaborate with other scientific disciplines such as microbiology, ecotoxicology and biogeochemistry.

In the case of Hg, methylation, demethylation and photochemically-induced redox reactions are important processes regulating its cycle in the acuatic environments. The methylation of Hg inmmobilised in sediments lead to the formation of MeHg (which is a highly toxic species that can be bioaccumulated and biomagnificated in the trophic network). MeHg formation is a result of biotic or abiotic transformations caused by specific redox gradients and bacterial activity (Rodriguez Martin-Diomeadios et al, 2004). In addition, the transfer of gaseous Hg from intertidal sediments to the atmosphere has been reported in coastal lagooon with extensive intertidal areas. On the other hand, Sn compounds have been extensively used as pesticides, as toxic aditives in antifouling paints and during the processing of plastic materials. The use of trisubstituted organotin species such as tributyltin (TBT) in antifouling paints is being worldwide restricted but municipal solid wastes can be also considered as an important pool of organotin compounds. TBT can be degraded in the water column by dealkykation reactions to form less toxic species such as monobutyltin (MBT) or dibutyltin (DBT). In addition volatile Sn compounds can be formed in water and sediments from the methylation and hydridation of both inorganic Sn and butyltin compounds (Amouroux et al, 2000).

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It is clear therefore that environmental processes at the sediment-water interface play a major role in the biogeochemical speciation of metals. However, most of the studies carried our so far, have been conducted on relatively enclosed specific environments. Thus, there is a lack of studies on tidal environments that integrate the behavior of metals during tidal and seasonal cycles. Steady states in the intertidal biogeochemical procceses are not reached due to the transient nature of the sediments and therefore, it is extremely difficult to extract from tidal systems environmental quantitative information on biogeochemical processes and fluxes. Morevoer, coastal sedimentary stock also represents an enormous potential repository for lypophilic contaminants such as TBT and MeHg. However, major questions remain concerning their capabilities of remobilization, exchange with the water column and their possible transfer to the pelagic food web.

The Arcachon Bay (France) combines two important characterisctics for an adequate study of the biogeochemical cycle of organometallic species. First, it is an area of economical interest due to the oyster farming and the tourist activities and characterized by an important previous anthropogenic pressure of organotin compounds. Secondly, the study of intertidal environmental processes at the water-sediment and sediment-atmosphere interface can be performed as two thirds of its area is emerged at low tide. This work is supported by the ANR "blanc" (PROTIDAL) and PNEC (Chantier "Littoral Atlantique") National Programs to study the nature and the variability of the biogeochemical inter-tidal fluxes and processes of organometallic species of Hg and Sn occurring at the sediment-water interface in the Arcachon Bay following three different approaches: **1-**The exchange of the dissolved organometallic species between the sediment and the water column (benthic fluxes) will be determined by the use of benthic chambers. **2-**The influence of the tidal pump in the biogeochemistry and partition of the organometallic species will be study by the performance of diurnal cycles in which the samples are collected every two hours during a 24 hours period (day and night).**3-**The alkylation and dealkylation processes of the organometallic species will be studied in sediments and waters by the performance of field incubations under different environmental conditions using isotopically enriched organometallic species.

Methods

Site description

The Arcachon Bay (44°40'N, 01°10'W) is a 156 km^2 lagoon located on the French Atlantic coast. The tide amplitude oscillates between 1.1m and 4.9m. The internal part of the basin is emerged at low tide (115 km^2).

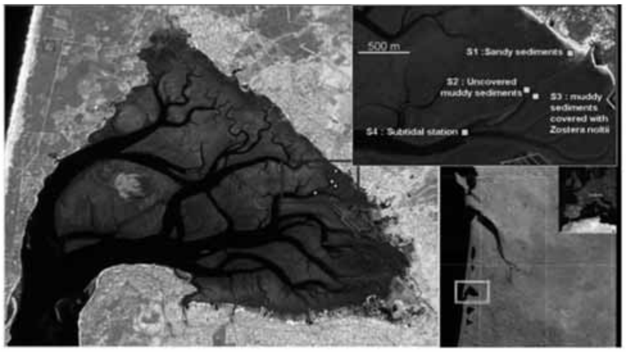

Figure 1 Map of the study area, showing the sampling stations.

The inter-tidal internal zone of the Arcachon bay covers 66% of the surface area, encloses the largest seagrass field of *Zostera noltii* in Europe and consists of muddy sediments, whereas the upper parts consist of permeable sandy sediments. Permeable sandy sediments also outcrop in the bed of small channels. Sands are covered by muddy sediments on the tidal flat. This research will be focus on the area arround the location of Cassy where three major groups of sedimentary environments were selected: Station 1 (sandy sediments of the upper part) Station 2 (uncovered muddy sediments) Station 3 (muds covered with *Zostera noltii*) and a subtidal station always covered with water (Station 4).

Benthic fluxes calculation

The benthic fluxes determined with the chambers were calculated as follows:

$$F= (C_f-C_i)V/(T_f-T_i)A$$

where (C_f-C_i) is the difference of concentration determined between the final and the initial samples, (T_f-T_i) is the total incubation time, between the final and the initial samples, V is the volume of water enclosed in the chamber and A is the surface area covered by the benthic chamber on the sediment surface.

Field incubation of water and sediments

Isotopically enriched organometallic species were added to both bulk and filtered water samples collected from Station 4 and incubated during 24 hours. In this way both biotic and abiotic degradation can be independently studied. Also, both groups of samples were divided into two subgroups: one was exposed to a diurnal cycle of light and the other were kept in dark conditions in order to discriminate the photochemically induced alkylation/delakylation processes. Concerning sediment incubations three different sediment samples were collected from the different stations, spiked with isotopically enriched organometallic species and mixed with 5 mL of interstitial adjacent water from each corresponding sampling point. The samples were dividded in two groups: one was exposed to a diurnal cycle of light and the other were kept in dark during 24 hours. The calculation of the extent of the different alkylation/dealkylation processes in waters and sediments was carried out by performing a mathematical isotopic pattern deconvolution of the isotopically enriched samples after GC-ICP-MS analysis (Rodriguez-Gonzalez et al, 2007).

Results and Discussion

Table 1 shows that the sediments and water above concentrations (employed for the calculation of the benthic fluxes) are typical of background contamination level of MeHg, Hg (II) and TBT.

Table 1 Water and sediment concebtrations for MeHg Hg(II) and TBT in three different stations from the Arcachon Bay (Cassy).

	Station 2		Station 3		Station 4	
	Water (ng L^{-1})	Sed. (ng g^{-1})	Water (ng L^{-1})	Sed. (ng g^{-1})	Water (ng L^{-1})	Sed. (ng g^{-1})
MeHg	0.03±0.01	0.9 ±0.1	0.04±0.01	0.7 ±0.2	0.03±0.01	1.7 ±1.3
Hg (II)	2.9 ± 4.1	222 + 31	1.5 ± 0.7	192 + 26	1.5 ± 1.2	205 + 5
TBT	0.8 ±0.1	4.3 + 0.9	0.2 ±0.1	2.2 + 0.5	0.9 ±0.1	3.4 + 0.7

Table 2 shows the range of benthic fluxes obtained for these species in different sampling campaigns. Each species-specific flux obtained in the Arcachon Bay is comparable to those obtained in other coastal environments. This data provides a preliminary agreement between the data obtained in the inter-tidal zone of the Arcachon Bay and those obtained in previous campaigns in sub-tidal sites using the same benthic chambers and the same and analytical procedures.

Table 2 Intersite comparison of the benthic fluxes ranges obtained for Inorganic Hg, MeHg and TBT in different sampling campaigns.

Site	Date	Type	Benthic Fluxes (ng m^{-2} h^{-1}) Hg (II)	MeHg	TBT
Arcachon Bay	March 2005	macro-inter-tidal	-131 to +142	-45 to +116	----
Arcachon Bay	May 2006	macro-inter-tidal	-6 to +14	-1.2 to 1.2	-14 to +4
Bay of Brest[a]	October 2002	macro-sub-tidal	-100 to +117	-2.5 to +2.6	-8.5 to +4.5
Thau lagoon[b]	May 2003	micro-sub-tidal	-57 to +22	-1.2 to +2.8	-2.5 to +57.4

[a] Amouroux et al (Unpublished results) [b]Point et al, 2007.

References

Amouroux, D., Tessier, E., Donard, O.F.X., 2000. Volatilization of organotin compounds from estuarine and coastal environments. Environmental Science and Technology 34, 988-995.

Point, D., Monperrus, M., Tessier, E., Amouroux, D., Donard, O.F.X., Chauvaud, L., Thouzeau, G., Jean, F., Amice, E., Grall, J., Leynaert, A., Clavier, J., 2007. Biological control of trace metal and organometal benthixfluxes in a eutrophic lagoon (Thau Lagoon, Mediterranean Sea, France). Estuarine, Coastal and Shelf Science 72 (3), 457-471.

Rodriguez-Gonzalez, P., Monperrus, M., Garcia Alonso, J.I., Amouroux, D., Donard, O.F.X. Comparison of different numerical approaches for multiple spiking species-specific isotope dilution analysis exemplified by the determination of butyltin species in sediments. Journal of Analytical Atomic Spectrometry 22, 1373-1382

Rodriguez Martin-Doimeadios, R.C., Tessier, E., Amouroux, D., Guyoneaud, R., Duran, R., Caumette, P., Donard, O.F.X., 2004. Mercury methylation/demethylation and volatilization pathways in estuarine sediment slurries using species specific enriched stable isotopes. Marine Chemistry 90, 107-123.

Fate of mercury and butyltin compounds in the turbid plume of the Adour estuary: reactivity and dispersion along the Basque Coast

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Introduction

Contamination of the environment by mercury and butyltin compounds is a major global issue owing to their accute toxicity. Along estuarine gradients, mercury and butyltin compounds may undergo strong speciation changes resulting in different biovailability due to changes in salinity regime, redox potential, properties of the dissolved organic matter, photochemical reactions, and sediment ressuspension (Stoichev et al., 2006). During the transport through the estuarine gradient changes in the composition of suspended matter may occur, as well as degradation of particulate (POC) and dissolved (DOC) organic carbon, eventually releasing these species to the water column.

Moreover, mercury and butylin compounds can be subjected to transformations. Their concentration in aquatic systems is thus controlled by formation, degradation and exchanges between compartments which can be driven by both biological activities and abiotic mechanisms (Monperrus et al., 2007). For example, the net amount of the highly toxic MeHg is a function of the concentrations and processes that regulate the reactivity of MeHg or its precursor, divalent mercury. Bio-mediated pathways (i.e., biomethylation, bioredox reaction) have been proposed to play a significant role for mercury species transformations. However in natural waters too scarce investigations have been performed to clearly understand the transformation potentials as well as chemical and biological pathways involved. There remains an incomplete understanding of the factors controlling the particle-water reactivity and the transformations of mercury and butyltin compounds in estuaries, where reaction conditions change markedly on going from river to the sea.

The work presented here has attempt to adress this question by combining particulate and dissolved concentration measurements along the salinity gradient in the water column of the plume with specific water incubation experiments using stable isotopes. We have investigated the spatial variations of mercury and butyltin species concentrations from a longitudinal and vertical study of the Adour plume. In situ experiments using isotopically labeled species (^{199}Hg(II) and Me^{201}Hg, ^{117}TBT and ^{119}DBT) were used to investigate transformation mechanisms, such as methylation, demethylation, reduction and debutylation, under different experimental conditions in order to assess the relative contribution of photochemical versus biological processes to these mechanisms.

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Methods

Sampling strategy

Samples were collected in the Adour Estuary (South France) during spring between 7th and 13th April 2007 during the campaign METADOUR2 aboard the French research vessel "Côte de la Manche" (CNRS/INSU).

Located in the south-west of France, the Adour estuary is flowing into the Gulf of Biscay (Atlantic Ocean). The whole mixing zone of this estuary (0-25 km) presents a narrow channel exhibiting a width about 500 m to only 200 m at the mouth. This results in a very low residence time for both waters and particles entering the estuary, suggesting a dominant transfer to the ocean during medium to high flow conditions. The water flow entering the estuary during the campaign was comprised between 400 $m^3.s^{-1}$ and 900 $m^3.s^{-1}$.

A total of 14 stations (Fig. 1) were sampled for the surface water in the Adour plume. 3 characteristic stations of the mixing zone were sampled at different depths: M01 located at the estuary mouth outflow, M02 located in the deeper part of the shelf and M03 located on the continental shelf in the outer estuary. Stations M01, M02 and M07 were also sampled for incubation experiments. For all the stations, depth profiles of hydrological parameters were determined using a CTD probe, (Seabird SBE-25).

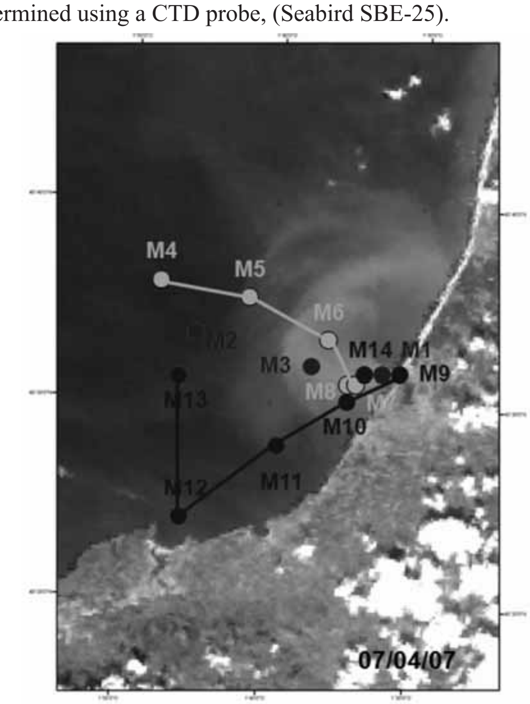

Figure 1: Satellite picture of the Adour estuary plume with sampling stations.

Collection, filtration and analysis - Water samples were collected using an acid-cleaned 5 L Teflon lined Go-Flo bottle (General oceanic, USA). The collected samples were filtrated (0.45 µm PVDF filters) under a portable laminar flow hood (ADS Laminaire) to avoid in-situ contamination. Filtered water was poured into Teflon bottles and acidified with HCl to 1% v/v and stored at 4°C in the dark until analysis. The filters were digested with HNO_3 under microwave radiations. Speciation analysis of mercury and butyltin compounds were performed using propylation-CGC-ICPMS (Monperrus et al., 2005). GF/F glass fibre filters (0.7 µm, Whatman) were used to sample suspended particulate matter (SPM), particulate organic carbon (POC) and phytoplankton pigments measurements (chloro *a*).

Incubation experiments - The experimental design for water incubations is described in figure 2. Briefly, known amounts of isotopically enriched species solutions ($^{199}HgCl_2$ and $Me^{201}HgCl$ for mercury experiments, ^{117}TBT and ^{119}DBT for butyltin experiments) were added to the water samples. The experiments were carried out over a complete diurnal cycle. Control assays were performed on filtered water samples and/or under dark conditions. At the end of the incubation period, aliquots of incubated bulk water samples were filtered in order to achieve species partitioning between dissolved and particulate phases. All incubations were stopped by adding high purity HCl (1% v/v) and stored at +4°C in the dark until analysis.

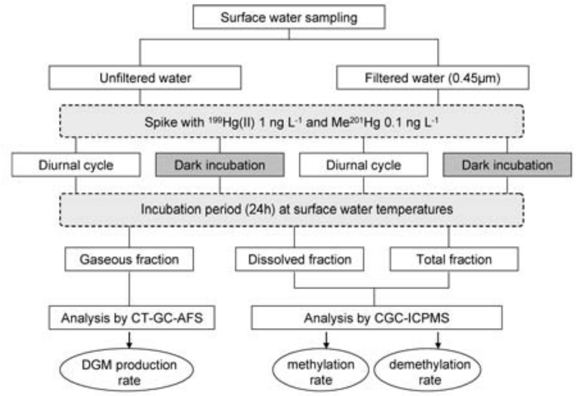

Figure 2: Flow chart of the experimental procedure for water incubations.

Results and discussion

Distribution of mercury and butyltin compounds in the water column - Typical water depth profiles are presented in figure 3 for hydrological parameters and organometallic species concentrations in the dissolved fraction for the station M03. This station is located on the continental shelf in the outer estuary and is directly submitted to the turbid estuarine plume. Surface water is characteristic of riverine water while below 15 meters depth mainly marine water occurs. A mixed layer is observed exhibiting intermediate salinity and a maximum of chlorophyll.

Transformation potentials of mercury and butyltin species - In situ experiments using isotopically labeled species have permit to determine methylation, demethylation and reduction rates of mercury species and debutylation rates of butyltin compounds.This work assesses also the relative contribution of photochemical versus biological processes to the different mechanisms (Monperrus et al., 2007). The dark incubation is employed as a control allowing the discrimination of photochemically induced transformation processes mainly occuring in surface waters. Incubation of filtered water samples allow to roughly discriminate abiotic processes from those mediated mainly by the plankton biomass (i.e. phyto and bacterio-plankton).

Acknowledgements

This research was performed in the framework of the project "Panache Adour" from the Réseau Recherche Littoral Aquitain funded by the Aquitaine Région. P. Anschutz, H. Etcheber and D. Poirier (EPOC UMR CNRS/Univ Bordeaux 1) are acknowledged for providing us with hydrological parameters measurements.

References

Stoichev, T., D. Amouroux, M. Monperrus, D. Point, E. Tessier, G. Bareille, O.F.X. Donard, 2006. Methyl mercury in surface waters of the Adour river estuary (South West France*). Chemistry and Ecology,* 22(2):137-148.

Monperrus, M., E. Tessier, S. Veschambre, D. Amouroux, O.F.X. Donard, 2005. Simultaneous speciation of mercury and butyltin compounds in natural waters and snow by propylation and species specific isotope dilution mass spectrometry analysis. *Analytical and Bioanalytical Chemistry*, 381:854-862.

Monperrus, M., Tessier, E., Amouroux, D., Leynaert, A., Huonnic, P., O.F.X., Donard, 2007. Mercury methylation, demethylation and reduction ratesin coastal and marine surface watersof the Mediterranean Sea, *Marine Chemistry*, 107:49-63.

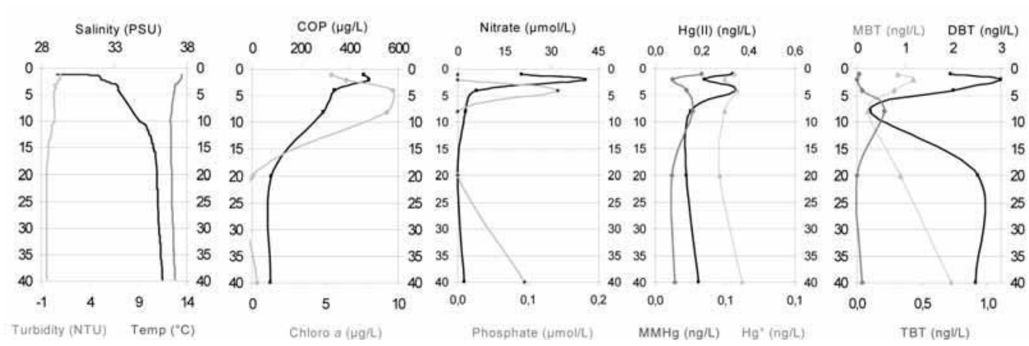

Figure 3: Depth profile for hydrological parameters and dissolved mercury and butyltin compounds at the shelf station (M03)

Baseline survey of imposex and TBT concentrations in *Nassarius reticulatus* and *N. nitidus* in the ports of Pasaia and Bilbao, Basque Country

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Introduction

Tributyl tin (TBT) is a biocide that has been widely used in anti-fouling paints for ships causing toxic effects in many different non-target organisms. Due to this toxicity, the EU Regulation 782/2003 will carry a total prohibition of TBT on hulls from 1st January, 2008. Thus, all ships entering a port in a Member State should not bear an active TBT-based antifouling coating. Before this total ban, a baseline survey of imposex in two of the most abundant whelks (*Nassarius reticulatus* and *N. nitidus*) in the Basque soft bottom areas was carried out. The imposex is the superimposition of male characters onto unpararasitized and parasitized females on gastropods due to an external agent, mainly TBT (Gibbs and Bryan, 1996). Due to this, various species of prosobranchs have been used as sentinel organisms. Among them *Nassarius reticulatus* have been studied in several European countries, whereas *Nassarius nitidus* has been studied occasionnally (Magnusson *et al.*, 2005; Pavoni, in press).

Methods

Imposex characterization

Whelks were collected at marinas, fishing ports and trading ports in order to provide an extensive coverage of the port areas of Bilbao and Pasaia, the two most important in the Basque Country. The gastropods were collected by hand (intertidal sites), or with baited hoop nets or diving (subtidal sites) during February-June 2007. The following parameters were determined for each station: Relative Penis Length Index (RPLI = mean female penis length * 100 / mean male penis length) and Vas Deferens Sequence Index (VDSI). RPLI was determinated following Stroben *et al.* (1992), whereas VDSI following Barroso *et al.* (2002). Higher values of VDSI and RPLI indicate higher degree of imposex.

Determination of MBT, DBT and TBT

The determination of TBT, dibutyltin (DBT), and monobutyltin (MBT) was carried out at the Unidad de Espectrometría de Masas of the University of Oviedo (http://www10.uniovi.es/SCTs). The determination was undertaken in the whole tissues of pooled females and in sediments for each station using CG-MS with isotopic dilution. The methodology is detailed in García Alonso *et al.* (2002). The spike solution certified in isotopic composition and concentration containing a mixture of MBT, DBT and TBT enriched in ^{119}Sn was supplied by ISC-Science (Gijón, Spain, http://www.isc-science.com).

Results

In the Port of Bilbao (Figure 1) the RPLI ranged from 2 to 68% in *Nassarius reticulatus*, whereas from 10 to 72% in *N. nitidus*. The VDSI ranged from to 0.8 to 4.8 in *N. reticulatus*, whereas from 2.2 to 5 in *N. nitidus.* In *N. reticulatus* and in *N. nitidus* the highest degree of imposex was found in the harbours of Las Arenas and Santurtzi, respectively. The lowest values of imposex were found in the outer part of the sampled area.

In the Port of Pasaia (Figure 2) the RPLI ranged from 7 to 92% in *N. reticulatus*, whereas from 50 to 86% in *N. nitidus*. The VDSI ranged from to 0.6 to 5 in *N. reticulatus*, whereas from 4.7 to 5 in *N. nitidus.* In both species the highest degree of imposex was found in the proximity of the shipyard of Lezo.

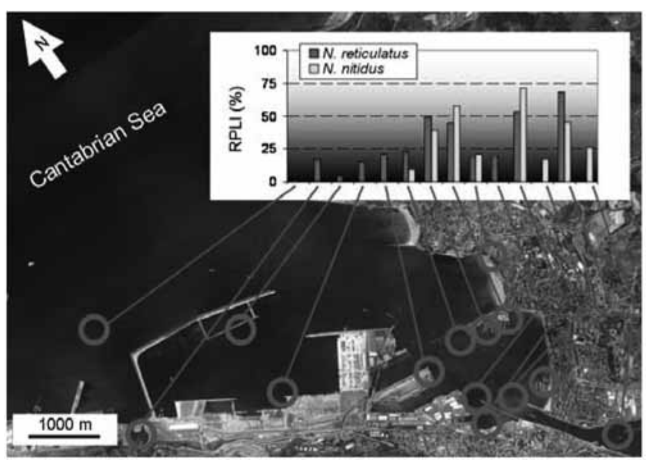

Figure 1 Relative penis length index in the Port of Bilbao

Relationships between TBT concentrations in sediments and organism tissues and between TBT concentration and biological effect were also studied.

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Discussion

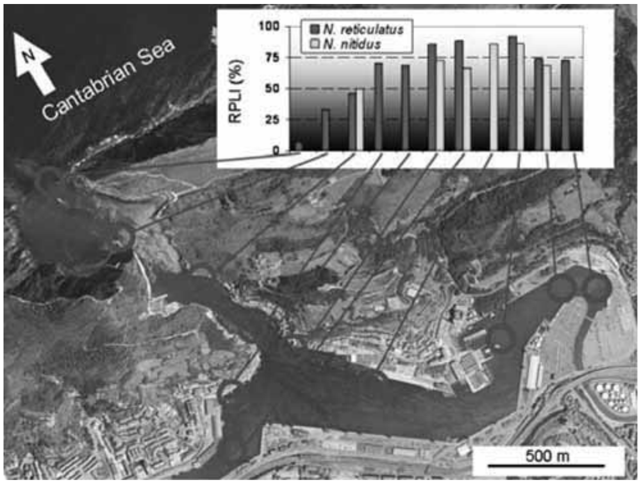

Figure 2 Relative penis length index in the Port of Pasaia

In general, the lower values of imposex were found in the outer part of both port areas, whereas the higher ones were found in sampling sites with higher shipping traffic or shipyard activity together with high water residence times.

Comparing the two port areas, the port of Pasaia reported higher values of imposex. This is probably due mainly to (i) the presence of a shipyard and, (ii) the higher water residence time (Borja et al., 2006).

Conclusions

Imposex levels in *Nassarius reticulatus* and *Nassarius nitidus* at several sites of the two main ports of the Basque Country coast are given as a base-line for future evaluation of the effectiveness of the ban on the use of organotin-based antifouling in 2008.

Acknowledgements

This study is funded by the Department of Environment and Land Plannig of the Basque Government and the Departamento para la Innovación y la Sociedad del Conocimiento of the Diputación Foral de Gipuzkoa. J. G. Rodríguez was supported by the programme Torres Quevedo (Ministerio de Educación y Ciencia and Fondo Social Europeo). We wish to thank also several people from AZTI and Instituto Don Bosco for their sampling and laboratory labours (Almudena, Bea, Carlos, Carlota, Deniz, Ekaitz, Inma, Marivi, Maite, Miguel, Pedro, Ramón, Xiker).

References

Barroso, C.M., Moreira, M.H., Bebianno, M.J. (2002) Imposex, female sterility and organotin contamination of the prosobranch *Nassarius reticulatus* from the Portuguese coast. *Marine Ecology-Progress Series*, 230, 127-135.

Borja, A., Galparsoro, I., Solaun, O., Muxika, I., Tello, E.M., Uriarte, A., Valencia, V. (2006) The European Water Framework Directive and the DPSIR, a methodological approach to assess the risk of failing to achieve good ecological status. *Estuarine Coastal and Shelf Science*, 66, 84-96.

García-Alonso, J.I., Encinar, J.R., Gonzalez, P.R., Sanz-Medel, A. (2002) Determination of butyltin compounds in environmental samples by isotope-dilution GC-ICP-MS. *Analytical and Bioanalytical Chemistry*, 373, 432-440.

Gibbs, P. E. y Bryan, G. W. 1996. TBT-induced imposex in neogastropod snails: masculinization to mass extinction. In Tributyltin: case study of an environmental contaminant (de Mora, S. J., editor. pp. 212-236. Cambridge University Press, Cambridge.

Magnusson, M., Borgegren, A., Granmo, Å., Cato, I. (2005) *Eventuellt samband mellan halten tennföreningar i vävnaden hos nätsnäckan Nassarius nitidus och halten tennföreningar i sedimentet. Rapport Göteborgs universitet. Naturvårdsverket och Sveriges geologiska undersökning.*: 21.

Pavoni, B., Centanni, E., Valcanover, S., Fasolato, M., Ceccato, S., Tagliapietra, D. Imposex levels and concentrations of organotin compounds (TBT and its metabolites) in *Nassarius nitidus* from the Lagoon of Venice. *Marine Pollution Bulletin*, In Press, Corrected Proof.

Stroben, E., Oehlmann, J. y Fioroni, P. 1992. The morphological expression of imposex in Hinia reticulata (Gastropoda: Buccinidae): a potential indicator of tributyltin pollution. Marine Biology 113:625-636.

Imposex and Butyltin Bioaccumulation in the gastropod *Nassarius reticulatus* (L.) along the Spanish Cantabrian coast

Naiara Albaina[*1], Rodolfo Barreiro[1], Lucía Couceiro[1], Julián Díaz[2], Jose Ángel Irabien[2], Jose Miguel Ruiz[1]

Tributyltin (TBT) is an organometallic compound traditionally used as a biocide in antifouling ship bottom paints. Further to some previous partial bans, a total prohibition on TBT application took effect on 1st January 2003 (www.imo.org). Since the environmental levels of TBT are expected to decline thereafter, the OSPAR Convention for Protection of the Marine Environment of the NE Atlantic has included organotins as the 5th set of pollutants for mandatory monitoring to coincide with the IMO ban (www.ospar.org). OSPAR compulsory vigilance studies on other contaminants mostly consist of registering concentrations in biota (generally mussels) and sediments. In the case of TBT, however, signatory countries must monitor not only its levels in gastropod molluscs, but also (for first time ever) the incidence of some specific biological effects (*i.e.* imposex, the superimposition of male sexual characteristics onto female gastropods). Imposex coastal monitoring started focusing on *Nucella lapillus* (L.), but *Nassarius reticulatus* (L.) has been suggested as a suitable alternative for southern OSPAR areas.

A 12 point survey along the Cantabrian coast of Spain was performed during August 06 (from the Bidasoa to the Eo estuaries) and included stations with high shipping activity and stations from supposedly clean areas. Samples of *Nassarius reticulatus* were collected and treated as usual. Imposex assessment was carried out and included determination of the relative penis length and vas deferens sequence indexes (RPLI and VDSI, respectively). The concentration of butyltin species was determined in a blind manner by the Universidad de Cantabria (Santander, Spain).

This survey shows that TBT and/or its specific biological effects are ubiquitous in the study area. Results will be compared to those from studies of neighbouring regions and discussed in relation to both the partial and total ban of these compounds in antifouling paints. This information will serve as a baseline for future monitoring surveys in the area.

Acknowledgements

This survey stems from a Cooperation Agreement between the UDC and the Instituto Español de Oceanografía which, in turn, was originally funded by the Spanish Ministerio de Medio Ambiente.

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Short-term Oxidation-Reduction processes within a hypoxic estuary, using an *in situ* Mass Spectrometer. Comparison with classical oceanographic tools

Itziar Tueros [a], Ángel Borja [a], Javier Franco [a] and Victoriano Valencia [a]

Introduction

The Oiartzun river estuary holds the second commercial harbour of the Basque Coast, Northern Spain. The special morphology of the estuary (like a small fjord) is strongly modified for navigation purposes (Figure 1) (Borja *et al.,* 2006). River basin and the corresponding river flow are very small, whereas the estuarine volume is relatively high. The estuary is mesotidal, with high residence times of the water masses, especially in the innermost reaches (Borja *et al.,* 2006). The wastewater treatment in recent years has produced important improvements in the estuarine water quality (Franco *et al.,* 2004); however, high organic matter loads (mainly from domestic wastes) are still discharged into the inner locations. This produces strong and relatively fast oxygen consumption, enhanced by heavily reduced and organic-matter-rich sediments. This leading frequently to hypoxia events (measured), denitrification (observed, measured) and sulphaterreduction (empirical sulphide smell).

The aims of this contribution are:

- To determine if the concentrations of the molecular species (non ionic forms in the dissociation or hydrolysis equilibria), associated to the abovementioned processes, are high enough to be detected
- To determine these patterns in quantitative or qualitative ways.
- To check and compare classical oceanographic monitoring data with data obtained using an *in situ* underwater mass spectrometer, studying problems and complementarities associated to both methodologies.

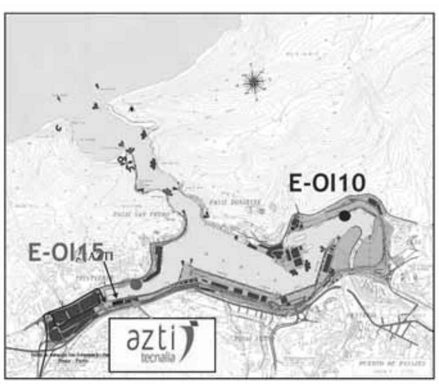

Figure 1. Oiartzun estuary as study case, including two of the sampling stations

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Methods

The study was undertaken by means of an In-Spectr 200-200 Underwater Mass Spectrometer (UMS) (Figure 2), manufactured by Applied Microsystems, based in the model developed in the University of South Florida (Short *et al*., 2001; Short *et al*., 2006) The system is able to collect and analyze samples, down to 200 m water depth, and measure analytes up to 200 Atomic Mass Unit (A.M.U.). The basic instrumentation is a linear quadrupole coupled to a hydrophobic polydimethylxiloxane (PDMS) membrane that pervaporate non-ionic species such as molecular dissolved gases and volatile organic compounds (Wenner *et al*., 2004; Kibelka *et al*., 2004)

The UMS was used to measure NH_3, CO_2, O_2, CH_4 and H_2S along a tidal cycle in surface and bottom water, together with CTD measurements (temperature, salinity, dissolved oxygen, pH, light transmission, and chlorophyll) and laboratory analysis of ammonium, nitrite, nitrate, phosphate, silicate, sulphide, TOC, etc. in discrete samples (surface and bottom) taken by Niskin bottles.

Hence, this contribution couples classical marine monitoring data (*in situ* CTD continuous profiles and discrete depth water samples analysis) with continuous *in-situ* UMS measurements. The results are used for calibration/quantification of UMS data and for monitoring improvement, with better spatial and temporal resolution than with classical methods.

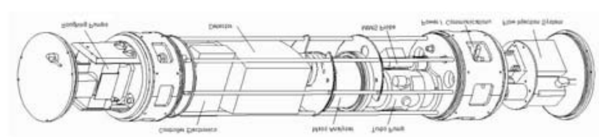

Figure 2. Underwater Mass Spectrometer

Results

Figure 3 shows the values of the dissolved oxygen saturation for the sampling sites indicated in the Figure 1, based on a seasonal monitoring in the Oiartzun estuary, since 1994; these measurements were carried out by means of a CTD. The sampling station E-OI10 is affected by the main tributary, the Oiartzun River, whereas the station E-OI15 (our study site) is located in the Herrera harbour. Events of hypoxia, denitrification and sulphaterreduction are quite frequent, with some reactivation (frequency and intensity) along the last two years.

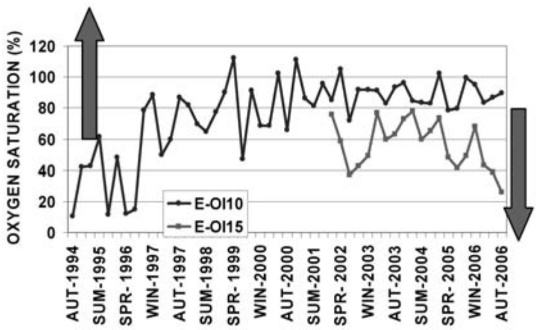

Figure 3. Average percentage of dissolved oxygen saturation at the sampling sites located in Figure 1

During a series of measurements, conditions of severe hypoxia have been detected, with oxygen saturation percentages between 10% and 30%. Large content of total organic carbon and very high concentrations of ammonium and phosphate in comparison with the oxidized nitrogen values indicated a strong oxygen demand, typically related with high loads of urban waste waters. Saline stratification differentiates surface and bottom sampling levels, with higher nutrient and lower dissolved oxygen concentrations in low salinity surface waters than in bottom waters.

In these conditions, good agreement has been obtained between data from classical methods (CTD, laboratory analysis) and from field measurements performed with the UMS (vertical profiles and continuous measurements in a fixed layer). Multisignal records from the UMS reproduce well the inverse behaviour of the carbon dioxide and dissolved oxygen concentrations, and similar pattern has been observed for "free", un-ionized ammonia and oxygen concentrations.

In comparison with results from other measurements and analysis, UMS records discriminate samples in time (tidal variations) and water depth (stratification). In terms of normalised signal, resolution for dissolved oxygen is ≈ 0.05 $mL·L^{-1}$ (≈1% in saturation). For CO_2, variations related to 1 $mg·L^{-1}$ in inorganic carbon, 0.05 pH units and 0.1 $mL·L^{-1}$ in dissolved oxygen can be detected. For ammonia, concentrations and changes around 10 $\mu mol·L^{-1}$ in total ammonium are detectable by the UMS. For sulphide, some qualitative differences related with the stratification can be observed but, at low concentrations of total sulphide, free H_2S could not be detected by UMS in these conditions.

Conclusions

Hypoxia, denitrification and sulfaterreduction processes are detected in the Oiartzun estuary by classical monitoring tools in the study area. Underwater Mass Spectrometer is a valuable tool in these studies for the determination of molecular dissolved gases related with biogeochemical processes, as oxygen, carbon dioxide, ammonia, hydrogen sulphide, methane, etc. Responses in O_2, CO_2 and NH_3 are in agreement with results using classical methods. Further development is needed in laboratory calibration and field deployment strategies.

Acknowledgements

This study was partially supported by the Basque Government (Departamento de Medio Ambiente y Ordenación del Territorio and Programa ETORTEK del Departamento de Industria, Comercio y Turismo). We are very grateful to the laboratory and sampling staff of the Marine Research Division (AZTI Tecnalia).

References

Bald, J., A. Borja, I. Muxika, J. Franco and V. Valencia. Assessing reference conditions and physico-chemical status according to the European Framework Directive: a case-study from the Basque Country (Northern Spain). 2005 Marine Pollution Bulletin, 50: 1508-1522 .

Borja, A., I. Galparsoro, O. Solaun, I. Muxika, E.M. Tello, A. Uriarte and V. Valencia, 2006. The European Water Framework Directive and the DPSIR, a methodological approach on assessing the risk of failing to achieve the good ecological status. Estuarine, Coastal and Shelf Science, 66: 84-96.

Franco, J., A. Borja and V. Valencia (2004) Overall assessment - human impacts and quality status. In Borja, A. and Collins, M. (Eds.). Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series nº 70. pp 581-597. Elsevier. Amsterdam, 2004.

Kibelka, G.P.G., R.T.Short, S.K.Toler, J.E. Edkins and R.H. Byrne. (2004) Field-Deployed Underwater Mass Spectrometers for Investigation of Transient Chemical Systems. Talanta 64, 961-969.

Short, R.T., D.P. Fries, M.L.Kerr, C.E. Lembke, S.K.Toler, P.J. Wenner and R.H. Byrne. (2001) Underwater Mass Spectrometers for in-situ chemical analysis of the hydrosphere. Journal of American Society of Mass Spectrum. 12, 676-682.

Short, R.T., et al., Detection and quantification of chemical plumes using a portable underwater membrane introduction mass spectrometer. Trac-Trends in Analytical Chemistry, 2006. 25(7): p. 637-646.

Wenner, P.G., et al., Environmental chemical mapping using an underwater mass spectrometer. TrAC Trends in Analytical Chemistry, 2004. 23(4): p. 288-295.

Lead and Zinc in the sediments of Corme and Camariñas Galician Middle Rias: Background equations, enrichment levels and comparison with the large Vigo and Pontevedra Western Rias

Ana V. Filgueiras*[a], Sabela Insua[a], Ricardo Prego[a] and Francisco Díaz-Fierros[b]

Introduction

In the context of the biogeochemical cycles of metals, sediments of coastal systems afford useful information on the land-ocean exchanges because their estuarine areas behave as metal traps where the metals from population and industries spills are accumulated. This is the case of metals in the sediments of the large Western Galician Rias where contamination state is well known (Prego and Cobelo-García, 2003). However, there are small rias which background levels of metals and contamination of their sediments are not yet defined, as occurs with the Middle Galician Rias of Corme (27 km^2) and Camariñas (17 km^2). The main fresh water input is the Anllóns River (11.4 m^3·s^{-1}) and the Grande River (8.3 m^3·s^{-1}), respectively.

In the clasification of Torre-Enciso (1958) Corme and Camariñas are defined as Middle Rias. These rias can be divided in two differentiated zones: the middle-outer one, mainly dominated by oceanic influence, and the inner one, with typical estuarine characteristics. Rias basin is mainly composed by medium and siliciclastic sand and some rocky shallows.

Respect to the human impact, the Corme Ria supports a dispersed population of 18,100 inhabitants which more important towns are Laxe, Corme and Ponteceso. The primary sector is the most important activity in the area with a very scarce building and fishing industry. Likewise, 6,500 people live around the Camariñas Ria, essentially in the towns of Muxía and Camariñas, whose activity does not differ from that mentioned above. The objective of this study is to define ranges, background levels and contamination state of lead and zinc in these small rias and to compare it with western larges rias.

Methods

Sampling and Analysis

In order to study the metal presence in these two small rias, placed close to the Finisterre Cape, samples of superficial sediment were taken aboard of R/V *Mytilus* with a Van Veen grab. A polyethylene spatula was employed to collect the top surface sediment, which was stored in plastic flasks in refrigerator at 4ºC. Later, samples were oven-dried at 50ºC, sieved to obtain the fine fraction (<63μm) and stored in plastic tubes.

The sediment samples were microwave-digested (Milestone 1200 Mega) in Teflon bombs using a mixture of HNO_3 and HF (Merck Suprapur) according to EPA guideline 3052 (EPA, 1996). Lead concentration was quantified by means of electrothermal atomic absorption spectrometry (ETAAS) using a Varian 220 spectrum equipped with Zeeman background correction; while Zn, was analysed by means of flame atomic absorption spectrometry (FAAS) using Varian 220 equipment with deuterium background correction. The accuracy of the analytical procedure was checked using the reference material PACS-2 (marine sediment reference material, NRCC), obtaining values of 176±16 μg g^{-1}, certified 183±8 μg g^{-1} for Pb and 356±6 μg L^{-1}, certified 364±23 μg L^{-1} for Zn.

Results and Discussion

Lead and zinc levels in estuary and ria areas of the Camariñas and Corme Rias were summarize in Table 1. In the Anllons and Grande Estuaries Pb and Zn concentrations decreased towards the estuary mouth. Lead concentrations in both Rias are lower than those summarize by Marmolejo-Rodriguez et al. (2007) and Prego and Cobelo-García (2003) in the Vigo and Pontevedra inner zone. Nevertheless, zinc concentrations in Corme are as high as in Western Rias. This could be explained with the local geochemistry of Anllons river basin (Guitián, 1992), in opposition of the Western Rias case where Zn increase is caused by contamination.

The highest levels of Pb are mainly focused in the harbour of Laxe and in the neighbouring areas of Camariñas and Corme harbours (Fig.1) while Zn is only high in the Corme harbour (Fig.2). As related previously (Table 1), in these two Rias the concentrations of both metals are lower than in most contaminated Western Rias, with the exception of harbour areas. A possible explanation is the own shape of the Ria: short and sea open, with shorter water residence times.

To stablish the degree of contamination in a coastal environment is necessary to determine the metal reference concentrations in sediments. In general, it has been considered the standard level of Wedepohl (1991). However, the metal presence in the sediments varies according to the geochemical composition of the coastal system and their river basins. Thus, it is necessary to define a background metal level in a local sense. Metal concentrations will be normalized in the <63 μm fraction, because they present a very strong adsorptive potential for trace metals. In addition, Fe was chosen as normalizer because it is a conservative element associated to the fine fraction, which concentration is high in marine sediment and not altered by anthropogenic contributions. Therefore, with the aim of determine reference element equations as has been described by Cobelo-García and Prego (2003), metal concentrations in both rias and their estuaries

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[Pb] in mg·kg^{-1}

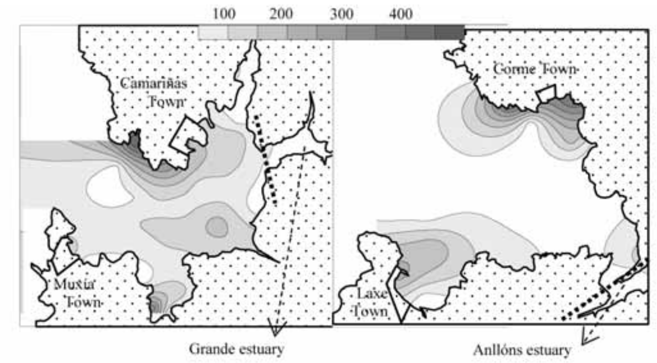

Figure 1. Pb distribution in Camariñas (left) and Corme (right) Rias.

[Zn] in mg·kg^{-1}

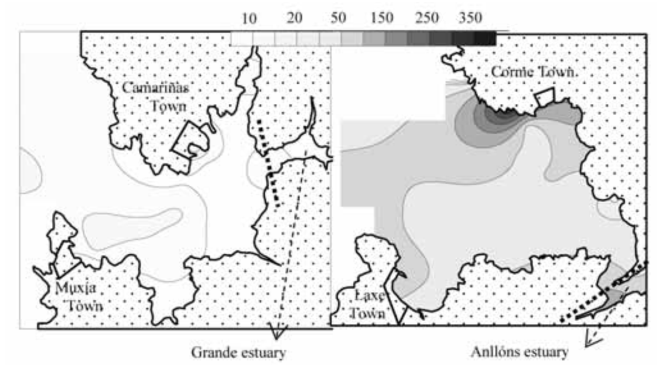

Figure 2. Zn distribution in Camariñas (left) and Corme (right) Rias.

were represented versus Fe. The following regression lines have been obtained:

$$[Pb] = 0.56\cdot[Fe] + 14.95 \qquad r = 0.64$$

$$[Zn] = 2.20\cdot[Fe] + 10.42 \qquad r = 0.91$$

where [Pb] and [Zn] is the concentration, in mg·kg^{-1}, calculated from the iron content, in mg·g^{-1}, of the sediment. This lead equation is in agreement with those calculated by Prego et al. (in press) for the Galician coast ([Pb] = 0.49·[Fe] + 13.1). However, zinc equation shows double slope ([Zn] = 1.19·[Fe] + 26.0) due to the local geochemistry, as related above. The background levels are an useful tool to determine the metal contamination of the surface sediments in both rias.

Table 1. Range and average concentrations of Pb and Zn in the estuarine and ria zones of the Corme and Camariñas Rias. Comparisson with Pontevedra (Marmolejo-Rodriguez et al., 2007) and Vigo (Prego and Cobelo-García, 2003; Prego et al., in press) Rias.

Ria	Zone (stations)	Pb (mg·kg^{-1})	Zn (mg·kg^{-1})
Corme	Estuary (13)	12- 52 (33±14)	43-217 (116±49)
	Ria (21)	7-412 (87±127)	18-361 (75±88)
Camariñas	Estuary (12)	10- 54 (32±16)	18-91 (42±23)
	Ria (31)	13-452 (108±98)	13-116 (46±32)
Pontevedra	Estuary (13)	41-135 (81±37)	60-157 (99±29)
	Ria (22)	55-120 (86±16)	34-150 (108±54)
Vigo	Estuary (14)	115-1852 (399±490)	103-182 (133±26)
	Ria (36)	38-280 (251±71)	33-1691 (590±596)

Conclusion

The small rias of Corme and Camariñas shown lower levels of lead and zinc than the southernmost large rias of Vigo and Pontevedra. Their small size and ocean open pattern, i.e. low seawater residence times, may be favourable to a dilution of contaminants. The Middle Ria exceptions are the harbour areas, where metal enrichment factors ($Me_{EF} = [Me]_{measured}/[Me]_{Fe\ regresion}$) are higher than 6 times the background concentration, which implies these areas present a very severe contamination, according to the criteria of Hakanson (1980).

Acknowledgements

The authors would like to thank the cooperation from the crew of the R/V *Mytilus* and, particularly, to A. Labandeira and P. Ferro for their analysis help. Dr. Filgueiras would like to thank the Spanish Education and Science Ministry for their financial support (I3P researcher contract). This work is a contribution to the Spanish LOICZ program and it was supported by the projects *Evolución histórica de la influencia antropogénica en la cuenca del río Anllóns, su estuario y la ría de Corme-Laxe* (CICYT, REN2002-04629-C03) and *Resposta do ecosistema peláxico ao forzamento hidrodinámico: a transición inverno-primavera na plataforma galega.* (Xunta de Galicia, PGIDIT06RMA6040IPR).

References

Cobelo-García, A., Prego, R., 2003. Heavy metal sedimentary record in a Galician Ria (NW SPAIN): background values and recent contamination. *Marine Polution Bulletin*, 46: 1253-1262.

EPA 1996. Method 3052. Microwave assisted acid digestion of siliceous and organically based matrices. Available from <www.epa.gov/epaoswer/hazwaste/test/3052.pdf>

Guitián Ojea, F., 1992. Atlas Geoquímico de Galicia. Xunta de Galicia. Consellería de Industria e Comercio. Dirección Xeral de Industria.

Hakanson, L., 1980. An ecological risk index for aquatic pollution control. A sedimentological approach. *Water Research*, 14:975-1001.

Marmolejo-Rodriguez, A.J., Prego, R., Meywer-Willerer, A., Shumilin, E., Sapozhnikov, D., 2007. Rare earth elements in iron oxy-hydroxide rich sediments form the Marabasco River-Estuary System (pacific coast of Mexico). REE affinity with iron and aluminium. *Journal of Geochemical Exploration*, 94 (1-3): 43-51.

Prego, R., Cobelo-García, A., 2003. Twentieth century overview of heavy metals in the Galician Rias (NW Iberian Peninsula). *Environmental Pollution*, 121 (3): 425-452.

Prego, R., Fero, P., Trujillo, C., *in press*. Zinc and lead contamination of surface sediments in the main harbours of the Galician Rias. *Journal of Iberian Geology*.

Torre Enciso, E., 1958. Estado actual del conocimiento de las Rias Gallegas. In: *Homenaxe a Otero Pedrayo*, Ed. Galaxia. pp. 237-250.

Wedepohl, K.H., 1991. The composition of the upper earth's crust and the natural cycles of select metals, in: Merian, E. (Ed.), *Metals and their Compounds in the Environment*, Part I, Chapter I.1. VCH, pp 3-17.

A comparative study of the dissolved Cd and Cu speciation along the salinity gradient of the Loire estuary-North Biscay continental shelf system

Matthieu Waeles,*[a] Ricardo Riso,[a] Jean-François Maguer[a] and Jean-François Guillaud[b]

Introduction

Estuaries play a key role in the transfer of trace metals to the ocean (Martin and Window, 1991). High amount are transported through these systems which are characterised by strong chemical and physical gradients. Thus, trace metals can undergo reactions which will affect the quantities and the chemical forms exported to the marine environment.

A large number of studies have been conducted on cadmium and copper in estuaries. In the case of Cd; they have shown unambiguously that this metal, bound to suspended matter, is mobilised when river water mixes with seawater. However, the mechanism at the origin of desorption is not fully understood, though speciation calculations have suggested formation of stable chlorocomplexes (Comans et van Dijk, 1988). The behaviour of Cu varies from one estuary to the other and can show seasonal variations within a particular system. As for Cd, few investigations have been devoted to the speciation of Cu in estuarine environments and most of them were restricted to a certain section of the system of concern. In particular the variations of metal speciation in large estuarine plume are largely unknown.

The study reported here was conducted in the whole salinity gradient of the Loire estuary- North continental shelf system. In a first paper, we described the results obtained in winter 2001 for copper and cadmium speciation in this system (Waeles *et al*., 2004). In this work, we report the spring 2002 data (Gasprod campaign, RV Thalassa, PNEC Program) which have been obtained in a period of lower discharge. A comparative study between winter and spring is carried out for these two metals. As an example, the vertical distribution of copper speciation will also be presented and discussed.

Results and discussion

Dissolved metal behaviours in the Loire estuary

Figure 1 describes the variations of the various cadmium species along the salinity gradient. For both seasons, total dissolved Cd (TDCd) has a non conservative behaviour with a strong positive deviation from linearity indicative of a dissolved metal addition in the system. The examination of the various Cd forms shows that the Cd addition was linked at low salinities (S<12) to a rise in labile Cd (LabCd), whereas it was due to an input of organic forms (OrgCd) at higher salinities. One should note that the winter input of orgCd was particularly important and occurred until very high salinities (S=26). The dissolved cadmium addition has been observed in most of the estuaries that have been studied and have been attributed to the formation of stable and soluble chlorocomplexes from particle-desorbed cadmium (Comans and van Dijk, 1988). In the Loire estuary, this process likely occurs at low salinities as the rise of labile cadmium species follows the rise of TDCd concentrations. However, at higher salinities, our data indicated that the rise of TDCd can also be linked to inputs of organic metal.

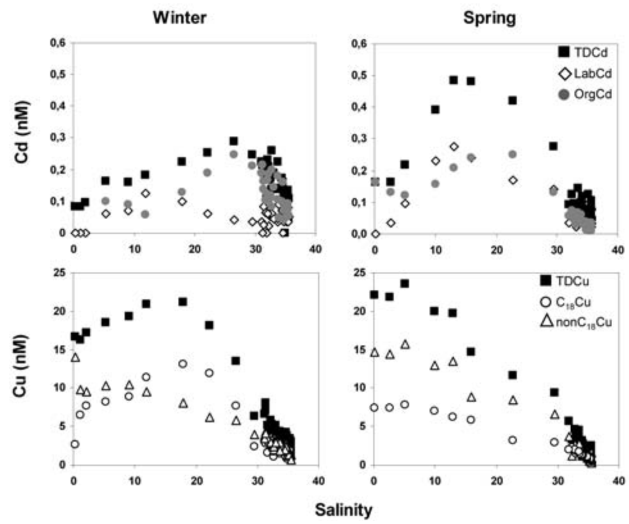

Figure 1. Metal salinity distributions

Different behaviours for dissolved copper were observed in winter and spring (Fig 1). In winter total dissolved copper (TDCu) has a non-conservative behaviour with a positive deviation from linearity suggesting an addition of metal. This addition was related to the one in extractable C_{18} organic copper (C_{18}Cu). In spring, TDCu and its various organic species showed a nearly conservative behaviour. It is well established that copper behaviour varies from one estuary system to the other, but variations within the same system have been much less documented (Waeles *et al*., 2005). Within the Loire estuary, the difference observed between winter and spring may originates from the fluctuation of the water discharge. Since floods took place before the winter sampling cruise, they likely favoured important inputs of organic ligands by the river, particularly of non-polar hydrophobic organic ones (Elbaz-Poulichet et al., 1994). These organic ligands may have induced a copper desorption from suspended particles during estuarine mixing.

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Fluxes of the various dissolved metal species

Metal concentrations in the riverine source waters were quantified as previously reported by fitting a linear regression between metal and salinity over the continental shelf (S > 30). Table 1 summarises the fluxes of the various metallic forms. For Cd, inputs of total dissolved metal have been estimated to 14 kg day^{-1} and 8.5 kg day^{-1} for winter and spring, respectively. Analysis of the relative contribution of the various dissolved species show that the metal was mainly brought as organic complexes in winter (78%) whereas the organic forms of Cd were calculated as being 55% of the metal flux in spring. For Cu, total dissolved metal fluxes were 343 and 216 kg day^{-1} for winter and spring, respectively. About 36% (winter) and 39% (spring) of Cu was brought as non-polar hydrophobic complexes.

Table 1. Dissolved metal fluxes (kg day^{-1})

	TDCd	LabCd	OrgCd	TDCu	C_{18}Cu	nonC_{18}Cu
Winter	14.0±1.1	3.1±0.2	10.9±1.3	343±14	122±13	215±22
Spring	8.5±0.6	3.8±0.5	4.7±1.1	216±10	84±2	128±10

Dissolved metal distributions on the continental shelf

Figure 2 illustrates the TDCd distribution in the surface waters of the North Biscay continental shelf in winter 2001 and spring 2002. In winter, concentrations of dissolved Cd were generally higher than 0.12 nM. At this season, the Loire highly affects the metal distribution over a large domain of the continental shelf, westwards to the nearby shelf break, and northwards up to the Iroise Sea. In spring, the effect of the Loire River is exerted over a much smaller area with TDCd values generally under 0.12 nM on the continental shelf. It is worth noting that the maximum in Cd concentration was situated in close to the mouth of the estuary in winter whereas it was confined within the estuary in spring. The differences in the observed levels can be explained by the amounts of metal brought by the Loire at the two seasons. The fact that the Cd maximum not beeing situated in the same area is linked to the differences in metal behaviour: in winter, the input of OrgCd to the dissolved phase was particularly important compared to the spring one and occurred until very high salinities.

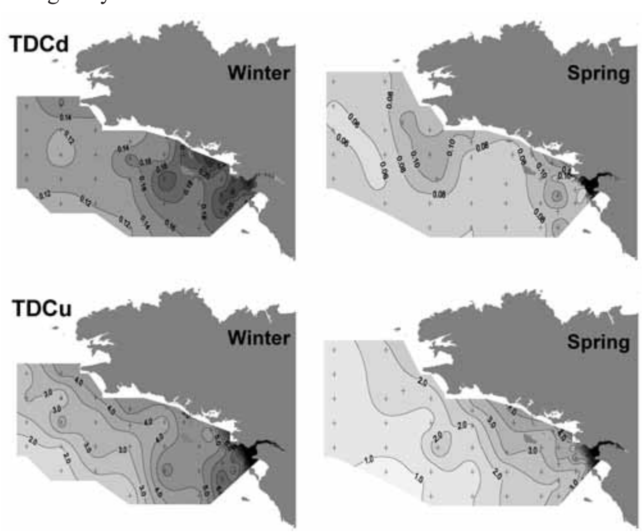

Figure 2. Distribution of surface-dissolved Cd and Cu (nM)

TDCu distributions in the surface waters are also presented in figure 2. In winter, as for Cd, the Loire effect for Cu is felt over a large domain, i.e. from the mouth of the estuary to the vicinity of the shelf break. At this season, TDCu levels are generally higher than 2 nM in the whole studied area. In spring, the influence of the Loire is less important and TDCu concentrations exibited values under 2 nM beyond the South Brittany point.

Dissolved metal speciation on the continental shelf

In winter, the LabCd/TDCd ratio (data not shown) varied from 20% in the coastal area close to the estuary and increased in higher salinity waters to reach 50% westwards of the studied domain. In spring the LabCd contribution increased also from east to west. However, higher ratios were measured with values close to 40 % near the mouth of the estuary and around 70% in the western area. The rise of the LabCd/TDCd ratio from east to west indicates a decrease of the organic fraction along the salinity gradient. This observation has also been reported by Baeyens *et al*.(1998) for the Scheldt plume. Moreover, our data highlight a seasonal variation in the organic speciation degree of Cd over the continental shelf. This variation can be related to the intensity of organic metal inputs within the estuary.

Different distributions were observed for Cu speciation between winter and spring. In winter, few fluctuations of the C_{18}Cu/TDCu ratio were reported over the whole continental shelf (42±8%). In spring, variations of Cu speciation were low in the area under influence of the Loire River, with quite constant values around 45%, whereas westwards, a more variable ratio was observed with values in the range 36-64%. In the case of copper our results show that the metal speciation on the continental shelf is controlled by the intensity of the river water discharge.

References

Baeyens, W., Goeyens, L., Monteny, F., Elskens, M. 1998 Effect of organic complexation on the behaviour of dissolved Cd, Cu, Zn in the Scheldt estuary. *Hydrobiologia*, 366: 81-90.

Boutier, B., Chiffoleau, J.F., Auger, D. Truquet, I., 1993. Influence of the Loire river on dissolved lead and cadmium concentrations in coastal waters of Brittany. *Estuarine, Coastal and Shelf Science*, 36: 133-143

Comans, R.N.J., van Dijk, C.P.J., 1988. Role of complexation processes in cadmium mobilization during estuarine mixing. *Nature*, 336: 151-154

Elbaz-Poulichet F., Cauwet G., Guan D.G., Faguet D., Barlow R., Mantoura R. F. C., 1994. C18 Sep-Pak extractable trace metals in waters from the Gulf of Lions. *Marine Chemistry*, 46: 67-75.

Martin, J.M., Windom, H.L., 1991. Present and future roles of ocean margins in regulating marine biogeochemical cycles of trace elements. In: Mantoura, R.F.C, Martin, J.M., Wollast, R. (Eds), *Ocean Margin Processes in Global Change.* John Wiley & Sons, New York, 46-67.

Waeles, M., Riso, R.D., Maguer, J.-F., Le Corre, P., 2004. Distribution and chemical speciation of dissolved cadmium and copper in the Loire Estuary and North Biscay continental shelf, France. *Estuarine, Coastal and Shelf Science,* 59: 49-57.

Waeles, M., Riso, R.D., Le Corre, P., 2005. Seasonal variations of dissolved and particulate copper species in estuarine waters. *Estuarine, Coastal and Shelf Science,* 62: 313-323

Atmospheric CO_2 Exchanges in the Arcachon lagoon: an integrative measure of intertidal ecosystem metabolism

Pierre Polsenaere,*[a] Gwenael Abril,*[a] and Patrice Bretel,*[a]

Introduction

The coastal ocean has been largely ignored in global carbon budgeting efforts, even if the related fluxes of carbon and nutrients are disproportionately higher in comparison with their surface area (Smith and Hollibaugh, 1993).

Primary Production in the Arcachon lagoon is dominated by Zostera seagrass meadows (intertidal zone, figure 1). Together with microphytobenthos and phytoplankton production, this photosynthetic activity represents a sink of atmospheric CO_2 and a major source of organic matter in aquatic environment. This synthesized organic matter feeds the benthic and pelagic respirations, which leads to a partial degassing of the initially fixed CO_2. Until now, production (light) and respiration (dark) have been measured with immersed (high tide) and emerged (low tide) benthic chambers. However, this technique is difficult to deploy and it integrates very badly spatial and temporal variability (seasons, day/night, and tide) of the ecosystem.

The objective of the present study is to use automatic CO_2 fluxes measurements by the Eddy-correlation (EC) technique to access to the net production of the tidal flat. This bench-mark method in terrestrial ecosystems has never been applied in the coastal zone. It allows us to characterize the metabolic state (in term of carbon flux) of the Arcachon lagoon (sink or source of atmospheric CO_2), and to identify the relevant environmental factors (tide, season day/night, horizontal flows...) which affect the CO_2 fluxes and carbon balance.

Methods

Eddy-correlation is the predominant method for integrative flux measurements and has achieved its popularity because of the relative robustness of both its theoretical background and modern environmental sensors (Lee et al., 2004). The first objective of this work is to evaluate the Eddy-correlation method in an intertidal zone under tidal influences (immersed and emerged), such as the Arcachon lagoon (figure 1).

Since a flux has the dimension of a concentration multiplied by a velocity, the technique consists of high frequency (10Hz) measurements of the vertical component of wind velocity (with an ultrasonic anemometer *Gill*) and atmospheric pCO_2 (with an Infra Red Gas Analyzer (IRGA) *Licor*) above an interface.

Correlating these two parameters, we can get continuous data of CO_2 flux at the atmosphere/water interface during high tide and atmosphere/sediment interface during low tide. Thus, we can obtain some insights on intertidal ecosystem metabolism.

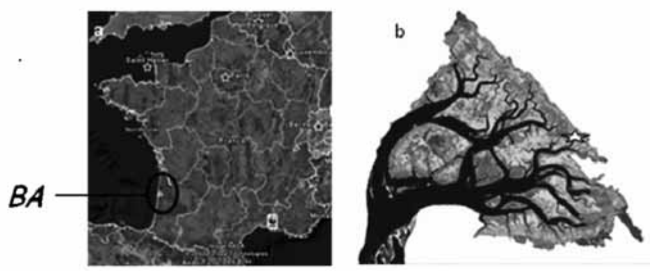

Figure 1: The Arcachon lagoon. a. Google earth photo; b. *spot* image (Virginie Lafon, G.E.O Transfert, EPOC 5805); the star represents Cassy site and green color represents Zostera meadows cover.

Figure 2 shows the eddy-correlation system deployment in the Arcachon lagoon (Cassy, figure 1) during the PNEC experiment (27/09 to 06/10 2007).

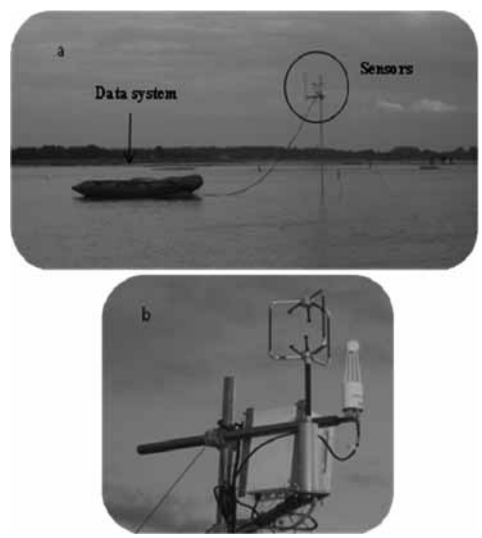

Figure 2: photography of eddy-covariance system in Cassy (Arcachon lagoon)

a. The two captors are on a fixed mast and the data system in the zodiac; b. The two EC sensors, on the left the ultrasonic anemometer *Gill* and on the right, the IRGA *Licor*.

This technique is very interesting because it allows integrating automatically spatial and temporal variations of the ecosystem (contrarily to static chambers measures). For example, when sensors are placed at one meter above the

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sea (or substrate), we integrate an area of about one hundred meters, two meters above, about two hundred meters are integrated. However, it is a measure which spatially integrates temporal variations. So, one of the hurdles resides in the fact that, under tidal influences, the « footprint » (integrated area) is not constant.

Results

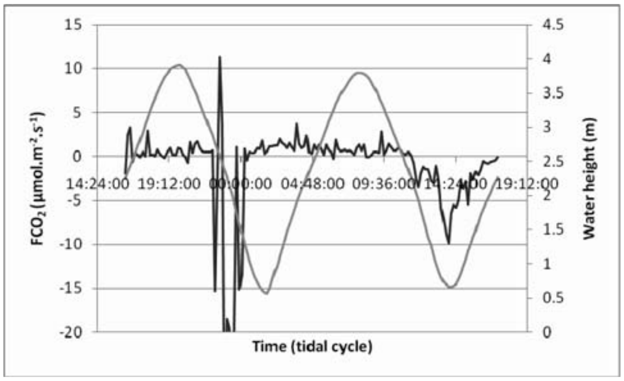

Figure 3: CO_2 flux (µmol.m^{-2}.s^{-1}) in the Arcachon lagoon (Cassy) in relation with uncorrected water height (meters) during a tidal cycle (01-02/10/207).

The first results obtained by the eddy-correlation technique, during the PNEC 2007 experiment, show daily and tidally variations of CO_2 fluxes in the Arcachon lagoon. CO_2 flux at low tide seems to be negative (from the sediment to the atmosphere, sink) which let us think to a (weighty) photosynthetic activity realized by microphytobenthos, zostera meadows and aquatic plants (low tide afternoons sun-filled). In contrast, flux inverts at high tide, CO_2 evades to the atmosphere (source). We can guess that autotrophic activities in the sediments at low tide, fuel heterotrophic activities in the water and sediments at high tide. Of course, these first results need to be comforted, in particular to distinguish the daily and tidally patterns but also different time scales (seasons, annual…). Moreover, the technique is not totally validated yet.

Conclusions and Perspectives

This work presents first a technical aspect with the eddy-correlation system deployed in the Arcachon lagoon. Because it is the first time that a work like this is carried out in the tidal flat, some issues must be investigated. For example, horizontal flows (river inputs and tidal outputs) of carbon are not taken into account with this technique.

The second aspect concerns knowledge on coastal zones functioning, in particular on environmental factors that influence CO_2 flux in the Arcachon lagoon (tide, day/night, seasonal variations, horizontal water movements).

A conceivable application is the zostera meadows survey, especially their growth dynamic. Presently, meadows are vanishing, and the reason of that is not well known.

We plan to use the eddy-correlation technique further inside the lagoon to cover a representative area of zoster meadows. From February 2008 starting point, during two years, every two months, we will deploy the EC sensors during a tidal cycle at least, with additional pCO_2 in water, chlorophyll a … measurements.

Acknowledgements

We express our gratitude to the municipality of Lanton (Arcachon lagoon, France). This study was supported by the French National Program on Coastal Environment (PNEC "Chantier Littoral Atlantique") and the ANR project PROTIDAL. We are grateful to Dominique Serça (Laboratoire d'Aérologie de Toulouse) for lending us EC sensors used during the PNEC experiment. Finally, thanks to Jean-Marc Bonnefond (INRA Bordeaux) for his help to use and achieve these first computations with the EdiRe Software.

References

Abril, G., Borges, A.V., 2004. Carbon dioxide and methane emissions from estuaries. In: Tremblay, A., Varfalvy, L., Roehm, C., Garneau, M. (Eds.), Greenhouse Gases Emissions from Natural Environments and Hydroelectric Reservoirs: Fluxes and Processes. *Springer-Verlag, pp. 187-207.*

Borges, A. V., 2005. Do we have enough pieces of the jigsaw to integrate CO_2 fluxes in the coastal ocean? *Estuaries* Vol.28, No. 1, p. 3-27.

Gazeau, F, Smith, V., S., Gentili, B., Frankignulle, M., Gattuso, J.P. 2004. The European coastal zone: characterization and first assessment of ecosystem metabolism. *Estuarine, Coastal and Shelf Science*, 673-694.

Huertas, E., I., Navarro, G., Rodriguez-Galvez, S., Lubian, M., L. 2006. Temporal patterns of carbon dioxide in relation to hydrological conditions and primary production in the northeastern shelf of Gulf of Cadiz. *Deep Sea Research II*, 1344-1362.

Kaimal, J.-C., Finnigan, J.-J., 1994. Atmospheric Boundary Layer Flows. Their structure and measurement. *Oxford University Press*. Chap. 1.

Moncrieff, J., Clement, R., Finnigan, J., Meyers, T. 2004. Averaging, detrending and filtering Eddy covariance time series. X. Lee et Al. (eds.), *Handbook of Micrometeorology*, 7-31.

Factors governing the mobility of metals in sediments of the estuary of the Nerbioi-Ibaizabal River (Bay of Biscay, Basque Country): chemometric approach

Silvia Fernández, Gorka Arana, Alberto de Diego, Juan Manuel Madariaga

The estuary of the Nerbioi-Ibaizabal is an area that has been put under an importan industrial activity along its history. It is located in one of the most important urban areas (Bilbao) of the Cantabric coast.

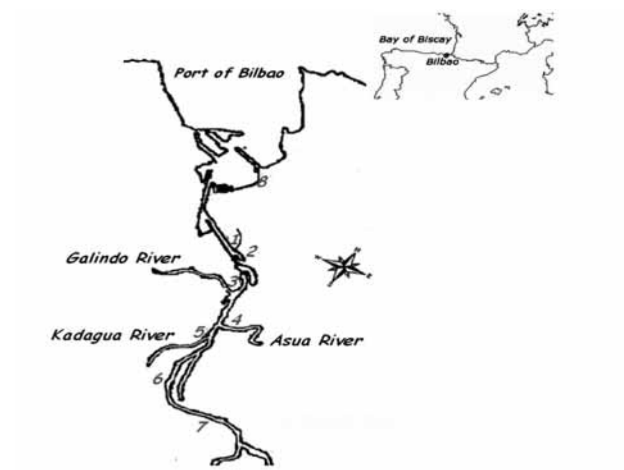

Figure 1. Sampling points in the estuary of the Nerbioi-Ibaizabal River: 1. Gobela River, 2. Udondo, 3. Galindo River, 4. Asua River, 5. Kadagua River, 6. Zorroza , 7. Alde Zaharra and 8. Arriluze.

Many factors and variables govern trace metal behaviour in sediments in complex ways. Understanding metal behaviour in intertidal systems is further complicated because it concerns highly dynamic systems that are continuously subjected to quickly changing environmental conditions governed by alternating low and high tides. The main objective of this work was to understand the main trends in mobility of metals from sediments to the water layer, and vice versa, in the Nerbioi-Ibaizabal estuarine system, and identify the factors governing these processes.

Introduction

Trace metal pollution has become a serious problem in many coastal areas of the world. Changing environmental conditions (e.g. redox, conductivity, pH, organic content,...) may cause remobilisation of trace elements previously accumulated in sediments. Understanding these kind of processes is important in environmental studies and risk assessment.

The estuary of the Nerbioi-Ibaizabal River is a drowned river valley located on the continental shelf of the Cantabrian coastline in the south-eastern Bay of Biscay. It is 15 km long and is formed by the tidal part of the Nerbio-Ibaizabal River (68% of the fresh water input), with four important tributaries (Kadagua 27%, Asua 0.7%, Galindo 4% and Gobelas 0.3%) discharging in the main course. There is a population in the surrounding area of about one million people, generating considerable amounts of industrial and urban wastewater, most of it treated nowadays in a huge sewage plant located in the riverside of Galindo (Belzunce, 2001). The estuary has been seriously affected by industrial activities along the last century. Since the early 1980s pollution in the estuary has considerably decreased, due to decay in industrial activity, implementation of environmental protection policies and closure of mines. Nevertheless, the estuary still presents considerable pollution levels both in water and sediments (Cundy, 2003).

The aim of this work is to understand the main trends in mobility of metals from sediments to the water layer, and vice versa, in the Nerbioi-Ibaizabal estuarine system, and identify the factors governing these processes

Methods

Water (in contact with sediment) and sediment was sampled in May, September and December 2005, and March 2006, both at low and high tide, at eight points of the estuary (Figure 1) using an all-plastic Van Dorn type sampler for water. Asua, Gobela, Kadagua and Galindo are located in tributary rivers. Alde Zaharra and Zorrotza are in the main channel, Udondo is a closed dock and Arriluze is in the mouth of the estuary.

Water temperature, conductivity, pH, redox potential and dissolved oxygen were recorded in situ by a multiparametric probe.

Once in the laboratory, the sediment samples were frozen at -20ºC, lyophilized and sieved. The fraction below 65 µm was reserved for analysis. The samples of water were immediately filtered (45 µm) and acidified with HNO_3 at a final pH of about 2.

The mobility of 12 elements (Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Sn and Zn) was measured using the extraction procedure described in the German Norm DIN 19730, slightly modified to used autochthon water from the estuary as extractant instead of a synthetic ammonium nitrate solution (shaking 20 g of each sediment with 50 mL of water during 2 h at constant low stirring). Two mobility experiments were carried out per sediment, using water collected at i) high and ii) low tide.

The pH in sediment was measured in a 1/5 sediment/distilled water suspension after equilibrium for 18 hrs., and the conductivity was measured in the filtrate of a 1/5 sediment/

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distilled water suspension, shaken for ½ hrs. The carbonate content was determined by back-titration, with 0.5 M NaOH, of an excess 0.25 M H_2SO_4 added to 1 g of sediment. The organic matter content was determinated by measuring the weight loss after incineration of oven-dried samples (2 h at 450 ºC).

Trace elements were extracted from sediments by microwave assisted acid digestion with HCl and HNO_3.

The concentrations of Al, As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, Sn and Zn in water samples and sediment extracts were simultaneously measured by ICP/MS (Elan 9000, Perkin Elmer, Boston, MA), using the external calibration method with internal standard correction.

Results and Discussion

The mobilized portion (M_i, 0%) of a given element, referred to dried sediment, can be calculated by means of the following expression:

$$Mi = 2.5 \frac{(C_1\text{-}C_0)}{1000C^{T}_{sed}}$$

where C_1 and C_0 are the concentrations ($\mu g \cdot L^{-1}$) of the element in water after and before the mobility experiment, respectively, and C_{sed} the concentration ($mg \cdot Kg^{-1}$) of the element in the sediment.

In general, mobilization potential from sediment to water layer was obtained when using water collected at high tide as extractant, suggesting that mobilization/deposition cycles could take place depending on the tidal situation.

Principal component analysis (PCA) of the hole data set was performed by means of the Unscrambler 9.2 program.

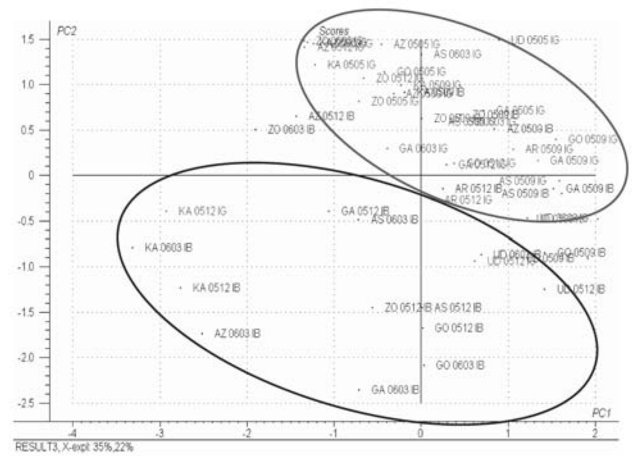

Figure 2. Score plots from the PCA analysis of the whole data set: 0505 May, 0509 September, 0512 December 2005 and 0603 March 2006, IB low tide, IG high tide.

Two different behaviours were identified after PCA of the results. A first group is characterised by high salinity conditions (samples collected at high tide, sampling points close to the mouth of the estuary or in closed docks, sampling campaigns in hot and dry season) and a second one by low salinity conditions (basically samples collected at low tide). Conductivity and, to a lower extent, organic content in sediments seem to control mobilisation/deposition processes.

Conclusions

Metal mobility from the sediment to the water layer was found to decrease in the next order: Mn > Ni > As ~ Cd Co ~ Cr ~ Fe ~ Cu ~ Zn ~ Pb ~ Sn > Al.

Conductivity of the sediment, connected to salinity conditions, seems to be a key parameter to explain the mobility behaviour of trace elements in the estuary of the Nerbioi-Ibaizabal River.

Acknowledgements

This work has been financially supported by the Basque Government through the ETORTEK BERRILUR II (IE06-179) project. Silvia Fernández is grateful to the UPV/EHU for her pre-doctoral fellowship.

References

Belzunce, M. J., Solaun, O., Franco, J., Valencia, V., Borja, A., 2001. Accumulation of organic matter, heavy metals and organic compounds in surface sediments along the Nervion Estuary (Northern Spain). *Marine Pollution Bulletin* , 42: 1407-1411.

Cundy, A. B., Croudace, I. W., Cearreta, A., Irabien, M. J., 2003. Reconstructing historical trends in metal input in heavily-disturbed, contaminated estuaries: studies from Bilbao, Southampton Water and Sicily. Applied Geochemistry, 18: 311-325.

Enhanced Design and Manufacturing of Water-borne Spills Recovery Systems (SPILLREC): State of Progress

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Introduction

The creation of a Community framework for cooperation in the field of accidental or deliberate marine pollution, resulted from several policies in environmental protection and maritime policies such as the Helsinki Convention 1992 for the protection of the Baltic Sea, the Bonn Agreement 1983 for the protection of the North Sea, the Barcelona Convention 1976 for the protection of the Mediterranean Sea, and the Lisbon Agreement for the protection of the North-East Atlantic. Such framework was established for the period 1 January 2000 to 31 December 2006, and it aims to: (a) support and supplement Member States' efforts; (b) contribute to improving the capabilities of the Member States for response in case of incidents; and (c) strengthen the conditions for and facilitate efficient mutual assistance and cooperation.

The SPILLREC project aims follows the abovementioned framework and policies. This project aims at enhancing competitiveness of European SMEs and RTD organizations in the area of waterborne spill response by innovating on design, computer analysis, materials, and manufacture of spill recovery structures and systems. The project will design, produce and test a new spill response structural system, the SPILLREC System and an Open Source code for multi-physical modelling and simulation of fluid-structure interaction in spill recovery systems, the SPILLREC Application. We present the state of progress of the first year of project.

Contractors involved: The SPILLREC project has been the outcome of cooperative RTD work between 4 leading European research groups from Germany (FHM) and Spain (CIMNE, UB-IAFI, AZTI-Tecnalia), 4 SMEs from Germany (OPTIMAL, TAO), Spain (BUILDAIR), and the UK (OPEC), and a harbour organization from Spain (APB). The SMEs will actively exploit both internally and externally the new design and manufacturing technologies for spill recovery.

Tasks of the project

The work plan has been divided into seven work packages (WP), and the project will last two years (Figure 1):

- WP1. Problems and requirements identification.
- WP2. Design and development of the SPILLREC Application.
- WP3. Implementation of spill recovery systems models to the SPILLREC Application.
- WP4. Design of the SPILLREC System.
- WP5. Manufacture of the SPILLREC System prototype.
- WP6. Dissemination and exploitation plan.
- WP7. Project management .

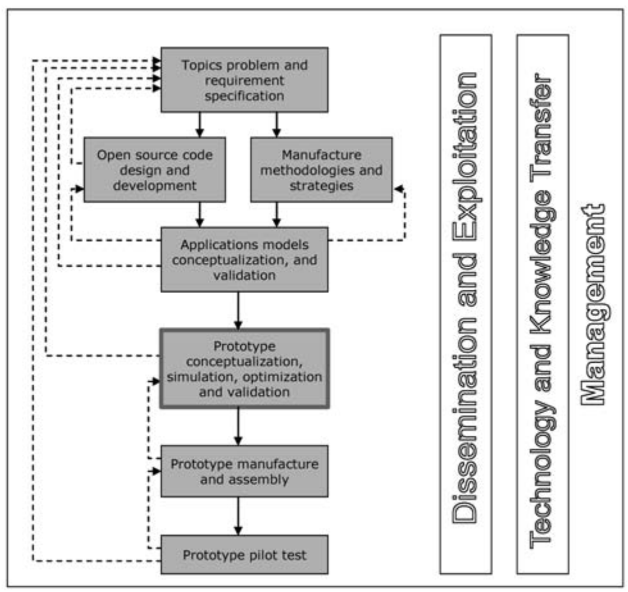

Figure 1 .Work Plan Flowchart. At this moment, the project initiates the phase of prototype conceptualization, simulation, optimization and validation.

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Results achieved and expected

At the end of the project, there will be two specific project outputs:

1. Two innovative spill recovery systems, the SPILLREC Systems that are economical and easy to store, transport, use, recover and maintain. These prototypes do not improve the economic cost and the oil recovery effectiveness in comparison with the standard mechanical methods. Consequently, the economical and technical design of the prototypes has been focused on the competition in terms of: 1) rapid implementation, use and recovery; 2) reusability; 3) floatability, modular design and compactability; 4) flexibility under extreme meteorological conditions; and 5) synchronization with other mechanical methods. The SPILLREC System will also comply with European environmental regulations and standards, as well as with the objectives of the European developing initiatives on maritime pollution (Figure 2 and 3).

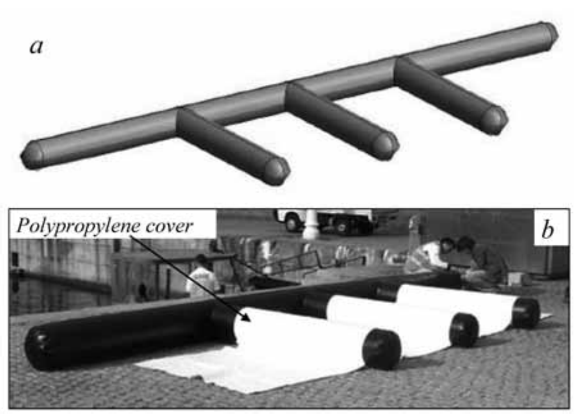

Figure 2. Prototype 1: Inflatable structure with polypropylene cover. a) 3D view, b) Assemblage of the manufactured Prototype 1.

Figure 3. First experience of Prototype 1 in the Barcelona harbour. Spill oil simulation using an Oloid water circulation device.

2. An easy to use, scalable and economical Open Source multi-physics modelling and simulation application for fluid-structure interaction of waterborne structures, the SPILLREC Application (Figure 4). The SPILLREC Application will provide many capabilities not existing in the field of spill recovery response, such as the ability to simulate the interaction of structures and multiple fluids (i.e. water surroundings, oil containment, wind effects). The SPILLREC Application will be able to model and analyse all existing scenarios in the deployment and operation of spill recovery structural systems.

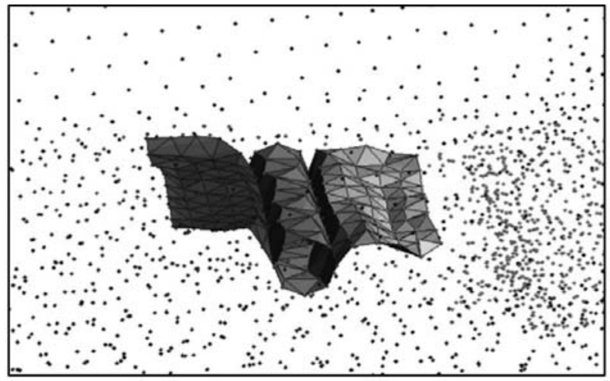

Figure 4. SPILLREC Application: Finite element technology to simulate the interactions between fluids and floating bodies and to study the behaviour of structural membranes.

Acknowledgements

This work is sponsored by the European Commission, within the Framework of a Co-operative Research Project (Project no. COOP-CT-2006-032433).

Direct analysis of trace elements in estuarine and coastal seawater from the Bay of Biscay by Collision Cell –Quadrupole ICPMS

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Introduction

Methods allowing a rapid evaluation of the transport and dispersion of metallic contaminant and trace element inputs to the coastal environment are still challenging. Both low concentrations of these elements and large matrix effects have led to tedious and time consuming methodologies to investigate trace metals cycling in the coastal marine environment.

The application of the European Water Framework Directive, requires a better knowledge of the biological and biogeochemical mechanisms of aquatic environments. In this context, the Adour estuary has been since 2000 an interesting location of several studies focused on sediments, bacterial communities (Goni-Urriza et al., 2007) and river waters (Point et al., 2007a). These previous works have highlighted the importance of the contribution of the drainage basin in the metallic composition of the river waters. The purpose of this work is to study more precisely the metal composition of the turbid plume of the Adour estuary (coastal seawaters).

In order to get rid of the salty matrix, one way consists in a pre-concentration of the trace elements on a chelating resin (Point et al., 2007b). However, this method implies a tedious sample preparation if the objective is to study a large range of trace elements. The second way to reduce the spectral interferences caused by the the salty matrix is the use of a-ICP/MS equipped with a collision cell (CC) when analysing directly 10-times-diluted sea-water sample. The development of such methodologies is directly related to the ICP/MS system and its collision/reaction cell design. The Agilent Technologies 7500c ICP/MS (Leonhard et al., 2002) and the Perkin Elmer Elan DRC ICP/MS (Louie et al., 2002) have already been applied to the analysis of trace elements in certified reference seawater (CASS-4, NASS-4 and NASS-5), estuarine seawater (SLEW-3) or artificial seawater. In this work the potential of the Thermo Elemental X-Series CC system for the direct analysis of a large range of trace elements (from ^{51}V to ^{238}U) in 10-times diluted coastal seawater will be evaluated.

This work has been carried out within the framework of the Aquitaine Region "flux of contaminants" programme, and is focused on the development of a rapid and robust method to investigate the biogeochemistry of trace metals at various coastal sites (e.g. Adour estuary plume, Arcachon bay). The analytical objective of this work is the substitution of the conventioanl sample preparation steps by a simple 10-times dilution of the samples while scanning a large range of elements to reach the maximum information in terms of metallic composition.

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Methods & Results

All seawater samples, which are certified reference materials such as CASS-4 (NRCC) and NASS-4 (NRCC) or natural coastal seawater from the Adour estuary are diluted 10 times using ultrapure water (Millipore, 18MΩ) before analysis. To cover the all range of elements, 3 multi-elemental solutions are used (Analab, CCS-4, CCS-5 and CCS-6).

Trace element analysis is performed by ICP/MS (Thermo Elemental X Series) equipped with a collision cell. The reduction of the interferences is achieved by the use of a $He-H_2$ mixture.

The results obtained in this work will be presented using the following layout:

- The CC-ICP/MS performances such as the optimisation of the interface especially devoted to complex matrices and the optimisation of the collision cell parameters.
- The validation of the entire methodology using certified reference materials
- The application to natural seawater samples originating from the Adour plume.

P. Pinel-Raffaitin thanks the Aquitaine Region for its Postdoctoral fellowship. This work was supported by Aquitaine Région in the framework of the Réseau Rccherche Littoral Aquitain. Thermo Scientific is thanked for the loan of the X serie 2 ICPMS.

References

Goni-Urriza, M.S., Point, D., Amouroux, D., Guyoneaud, R., Donard, O.F.X., Caumette, P., Duran, R.., Bacterial community structure along the Adour estuary (French Atlantic coast): influence of salinity gradient versus metal contamination. *Aquatic Microbial Ecology*, 2007. 49: 47-56.

Leonhard, P., Pepelnik, R., Prange, A., Yamada, N., Yamada, T., Analysis of diluted sea-water at the ngL-1 level using an ICP-MS with an octopole reaction cell. *Journal of Analytical Atomic Spectrometry*, 2002. 17: 189-196.

Louie, H., Wu, M., Di, P., Snitch, P., Chapple, G., Direct determination of trace elements in sea-water using reaction cell inductively coupled plasma mass spectrometry. *Journal of Analytical Atomic Spectrometry*, 2002. 17: 587-591.

Point, D., Bareille, G., Amouroux, D., Etcheber, H., Donard, O.F.X., Reactivity, interactions and transport of trace elements organic carbon and particulate material in a mountain range river system (Adour River, France). *Journal of Environmental Monitoring*, 2007a. 9: 157-167.

Point, D., Bareille, G., Pinaly, H., Belin, C., Donard, O.F.X., Multielemental speciation of trace elements in estuarine waters with automated on-site UV photolysis and resin chelation coupled to inductively coupled plasma mass spectrometry. *Talanta*, 2007b. 72: 1207-1216.

Comparison of recent and background trace metal levels in sediments from the basque continental mud-patch.

Gilles Bareille[a], Olivier Weber[b], Jean-Marie Jouanneau[b] and Olivier Donard[a]

Introduction

In aquatic environments, trace metals largely interact with both fine-grained suspended, colloidal materials and phytoplankton and zooplankton through adsorption and bioaccumulation processes and subsequently be added by deposition to the streambed (Turner et al., 2002). Sediments may act, then, as important sinks of trace metals in aquatic systems (Calmano et al., 1993). Bed sediments from both estuarine and continental shelf areas can then integrated conditions over a longer time, recording changes in environmental variables and human-related activities such as improvements in wastewater handling and sewage treatment according to legislation and the alteration of industrial activities. The measured concentrations of deposit-related trace metals in bed-sediments may also vary because of biogeochemical processes that occur either in the water column (adsorption/desorption) or at the sediment-water interface through primary diagenetic redox reactions driven by degradation of organic material at the sediment-water interface and a number of physical post-depositional.

In this study, bed sediments and down-core sediment samples from a mud-patch located on the basque continental shelf of the Bay of Biscay to the southwest of Bayonne (Figure 1) were studied for trace metal levels variations. We examined to what extent trace metal levels recorded in the mud-patch during the last decade are linked to detrital inputs, human related inputs, crude oil pollution from the Prestige or to primary diagenetic redox reactions.

Methods

The investigation of trace elements were done in the solid-phase on spatial and temporal scales to identify metal pollution history and the main geochemical processes affecting the vertical distribution of metals. Sediment sample were collected during oceanographic campaigns EUSKASED aboard the French research vessel "Côte de la Manche" (CNRS/INSU). They were digested in PTFE Teflon bombs using a closed microwave oven (Multiwave 3000, Anton Paar) and trace metals Mn, Cr, Zn, Cu, As, Pb, Co, Cd, Ag, V and U analyses were carried out by inductively coupled plasma mass spectrometer (ICP-MS, Elan 6000, Perkin Elmer). The age of the sediment sections was assessed by using ^{210}Pb in excess and ^{14}C AMS dates. Grain-size effect was corrected by normalizing all elements to Li. ^{210}Pb in excess was used to calculate sedimentation rates.

Sediment samples previously analyzed for the same elements in closed coastal areas, i.e. the Adour and Nervion estuaries, the bays of Hendaye, Saint-Jean-de-Luz, Pasajes and Mundaka, were also used to assesd for potential sources.

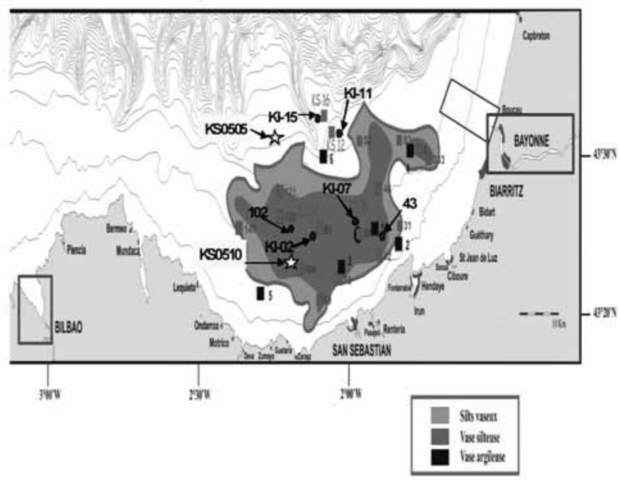

Figure 1. Map of the study area, showing the sampling stations.

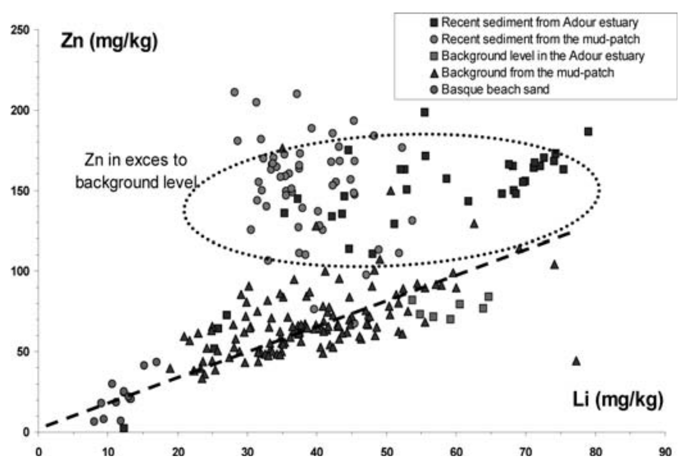

Figure 2. Example of distribution of zinc concentrations in sediments against lithium

Results and Discussion

Figure 2 shows the distribution of zinc against the lithium which was used to eliminate both grain size effect and carbonate diluting effet. Results indicated higher trace metals Cu, Zn, Cd and Pb levels for the upper part of the sedimentary

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column, from ten to twenty cm. Whereas, below this interval sediments invariably follow the strait line relating to the geochemical background encountered.

Concerning Ni and V, which consist of the most abundant trace elements encountered in crude oil, they distribution depend strickly on the detrital fraction as they are varying linearly to lithium. Although crude oil was observed to be deposited in surface sediment of the mud-patch, none impact on Ni and V sediment levels are found.

Comparing the observed increased in trace metal Cu, Zn, Cd and Pb and levels from closed estuaries and bays, it is difficult to identify the main sources. However, the observed values should not be originated primarily from the Adour estuary although the downstream section of this estuary has an important urban and industrial area that may contribute significant inputs to the coastal zone (Point et al., 2007, Stoikev et al., 2006). Nevertheless, this pattern is probably linked to the combination of either the input of trace metal connected to the increase in industrial activities during several decades and redox reactions driving redistribution of trace elements in the sedimentary column. Taking into account of the strong correlation recorded between Mn and Cu, Zn, Cd and Pb, we suggested that redox reactions at the oxic/suboxiv interface are driving the observed profile which is not the case in the Adour estuary salt marsh.

Conclusions

These study. indicated the occurrence of higher trace metals levels, mainly for Cu, Zn, Cd and Pb, in recent sediments deposited during recent decades. Observed concentrations could be not related to the geochemical background of the region, but rather to human related inputs. These excess in metals are furthermore strongly related to Mn suggesting that redox reactions at the oxic/suboxic zones are driving the observed profiles.

Acknowledgements

This work was sponsored by the Eurpean community, the CNRS and the University de Pau et des Pays de l'Adour and the CNRS. .

References

Calmano W. and Hong J., 1993. Binding and mobilization of heavy metal in contaminated sediment affected the pH and redox potential. *Water Science and technology*, 28: 223-235.

Point, D., G., Bareille, D., Amouroux, H., Etcheber, O.F.X Donard, 2007., Reactivity, interactions and transport of trace elements, organic carbon and particulate material in mountain range river system (Adour river, France). Journal of Environmental Monitoring, 9: 157-167.

Stoichev, T., D., Amouroux, M. Monperrus,D. Point, E. Tessier, G. Bareille and OFX Donard., 2006. Metheyl mercury in surface waters of the Adour river estuary (South west France). Chemistry and ecology, 22 (2): 137-148.

Turner, A., Milward, G.E., 2002. Suspended particles: their role in Estuarine biogeochemical cycles. Estuarine, Coastal and Shelf Science, 55 (6): 857-883

DNA damage in the mussel (*Mytilus galloprovincialis*) digestive gland from Galicia and Biscay Bay, determined by 7, 8, dihidro-8-oxodeoxyguanosine immunohistochemistry

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Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a major concern in environment health assessment. Although natural sources of PAHs in the environment include forest, grass fires, oil seeps or volcanoes, (Albers, 1995) nowadays the main sources of PAHs releases in the marine environments are anthropogenic (EEA, 2003). The effects of PAHs on organisms have been widely described in a great variety of species, including sentinel species such as mussels, and alterations described range from molecular to individual levels (Albers, 1995). Among other alterations it has been reported that PAHs produce severe changes in the DNA (Jha, 2004). In molluscs, PAHs are metabolized within the digestive gland and during this process and increased formation of reactive oxigen species (ROS), such as superoxide anion, are formed. ROS may react and oxidise other cellular components such as DNA, which finally results in cell damage (Machella et al., 2005).

The selective formation of 7,8-dihydro-8-oxodeoxyguanosine (7,8 oxo-dG) acomplished by the action of the ROS produced during PAH metabolisation is widely accepted as indicative of oxidative damage in DNA (Machella et al., 2005). The detection of 7,8-oxo-dG in marine organisms is of increasing interest to investigate the hazards of environmental genotoxins in ecotoxicology (López-Barea and Pueyo, 1998).

Presently, special attention has been paid to the "Prestige" oil spill (POS). The "Prestige" sunk in November 2002 in front of the Galician coast (Northwestern Iberian Peninsula). As a result, more than 60 thousand tonnes of heavy fuel oil were leaked into the sea, affecting at different degrees more than 1000 Km of coastline along the Bay of Biscay. In order to assess whether POS effects included DNA damage in sentinel mussels (*Mytilus galloprovincialis*), samples were collected along the coast of Biscay Bay during years 2004-2005 and DNA damage in digestive gland was determined after 7,8 oxo-dG immunohistochemistry.

Material and Methods

Mussels were collected in 3 locations in Galicia and 5 locations in the Basque Country between July 2004 and April 2005. After dissection, digestive glands of ten animals per sampling point were routinely fixed and paraffin embedded. Paraffin sections (3-4 µm thick) were dewaxed, hydrated and incubated in the primary antibody for 7,8 oxo-dG immunohistochemistry. The final reaction was visualized by peroxidase immunoprecipitation.

Quantification of 7,8 oxo-dG -positive cells was achieved by direct cell counting under the light microscope. In order to estimate the proportion of positive cells in the digestive epithelium, a total of 500 cells were counted per sample. Data were then transformed into counts-per-hundred for the presentation of the results.

One-way analyses of variance (ANOVAs) and subsequent Duncan's test for multiple comparisons between paired means was further applied to detect significant ($p<0.05$) differences between means.

Results and Discussion

Positive reactive nuclei were observed in the digestive epithelium as well as in the epithelium of the stomach and ducts. The connective tissue cells surrounding the digestive albeoli also showed strong positive staining. On the other hand, no positively marked nuclei was observed in control samples incubated without primary antibody (Figure 1).

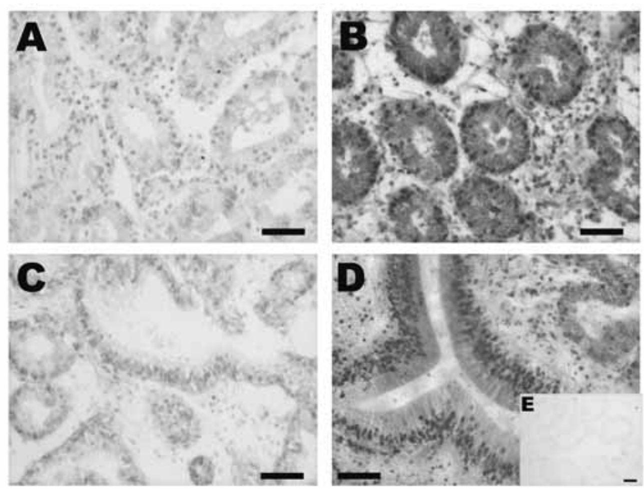

Figure 1: 7,8 oxo-dG immunostaining in the digestive gland of mussels from Hondarribia in April 2005 (A), July 2004 (B) and October 2004 (C). (D) Positive reaction in the epithelium of a primary duct. (E) Control staining without primary antibody. Scale bar 25 µm.

Overall, mussels from Galicia showed stronger labelling than mussels from the Basque coast. Moreover, in general terms, mussels collected in spring showed more abundant and more intensely labelled nuclei than mussels collected in autumn and summer, except for Hondarribia where positive nuclei and their intensity reached higest values in summer.

According to preliminary results regarding the quantification of 7,8 oxo-dG positive nuclei, there exist significant differences between sampling sites and sampling periods (Figure 2).

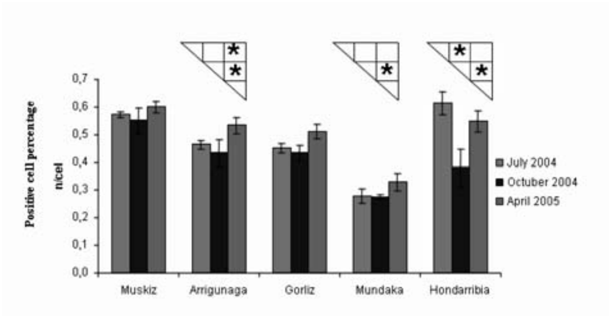

Figure 2 Quantification of 7,8 oxo-dG immunostaining in the digestive epithelium. Upper matrix asteriks shows significant differences between groups according to the Duncan-s test ($p<0.05$ level).

Mussels from Mundaka showed low values of 7,8 oxo-dG-positive cells. In contrast, mussels from Muskiz and Hondarribia showed the highest values indicating more affected areas. On the other hand, it is worth noting that seasonality exerts a significant effect in the recorded values, with lower values recorded in autumn than in summer (except for Muskiz, where DNA damage is high in all the sampling periods and no seasonal trend is observed), particularly in Hondarribia.

In summary, the present results reveal that (a) 7,8 oxo-dG immunohistochemistry is a valuable tool to quantify DNA damage in *M. galloprovincialis* from Galicia and Biscay Bay: (b) the level of DNA damage varies with season in the study area; and (c) DNA damage is less conspicuous in mussels from the Basque Coast that in those from Galicia. Nevertheless, more research is needed to determine whether the geographical differences observed can be due to the POS or to other reasons.

Acknowledgements

This work was funded by IMPRES (ETORTEK/SPRI, Basque Goverment) and PRESTEPSE (VEM2003-20082-CO6-01, MEC) research projects, as well as a grant for Consolidated Research Groups (BCTA, UPV/EHU-EJ/GV). We are indebted to Prof. MP Cajaraville for her helpful comments and to the laboratory staff for the technical support for sampling.

References

Albers P.H. 1995. Petroleum and individual polycyclic aromatic hydrocarbons.In: Handbook of ecotoxicology. Hoffman DJ., Rattner BA., Burlon GA., Cairns J. (Eds.) Lewis Publishers, CRC Press Inc., Boca Raton. Pp: 330- 355.

EEA (European Environment Agency). 2003. Chemicals in the European environment: a survey of monitoring and exposure information. Environmental issue report. EEA, Copenhaven. <http: //www.eea.eu.int> Taken in november 2005

Jha, A.N, 2004. Genotoxicological studies in aquatic organisms: an overview. Mutation Research. 378: 77–88.

López-Barea, J. C. Pueyo, 1998. Mutagen content and metabolic activation of promutagens by mollusks as biomarker of marine pollution. Mutation Research. 399: 3–15.

Machella, M. F. Regoli, R. Santella, 2005. Immunofluorescent detection of 8-oxo-dG and PAH bulky adducts in fish liver and mussel digestive gland. Aquatic Toxicology, 75: 335-343.

Biomonitoring in mussels after the Prestige´s oil spill by peroxisomal proteomics

Itxaso Apraiz,*[a] Miren P. Cajaraville[b] and Susana Cristobal[a]

The Prestige oil spill showed the importance of marine pollution monitoring and the availability of historical data series of pollution assessment in hazardous areas such as the Northern Spanish coast. Proteomics based techniques have been recently introduced in the environmental toxicology field. Our research group has been pioneer in developing peroxisomal proteomics as a new biomarkers approach based on the analysis of a protein expression signature (PES) obtained by comparative proteomics. Mussels *Mytilus gallopronvicialis* (Lmk., 1819) were collected in two stations in the NW coast and in other two in the N coast of the Iberian Peninsula in July 2004 and 2005. Digestive glands from 50 mussels per station were homogenized and fractions enriched in peroxisomes were obtained applying differential and density gradient centrifugations. Peroxisomal matrix proteins were subjected to two-dimensional electrophoresis (2-DE) and spot-volume percentage (vol. %) values were obtained. Vol. % values from each station were compared between the years 2004 and 2005 using the ImageMaster 2D Platinum software. The statistical analysis revealed differences in expression of several protein-spots from the different stations. After applying principal component analysis and heuristic clustering, the different 2-DE gels were separated in the space showing certain grouping patterns. Using immunochemistry and MALDI-TOF mass spectrometry, several protein-spots showing differences were putatively identified to be involved in xenobiotic metabolism as well as in oxidative phosphorylation, cytoskeleton formation and signal transduction. The results presented here strengthen the usefulness of proteomics techniques for environmental pollution monitoring. Moreover, the results obtained are unbiased since previous knowledge of pollutants mechanisms of toxicity is not needed.

Introduction

The disaster of the oil tanker Prestige, transporting 77,000 tonnes of heavy fuel-oil, on the Northwestern coast of Spain in November 2002 led to one of the largest spills in the maritime history. The unique characteristics of this oil spill regarding the type and volume of spilled oil, duration of the spill and the large extension of the coast affected by it, have attracted great attention from the scientific community.

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The new biotechnology platforms such as proteomics and transcriptomics could provide a powerful set of tools to environmental sciences. The development of these techniques for environmental applications from marine pollution assessment to chemicals risk assessment is growing in importance. Functional evidences and proteomics experiments suggest that variation in individual proteins is a major form of controlling cellular function. Proteomics-based methods could provide a more comprehensive view of toxicity due to the cascade of alterations triggered by exposure to pollution (1).

New methods that perform global analysis of proteins are especially powerful to provide molecular signatures that could overcome the traditional disadvantages of the single parameter biomarkers. However, on one hand, the lack of historical data from these global analysis techniques is maybe one of the reasons why these methodologies haven't yet been applied to large biomonitoring programmes. On the other hand, a proteomics-based method for the assessment of marine pollution should be highly reproducible, robust, and affordable. In line, several methods have been recently developed (2-4). In the last years, proteomics has been applied for the screening of protein expression signatures (PES) of exposure to model pollutants (5-8) and to field experiments (2-3, 9-10). The aim of this study was to apply a proteomics-based technique, peroxisomal proteomics to evaluate the biological effect of the exposure to fuel-oil and the evolution of the recovery two and three years after one of the largest environmental catastrophes occurred in the European navigation.

Methods

Mussels, *M. galloprovincialis*, 3.5-4.5 cm long, were collected in July 2004 and 2005 from two representative sampling stations in the NW coast of the Iberian Peninsula: Sao Bartolomeu do Mar and Aguiño, and two stations in the N coast: Mundaka and Hondarribia. The digestive glands from 50 mussels per station and year were dissected and immediately frozen. Homogenization of minced tissue and subcellular fractionation by differential and density gradient centrifugation in iodixanol was performed as previously reported (3). Proteins from peroxisome enriched fractions were then separated by 2-DE. Image analysis was performed on the obtained gels in order to find differences in protein vol. % values among the studied stations.

Data from each station was compared between sampling years using Student's *t*-test. Multivariate analyses (Principal Component Analysis and Hierarchical Clustering), were performed taking all the stations and years into consideration.
Immunodetection of the peroxisomal proteins PMP70, catalase, PH1 and AOX was performed using Western-Blotting on a 2-DE

gel. Putative identification of several protein-spots was performed by MALDI-TOF MS and peptide mass fingerprinting.

Results and discussion

Time dependent differences per station

Data from each station was compared between years using a Student's *t*-test. Only protein-spots appearing in more than half of the gels were taken into the analysis and a *P* value of 0.001 was used as cutoff. Protein-spots showing differences in vol. % were considered significant provided that variances between years were homogeneous. Aguiño showed 19 protein-spots with differential vol. % values (figure 1A), Sao Bartolomeu showed 17 (figure 1B), Mundaka nine (figure 1C) and Hondarribia five (figure 1D). These differences in the number of significant protein-spots could be attributable to a bigger reduction in the total number of PAHs from 2004 to 2005 in Aguiño and San Bartolomeu, than in Mundaka and Hondarribia (personal communication).

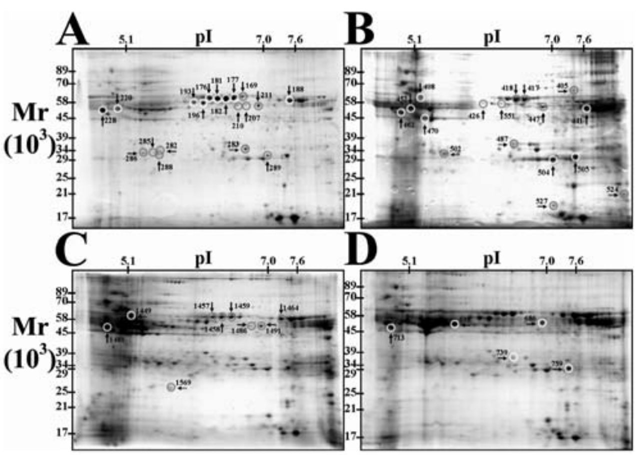

Figure 1. 2-DE gel images showing the protein-spots that differed in volume percentages between years 2004 and 2005..

Multivariate analyses

As for the PCA results, three principal components were able to explain 66.6 % of the total variability in the data (figure 2A). Major differences between the northwest and northern sites were found in the year 2004. In 2005 this grouping is broken and Aguiño and Mundaka seem to look more alike, whereas Hondarribia seems to show similarities to 2004's Aguiño and Sao Bartolomeu, and Sao Bartolomeu 2005 stands on its own. Whether or not differences in the year 2004 are attributable to increased pollution levels in the northwest coast can be arguable.

Results from the hierarchical clustering (figure 2B) seem to agree with those from the PCA analysis, suggesting that spatiotemporal differences exist in the amount of the different proteins under investigation.

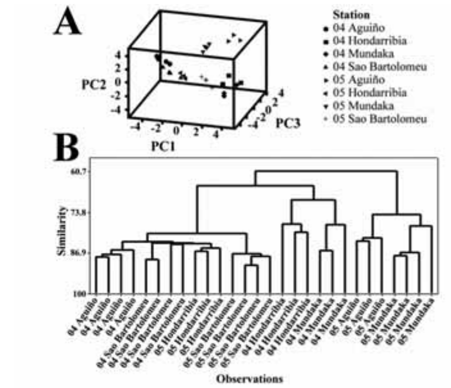

Figure 2. Multivariate analyses.

Putative protein-spot identification

Several peroxisomal proteins were identified by 2-DE gel Western Blotting. These protein-spots correspond to several of the spots showing differences in the statistical analyses.

Additional putative protein-spot identification of statistically significant protein-spots was performed by peptide mass fingerprinting.

The identified protein-spots take part in xenobiotics metabolism, oxidative phosphorylation, cytoskeleton formation and signal transduction.

Conclusions

The results hereby presented could point to a possible increased rate of the metabolism of xenobiotics in the stations closest to the oil spill in the year 2004 compared to 2005.

Acknowledgements

This project was partly supported by grants from the Spanish Research council (PRESTEPSE) and by the Basque Country Government (IMPRES, ETORTEK/SPRI).

References

Aardema, M.J., J.T. Macgregor 2002. *Mutation Research* 499:13-25.

Bjornstad, A., B.K. Larsen, A. Skadsheim, M.B. Jones, O.K. Andersen 2006. *Journal of Toxicology and Environmental Health A*, 69: 77-96.

Mi, J., A. Orbea, N. Syme, M. Ahmed, M.P. Cajaraville, S. Cristobal 2005. *Proteomics,* 5:3954-3965.

Amelina, H., I. Apraiz, W. Sun, S. Cristobal 2006. *Journal of Proteome Research,* 6:2094-2104.

Apraiz, I., J. Mi, S. Cristobal 2006. *Molecular and Cellular Proteomics,* 5:1274-1285.

Mi, J., I. Apraiz, S. Cristobal 2007. *Biomarkers,* 12:47-50.

Shepard, J.L., B.P. Bradley 2000. *Marine Environmental Research,* 50: 457-463.

Shepard, J.L., B. Olsson, M. Tedengren, B.P. Bradley 2000. *Marine Environmental Research,* 50:337-340.

Knigge, T., T. Monsinjon, O.K. Andersen 2004. *Proteomics,* 4: 2722-2727.

Rodriguez-Ortega, M.J., B.E. Grosvik, A. Rodriguez-Ariza, A. Goksoyr, J. Lopez-Barea 2003. *Proteomics,* 3:1535-1543.

Sediment-water exchanges of mercury and tin species in intertidal zones of the Arcachon Bay

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Introduction

The metals and organometals fluxes at the sediment-water interface are important pathways of their remobilisation in the coastal environments. Previous studies indicate that most of the flux intensities as well as the temporal and spatial variability are explained by micro and macroscale processes as the redox status of the interface and the macrobenthic organisms's activities (Point et al. 2007; Thouzeau et al. 2007). However intensity of these fluxes and controlling processes are still poorly understood. Hence, the behavior of mercury and tin species in the tidal zone of the Arcachon basin, submitted to continuously evoluting redox conditions, were studied in relation with primary production and respiration. Experiments were conducted as time series at the temporal scale of tidal and seasonal cycles.

Benthic flux experiments

Three different stations were investigated, two located within the intertidal zone: stations S2 (mudd only) and S3 (mud cover with Zostera nooltii) and one in the subtidal zone: station S4. For each investigated station, two series of 3 replicate benthic chamber incubations were performed in light and dark conditions (Amouroux et al., 2003). During each benthic chamber experiment the variation of major parameters was continuously measured. Additionally, discrete samples were collected at the beginning and at the end of the incubations in order to carry out the determination of the concentration of Hg and Sn species and other biogeochemical parameters such as nutrients, pH and alkalinity.

Samples analysis

After filtration and acidification of the water samples on site, mercury and tin speciation analysis was using a species-specific isotope dilution analysis DSIDA (Monperrus et al. 2007). In this procedure isotopic enriched species, e.g. ^{199}IHg, ^{201}MMHg and ^{119}BuSn were used to accurately quantify the endogenous species concentrations by GC- ICPMS.

Results and discussion

For 2005-2006, fluxes are in the range of 0.5 – 189 ng.m^{-2}.h^{-1} for IHg and 0.1 – 116 ng.m^{-2}.h^{-1} for MMHg. Mean fluxes are presented in figure 1 for 2 stations investigated in 2005. For TBT

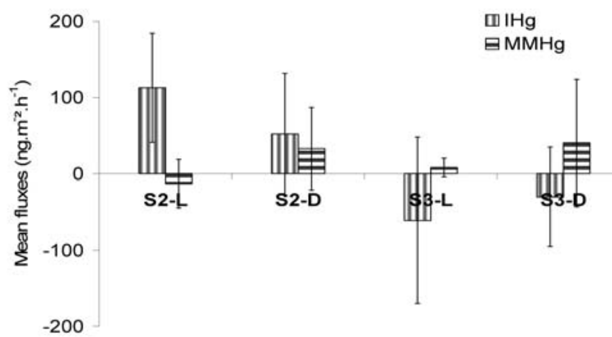

Figure 1. Hg species mean fluxes for 2 stations investigated during the 2005 campaign for dark (N) and light (L) conditions

in 2006, the fluxes obtained ranged from -23 – 18 ng.m^{-2}.h^{-1}. An important variability is observed between the fluxes values for Hg species between winter and spring conditions but also with the light conditions. For TBT, flux direction seems also to be influenced by the light conditions during spring conditions. These preliminary results show important variations in fluxes intensity with both seasonal and diurnal conditions. Significant correlations between metals fluxes and major paramaters, like MMHg and O_2 fluxes have been partly established. It suggests that the transient redox changes occuring at the tidal scale and the O_2 production/consumption could drive or partially influence species fluxes.

Acknowledgements

This work was supported by the French National Program for Coastal Environment (PNEC) and the ANR project PROTIDAL.

References

Point, D., M. Monperrus, et al. (2007). «Biological control of trace metal and organometal benthic fluxes in a eutrophic lagoon (Thau Lagoon, Mediterranean Sea, France).» *Estuarine, Coastal and Shelf Science* 72(3): 457-471.

Thouzeau, G., J. Grall, et al. (2007). «Spatial and temporal variability of benthic biogeochemical fluxes associated with macrophytic and macrofaunal distributions in the Thau lagoon (France).» *Estuarine, Coastal and Shelf Science* 72(3): 432-446.

Amouroux D., Monperrus M., Point D., Tessier E., Bareille G., Donard O.F.X., Chauvaud L., Thouzeau G., Grall J., Jean F., Leynaert A., Clavier J., Guyoneaud R., Duran R., Goni M., Caumette P. (2003): Transfer of metallic contaminants at the sediment-water interface in coastal environments: role of the biological and microbial activity and diversity. *J. Phys. IV*, 107, Volume I, eds C. Boutron, C. Ferrari, pp. 41-44.

Monperrus, M., P. R. Gonzalez, et al. (2007). «Evaluating the potential and limitations of double spiking species-specific isotope dilution analysis for the accurate quantification of mercury species in different environmental matrices.» *Analytical and Bioanalytical Chemistry*

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Biodegradation of the Prestige crude oil and evidence of endogenous microbial degradation associated to tarballs collected offshore in surface water

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The *in vitro* biodegradation of the fuel oil from the Prestige's spill was evaluated. In this aim, either endogenous microorganisms, exogenous oil-adapted bacterial community obtained from sediments of Etang de Berre (France) and collected in the vicinity of oil refenery or an artificial consortium composed of four hydrocarbonoclastic bacterial strains were used and cultivated during 90 days in both oxic and anoxic environment. Therefore, 5 different conditions were assessed. Cultures were performed in artificial sea water with, as substrate, fuel from tar balls collected offshore in surface water. Our main results indicated that the most complex community, namely, culture containing sediments from Etang de Berre allowed to degrade around 78 % of the aromatic hydrocarbons. Not surprinsingly, this oil adapted community was most efficient in anoxic conditions compared to oxic conditions (around 63 % of degradation). Interestingly, biodegradation was perceptible when only endogenous tar balls community was incubated in oxic condition (around 43 %). In addition, we showed the impact of petroleum on these bacterial communities and their evolution during the 90 days of incubation using T-RFLP analyses based on 16S ribosomal RNA genes .

Introduction

On 13th November 2002, the Prestige oil tanker transporting 77 000 tonnes of heavy fuel oil sunk 30 miles off the Galicia coast (NW Spain). This accident caused the worst oil spill events to the marine ecosystem in the region.

Biodegradation by microorganisms is known to be an efficient processes in weathering leading to dispersion and final removal of oil in the environment (Swannell *et al.* 1996; Leahy & Colwell 1990). Thus, microbial degradation of petroleum has been abundantly studied and mechanisms involved in biodegradation processes are nowadays well documented (Atlas 1984). However, biodegradation differed according to the initial chemical composition of petroleum. In this study we were interested in studying the *in vitro* biodegradability of the Prestige oil either by endogenous microorganisms or by exogenous oil-adapted communities. Biodegradation was evaluated on the basis of changes in hydrocarbon composition and concentration relatively to an abiotic control. In addition, we assessed the impact of petroleum on these bacterial communities and their evolution through time using T-RFLP analyses based on 16S ribosomal RNA genes.

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Methods

Petroleum samples

Tar balls floating on surface water were collected offshore between San Sebastián (Spain) and Bayonne (France) 7 monthes after the wreck and conserved at -20°C.

Biodegradation experiments

Biodegradation was evaluated in 5 different experiments. Two experiments used oil adapted natural communities obtained from sediments of Etang de Berre (France) with incubation either in oxic or anoxic conditions. One experiment used a microbial consortium containing four different strains known for their capacity in degrading different petroleum components : *Cellulomonas sp*. IFO 16066 that degrades pyrene, *Pseudomonas stanieri* ATCC 27130T that degrades fluoranthene, *Sphingomonas subartica* KF3 that degrades pristane and *Hydrothermal vent* strain TB66 that degrades naphtalene. The consortium was incubated in oxic condition. Two experiments were performed without adding any exogenous microorganisms. In addition two abiotic controls were performed by acidification of medium and incubated either in oxic or anoxic conditions.

All the biodegradation experiments were performed in 100 ml flasks containing 20 ml of artificial seawater and 20 mg of tar balls of the Prestige petroleum.

Flasks were incubated with agitation during 90 days at 30°C .

Chemical analysis

Petroleum analysis focalised mainly on the aromatic fraction. Fractionation and quantification procedures have been reported elsewhere (Bordenave *et al.* 2004). Biodegradation was expressed in percent relative to either the oxic or anoxic abiotic controls according to the condition used for cultivation.

T-RFLP analysis

Genomic DNA was extracted from the different cultures with the Ultraclean soil DNA isolation kit (Mo Bio Laboratories, Solana Beach, California), as recommanded by the manufacturer. PCR was performed using a reaction mixture of 200 μM each dNTP (Qiagen), 1.5 mM MgCl2, 2.5 U of Taq polymerase (Eurobio), 1X PCR Buffer (Eurobio), and 0.2 μM each primer. The first primers used were the eubacterial primer 8-27F (Lane 1991), and the universal primer 1472- 1489R (Weisburg *et al.* 1991) to amplify specifically the 16S ribosomal gene. Amplification was performed in a MJ Research PTC-200 thermocycler by using initial denaturation step of 95 °C for 5 min, followed by 34 cycles of 94°C for 45 s, 52 °C for 45 s and 72 °C for 1 min, and a final extension at 72 °C for 5 min. PCR products were then purified, using the GFX DNA and Gel Band purification kit (GE Heathcare) as indicated by the supplier. Purified DNA (300 ng) was digested with 10 U of *Hae*III restriction enzyme (New England BioLabs) in a final volume of 10 μl at 37 °C during 3 h. Restricted PCR products (50 ng) mixed with 0.5 μl of TAMRA 500 size standard (Applied Biosystems) were denaturated in presence of 20 μl of formamide during 5 min at 95 °C. DNA fragments were separated according to their size by capillary electrophoresis at 15 000 volts for 30 minutes on an ABI PRISM 310 Genetic Analyser (Applied Biosystems). The 5' terminal fragments were visualized by excitation of the hexachlorofluescein molecule (hex) attached to the forward primer. The gel image was captured and analyzed using Genescan version 3.1 analysis software (Applied Biosystem, USA). T-RFLP profiles were normalized before statistical analysis.

Results and Discussion

Biodegradation was evaluted in the 5 different conditions after 90 days of incubation. To assess this parameter we focused mainly on the aromatic fraction of hydrocarbons which represents the major fraction (around 50 %) of this oil (http://csicprestige.iim.csic.es/informes/info01.pdf).

As illustrated in Figure 1, the oil composition was clearly affected in the culture containing sediments from Etang de Berre under anoxic condition (around 78 % of the aromatic hydrocarbons were degraded). Degradadtion by the aerobic community of this sediment was less efficient (around 63 %). Interestingly, biodegradation was also noticeable when only endogenous tar balls community was incubated in oxic condition (around 43 % of degradation). This result demonstrates that either the endogenous microorganisms of the Prestige oil or the microorganisms collected by the tar balls during their stay in seawater were able to degrade Prestige's petroleum. Biodegradation by the tar ball community in anoxic condition was only of 10 %. Finally, the addition of a hydrocarbonoclastic bacterial strains to tar balls community did not increase degradation of the aromatic compounds. The use of T-RFLP analyses based on 16S ribosomal RNA genes allowed to evaluate the impact of petroleum on all these bacterial communities and to study their evolution during the 90 days of incubation (data not shown in this abstract).

Acknowledgements

We acknowledge the financial support by the Region Aquitaine.

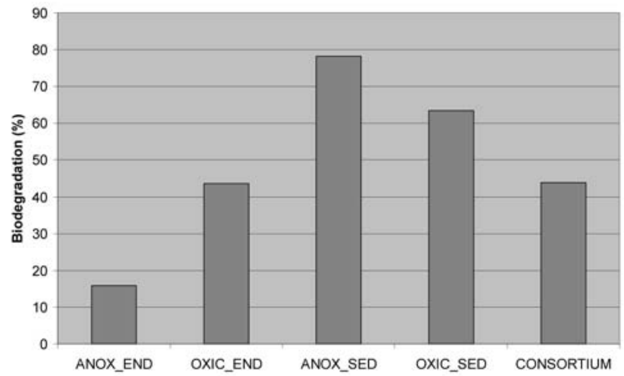

Figure 1. Biodegradation of aromatic compounds of the Prestige's oil by :tar ball endogenous community in anoxic or oxic conditions (ANOX_END and OX_END, respectively) ; oil adapted community from Etang de Berre in anoxic or oxic conditions (ANOX_SED and OX_SED, respectively) and an artificial consortium composed of 4 hydrocarbonoclastic strains

References

Atlas, M. 1984. *Petraleum microbiology*. Macmillan Publishing Compagny ed. New York, USA.

Bordenave, S., A. Fourçans, M. Goñi-Urriza, R. Guyoneaud, R. Grimaud, P. Caumette, R. Duran, R. Jézéquel, F. X. Merlin, T. Fourel, H. Budzinski, 2004. - Degradation of the "Erika" oil. *Aquatic Living Resources,* **17**, 261-267.

Lane, D. J. 1991. - rDNA sequencing. *In*: *Nucleic acid techniques in bacterial systematics*. E. Stachenbrady (eds). Wiley, Chichester, 115-175.

Leahy, J. G., R. R. Colwell, 1990. - Microbial-degradation of hydrocarbons in the environment. *Microbiological Reviews,* **54**, 305- 315.

Swannell, R. P. J., K. Lee, M. McDonagh, 1996. - Field evaluations of marine oil spill bioremediation. *Microbiological Reviews,* **60**, 342-&.

Weisburg, W. G., S. M. Barns, D. A. Pelletier, D. J. Lane, 1991. - 16S ribosomal DNA amplification for phylogenetic study. *Journal of Bacteriology,* **173**, 697-703.

Gaseous mercury exchange at the sediment-water-atmosphere interfaces in a macrotidal lagoon (Arcachon Bay, France)

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Introduction

Coastal lagoons such as the Arcachon Bay are considered to be major structural components of littoral habitats, acting as shelters, nesting and feeding grounds for aquatic organisms and birds. However, they are often perceived as sinks or storage areas for nutrients and metals. Macrotidal coastal ecosystems are also characterized by strong physico-chemical gradients, enhanced biological activity and intense sedimentation and resuspension cycles. As significant amounts of Hg are delivered to coastal waters from the watershed, atmospheric deposition, and urban sources, biogeochemical processing of Hg coupled to tidal regime, seasonal variability and associated physical disturbances and physicochemical changes (redox potential, temperature, oxygen, salinity) are likely to enhanced the reactivity and mobility of mercury buried in sediments.

The cycling of gaseous mercury species (mainly elemental mercury: Hg°) is of primary importance to Hg transport, residence time, and reactivity in natural waters (Mason and Sheu, 2002; Morel et al., 1998). The production of gaseous Hg species, via the reduction of inorganic Hg, favours the removal of labile reactant available for methylation and bioaccumulation in the local aquatic food web (Fitzgerald et al., 1991). The Hg volatilization can thus reduce the Hg burden in surface waters and sediments and can act as a natural attenuation process. Conversely, enhanced Hg° production and evasion to the atmosphere increases the potential residence time for Hg in reactive reservoirs (particularly the lower atmosphere, surficial sediments), which may promote the production and incorporation of methylmercury into food webs elsewhere. Therefore in the Arcachon Bay, where two thirds of the surficial sediment area is emerged at low tide, inter-tidal environmental processes will play a major role in the quantities of Hg exchanged between the different environmental compartments.

Thus, the overall objective of this study was to concurrently assess the inter-tidal and seasonal variability of the gaseous Hg exchange fluxes at the natural interfaces (sediment-water-air) of a coastal macrotidal lagoon. The influence of the tidal pump in the biogeochemical processes that affect gaseous Hg production and exchanges has been investigated in the Arcachon Bay during three different seasons and for various types of sediments. Flux intensities and effects of environmental factors, such as temperature, net radiation and sediments type have been compared in order to assess to role of sediments as a source or a sink, but also to determine influential factors and to predict exchange rates of gaseous Hg at natural interfaces.

This work is a contribution to the French PNEC (Chantier Littoral Atlantique) and ANR PROTIDAL programs.

Methods

Site description

The Arcachon Bay (44°40'N, 01°10'W) is a 156 km^2 lagoon located in the Southwest of France along the Atlantic coast (Figure 1). The tide amplitude oscillates between 1.1m and 4.9m. The inter-tidal internal zone of the Arcachon bay covers 66% of the surface area, encloses the largest seagrass field of *Zostera noltii* in Europe and consists of muddy sediments, whereas the upper parts consist of permeable sandy sediments. This area is of notable economic importance but also significantly exposed to anthropogenic pressure through large-scale oyster farming, tourism and yachting activities.

The present work was achieved arround the location of Cassy where three major groups of sedimentary environments were selected: Station 1 (sandy sediments), Station 2 (uncovered muddy sediments) and Station 3 (muds covered with *Zostera noltii*) (see Figure 1). Gaseous Hg fluxes were measured during three sampling campaigns in March 2005, May 2006 and October 2007.

Benthic fluxes determination

Triplicate benthic chamber incubations (3-4 hours) have been performed for S2 and S3 sampling station at high tide, following the operating conditions described by Point et al. (2007). The exchange of dissolved gaseous Hg (DGM) at the sediment-water interface was derived from the DGM concentration gradient measured during the incubation. DGM contents were obtained by purge and gold trapping followed by *in situ* cold vapor atomic fluorescence detection (CVAFS).

Sediment-atmosphere fluxes determination

Dynamic flux chambers (ORNL type, Kim and Lindberg, 1994) have been carried out to measure the transfer of Total Gaseous Hg species (TGM) at the sediment-atmosphere interface of the trhee stations at low tide. TGM flux was dtermined from the difference of concentrations between the inlet and outlet of the dynamic chamber, equiped with gold traps. The analytical step was also achieved by using *in situ* CVAFS detection.

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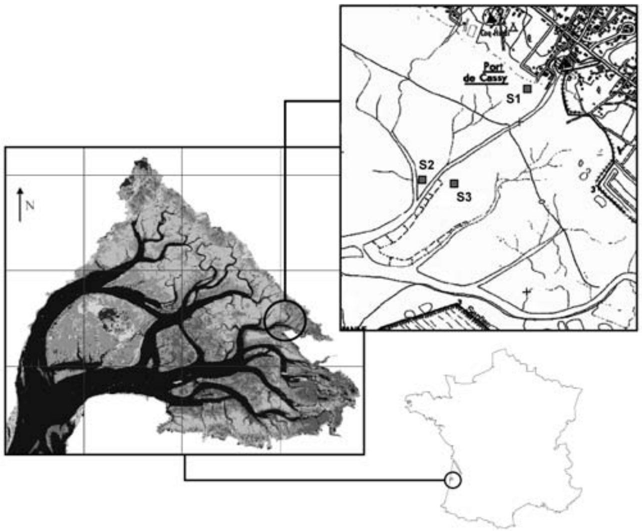

Figure 1. Location of the Arcachon Bay. Detailed map of the inter-tidal sampling stations.

Water-atmosphere fluxes determination

Finally, water-atmosphere fluxes have been calculated from the discrete measurements of DGM and TGM concentrations together with meteorological data, by implementing a water-atmosphere exchange model (Clark et al., 1995), developped for inter-tidal environments and adapted for gaseous Hg species.

Results

The DGM and TGM concentrations and flux densities measured for the inter-tidal stations are displayed in Table 1. The order of magnitude of the gaseous Hg species concentrations and fluxes are in good agreement with typical background levels recorded in coastal environments.

Table 1. Mean values of gaseous Hg species concentrations and associated flux densities measured at the sediment/water/air interfaces.

Site	DGM (ng m^{-3})	TGM (ng m^{-3})	Flux density (ng m^{-2} h^{-1}) Sed-water	Sed-Air	Water-Air
Arcachon Bay March 2005	113 ± 44	2.6 ± 0.8	-2.3 ± 0.8	21 ± 18	3.8 ± 1.6
Arcachon Bay May 2006	30 ± 19	0.9 ± 0.3	1.6 ± 1.0	56 ± 34	1.3 ± 0.9
Arcachon Bay Oct. 2007	41 ± 16	1.7 ± 0.6	3.8 ± 1.1	11 ± 10	1.8 ± 1.0
Gironde estuary Feb . 1998 [a]	37 ± 27	1.5 ± 0.9	-	-	5.8 ± 5.0
Adour Estuary April 2007 [a]	62 ± 27	-	-	-	2.1 ± 0.9

[a] Amouroux et al (Unpublished results)

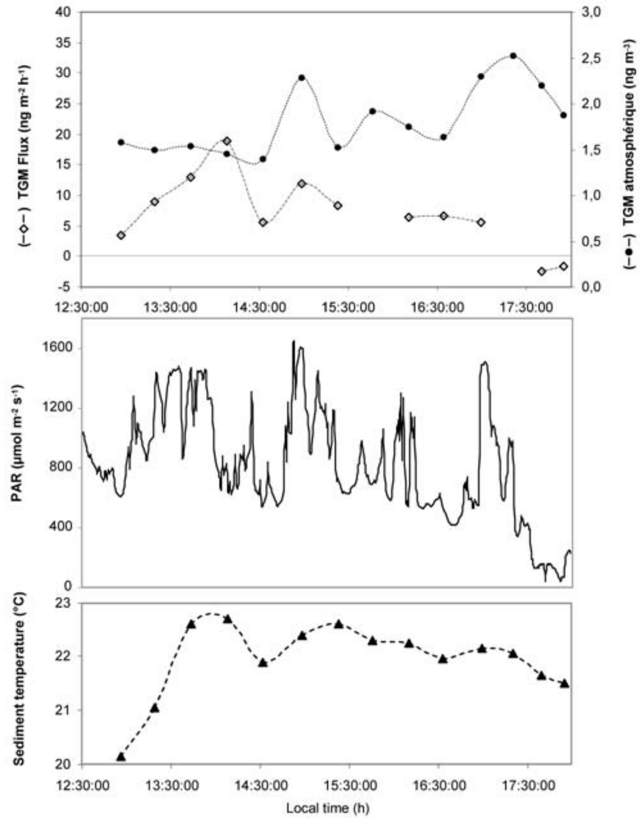

Figure 2 TGM concentrations and fluxes measured at the sediment-air interface in Station S3 (October 2007).

Figure 2 illustrates the variation of TGM fluxes at the sediment-air interface for the station S3. Incident light radiation and sediment temperature appear to be key parmeters that govern the gaseous Hg evasion from intertidal sediment to the overlying atmosphere.

References

Mason, R.P. and Sheu, G., 2002. Role of the ocean in the global mercury cycle, *Global Biogeochemical Cycles*, 16: 1-14.

Morel, F.M.M., Kraepiel, A.M.L., Amyot, M., 1998. The chemical cycle and bioaccumulation of mercury. *Annual review of ecology and systematics*, 29: 543-566.

Fitzgerald, W.F., Mason, R.P., Vandal, G.M., 1991. Atmospheric cycling and air–water exchange of mercury over mid-continental lacustrine regions. *Water, Air Soil and Pollution*, 56: 745–767.

Point D., Monperrus M., Tessier E., Amouroux D., Chauvaud L., Thouzeau G., Jean F., Amice J., Grall J., Leynaert A., Clavier J., Donard O.F.X., 2007. Biological control of trace metal and organometal benthic fluxes in a eutrophic lagoon (Thau Lagoon, Mediterranean Sea, France). *Estuarine, coastal and shelf science*, 72: 457-471.

Kim, K.-H. and Lindberg, S.E., 1995. Design and initial tests of a dynamic enclosure chamber for measurements of vapour-phase mercury fluxes over soils. *Water, Air and Soil Pollution*, 80: 1059-1068.

Clark, J.F., Schlosser, P., Simpson, H.J., Stute, M., Wanninkhof, R.; Ho, D.T., 1995. Relationship between gas transfer velocities and wind speeds in the tidal Hudson River by the dual tracer technique. *Air water gas transfer*, Jaehne, B., Monahan, E., Eds., Aeon Verlag: hanau, 785-800.

Establishment of a quantitative metal transport scheme at the watershed scale: application to copper in the Gironde Estuary

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Introduction

Trace elements in aquatic systems are derived from erosion and soil leaching, but human activities (e.g. mining, agriculture) also may represent important sources. Estuaries are key transition zones between continental and oceanic environments, characterized by intense redistribution of trace metals between the particulate and dissolved phases (e.g. Windom et al., 1991; Turner et al., 2002; Robert et al., 2004). Accordingly, net export of metals to the ocean is strongly influenced by estuarine internal reactivity (Monbet, 2006). The present work aims to i) identify and quantify the main Cu sources and fluxes in the Gironde watershed (Fig. 1), ii) identify and quantify the processes responsible for the distribution of dissolved Cu observed in the Gironde estuary and iii) establish realistic mass balances for Cu in this macrotidal estuary.

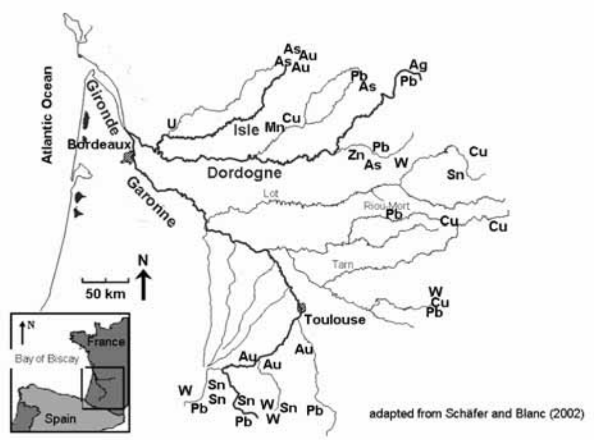

Figure 1. Map of the Gironde Estuary and its watershed.

Methods

This study is based on a long-term survey of river and estuarine surface water, fluvial and estuarine suspended particulate matter (SPM), stream sediments and estuarine sediments. Dissolved metals in brackish water samples were separated from the matrix and pre-concentrated using the liquid–liquid extraction method by Danielsson et al. (1982) or by solid-liquid extraction (DigiSEP Bleu, SCP SCIENCE; Delsuc, 2006; Strady et al., 2007). Sediments and SPM were digested by a tri-acid solution (HNO_3, HCl, HF) in closed Teflon reactors (Savillex®; e.g. Masson et al., 2006). Trace elements (Cd, Zn, Pb and Cu) were measured by ICP-MS. The analytical quality was continuously monitored by parallel analyses of international certified reference sediments and waters (SLRS-3, SLRS-4, BCR 320, PACS-1, SL-1). The obtained results were consistently within the certified concentration ranges and precision was better than 7% (rsd).

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Results and discussion

Water quality entering into the Gironde Estuary via the Garonne, Dordogne and Isle Rivers ranged from "poor" to "bad" (water quality criteria of the Agence de l'Eau Adour-Garonne) for many metals (e.g. Cu, As, Pb, Cr and Ni; Masson, 2007). Although only the Garonne River is known for historic Zn, Cd, Cu and Pb pollution (e.g. Audry et al., 2004a; Audry et al., 2004b), values measured in the Dordogne and Isle Rivers were rather similar or even higher.

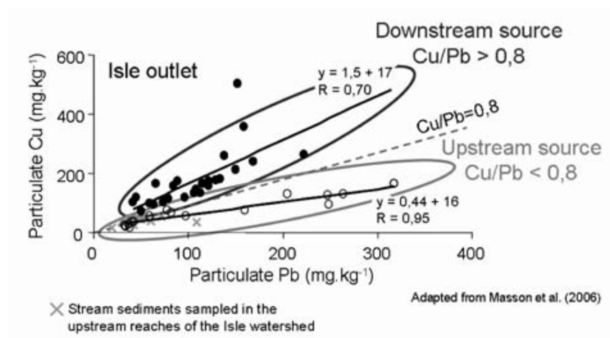

Figure 2. Relationship between particulate Cu and Pb concentrations in the Isle River from 1999 to 2002.

The element concentration ratios measured in the suspended particulate matter (SPM) have been used as tools to identify metallic sources in the Garonne, Dordogne and Isle watersheds (Masson et al., 2006). In the Dordogne and Isle watersheds, two main metal sources have been identified from Zn/Pb and Cu/Pb ratios (Fig. 2): (i) an upstream source of Zn, Cd, Pb and Cu attributed to geology and related mining activities in the Massif Central and (ii) a downstream source of Zn and Cu attributed to agriculture (mainly viticulture). Increasing Zn and Cu concentrations and Zn/Pb and Cu/Pb ratios from upstream to downstream suggest that agriculture may contribute more than 50% to particulate Zn and Cu fluxes entering into the Gironde Estuary via the Dordogne and Isle Rivers.

In the freshwater turbidity gradient and in the maximum turbidity zone (MTZ) of the fluvial estuary, Cu is released into the dissolved phase (<0.2 µm), mainly as "truly" dissolved Cu (<0.02 µm; Fig. 3). This addition, attributed to organic matter (OM) degradation (Masson, 2007), increased the dissolved Cu concentrations and fluxes along the fluvial reaches of the Gironde Estuary by 25%.

At the onset of salinity gradient, flocculation of dissolved OM (by "salting out") may be responsible of the strong decrease of dissolved Cu concentrations (Fig. 3). However, in the salinity gradient, Cu addition prevails over sequestration, suggesting important release from fluvial particles, MTZ particles and resuspended sediments (e.g. natural erosion, dredging; Fig. 4).

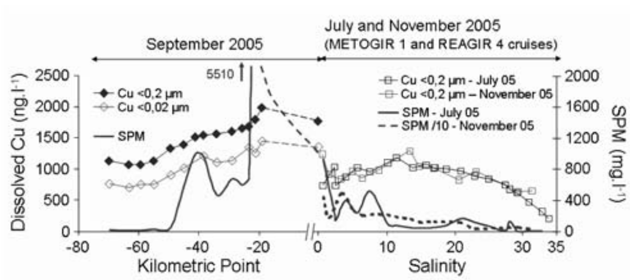

Figure 3. Dissolved Cu concentrations (<0.2 µm and <0.02 µm) in the fluvial estuary of the Garonne River (September 2005) in along the salinity gradient of the Gironde Estuary (July and November 2005).

Anthropogenic activities, mainly dredging in the estuary, contribute significantly (up to 70%) to Cu additions (Fig. 4; Audry et al., in press). Annual budget (2004) suggests that dissolved Cu produced in the estuarine biogeochemical reactor represents up to 40% of the total dissolved Cu fluxes exported from the Gironde Estuary to the coastal ocean (Fig. 4).

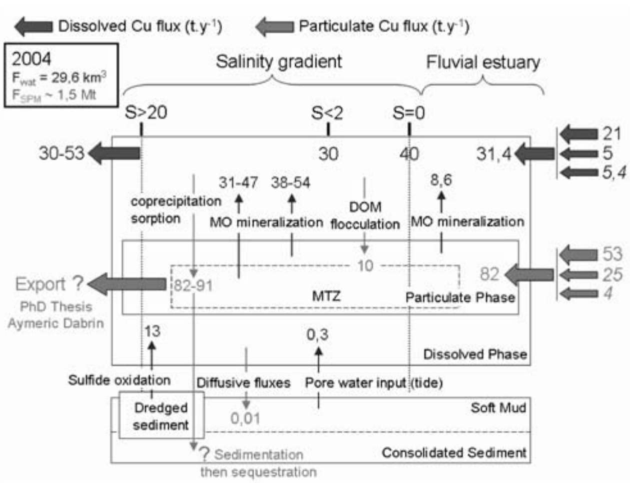

Figure 4. Quantitative conceptual scheme of the Cu cycle in the Gironde Estuary (2004).

Conclusions

This study represents the first attempt to integrate the major reservoirs and processes controlling Cu reactivity and especially exchanges between solid and liquid phases in the Gironde estuary. However, the mass balance between particulate Cu exported to the ocean and that stored in the estuarine sediment will have to be established to better understand the impact of estuarine processes on coastal water quality.

Acknowledgements

This work was supported by grants from 'le Ministère de la Recherche', 'l'Agence de l'Eau Adour-Garonne', the 'FEDER-Région Aquitaine', the ZAAG (INSU-CNRS) and the 'GIS-ECOBAG' (Groupement d'Intérêt Scientifique: Environnement, Ecologie et Economie du Bassin Adour-Garonne). We thank the crews of the RV "Côte d'Aquitaine" and "Côtes de la Manche" (INSU) and the CIRMAT Committee. The authors greatly acknowledge C. Bossy, Y. Lapaquellerie, N. Maillet, G. Lavaux, J.P. Lissalde, S. Castelle, A. Coynel, A. Dabrin, J. Delsuc, N. Girardot, and E. Strady for their contributions to field and laboratory work.

References

Audry, S., J. Schäfer, G. Blanc, C. Bossy, G. Lavaux, 2004a. Anthropogenic components of heavy metal (Cd, Zn, Cu, Pb) budgets in the Lot-Garonne fluvial system (France). *Applied Geochemistry*, 19: 769-786.

Audry, S., G. Blanc, J. Schäfer, 2004b. Cadmium transport in the Lot-Garonne River system (France) – temporal variability and a model for flux estimation. *Science of the Total Environment*, 319: 197-213.

Danielsson, L.-G., B. Magnusson, S. Westerlund, K. Zhang, 1982. Trace metal determinations in estuarine waters by electrothermal atomic absorption spectrometry after extraction of dithiocarbamate complexes into freon. *Analytica Chimica Acta*, 144: 183-188.

Delsuc, J., 2006. Réactivité des Eléments Traces Métalliques (Cd, Cu, Zn, Ni, Co, V et U) dans les gradients géochimiques estuariens - Etude expérimentale des cinétiques et équilibres de sorption des ETM dans les gradients de salinité et de turbidité. Master Research Report, University Bordeaux1, France, 30 pp.

Masson, M., G. Blanc, J. Schafer, 2006. Geochemical signals and source contributions to heavy metal (Cd, Zn, Pb, Cu) fluxes into the Gironde Estuary via its major tributaries. *Science of the Total Environment*, 370: 133-146.

Masson, M., 2007. Sources et transferts métalliques dans le bassin versant de la Gironde - Réactivité et mécanismes géochimiques dans l'estuaire fluvial de la Gironde. PhD Thesis, University Bordeaux1, France, 378 pp.

Monbet, P., 2006. Mass balance of lead through a small macrotidal estuary: the Morlaix River estuary (Brittany, France). *Marine Chemistry*, 98: 59-80.

Robert, S., G. Blanc, J. Schäfer, G. Lavaux, G. Abril, 2004. Metal mobilization in the Gironde Estuary (France): the role of the soft mud layer in the maximum turbidity zone. *Marine Chemistry*, 87: 1-13.

Turner, A., M. Martino, S.M. Le Roux, 2002. Trace metal distribution coefficients in the Mersey Estuary, UK: evidence for salting out of metal complexes. *Environmental Science & Technology*, 36: 4578-4584.

Strady, E., M. Masson, A. Dabrin, Y. Furusho, J.Y. Henry, J. Schäfer, G. Blanc, 2007. Détermination de V, Co, Ni, Cu, Mo, Cd et U dissous dans l'eau de mer par extraction en phase solide au moyen de cartouches d'extraction de métaux. Application à l'estuaire de la Gironde. SpectrAtom, 21-24 May 2007, Pau, France.

Windom, H., J. Byrd, J.R. Smith, M. Hungspreugs, S. Dharmvanij, W. Thumtrakul, P. Yeats, 1991. Trace metal–nutrient relationships in estuaries. *Marine Chemistry*, 32: 177-194.

Dissolved Vanadium in the Gironde estuary: behaviour and net fluxes

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Introduction

Behaviour of dissolved vanadium along estuarine salinity gradients is little documented. Few studies have reported non-conservative behaviour, with subtraction in the high salinity range (eg. Shiller and Boyle, 1987, Shiller and Mao, 1999; Auger et al., 1999). This observation was mainly attributed to local O_2 depletion inducing reduction of pentavalent V (Sadiq, 1988) and subsequent sequestration (Wehrli and Stumm, 1989; Emerson and Huested, 1991). The Gironde estuary (South Western France) is a highly turbid, macrotidal estuary (Allen et al., 1977) with a pronounced permanent Maximum Turbidity Zone (MTZ). This estuary is well known for historic pollymetallic pollution (Cd, Cu, Zn, …) mainly resulting from ore deposits and -treatment (e.g. Latouche, 1988; Blanc et al., 1999; Schäfer et al, 2002; Audry et al., 2004). Relatively high V concentrations in bivalves off the Gironde Estuary, revealed by the French Mussel Watch Programme (RNO) suggest that V may also be a part of this polymetallic pollution. During 2003-2007, ten sampling cruises were performed along the salinity gradient of the Gironde estuary, covering contrasting river discharge and seasons. The aims of this study were to (1) monitor the behaviour of dissolved V in surface water of the Gironde estuary (2) better understand its spatial and temporal variability and (3) estimate daily net fluxes exported out of the estuary.

Methods

Sampling

Estuarine surface and bottom waters were sampled along the salinity gradient of the Gironde estuary (0 to 34) onboard the RV "Côtes de la Manche". The hydrological conditions during sampling included low water discharge (169 m^3/s) and an high discharge (2600 m^3/s). Sampling was performed using clean techniques (Patterson and Settle, 1976), including immediate filtration (<0.2 µm), acidification (ultrapure HNO_3; 1/1000) and sample storage in acid cleaned polypropylene bottles at 4°C in the dark until analysis.

Laboratory analysis

Matrix separation and preconcentration of dissolved V was performed by solid-liquid extraction, using *Digi*SEP Blue® cartridges (functional group: amino di-acetate; SCP Science). This method provides quantitative recoveries (99±2%) and excellent precision, even when different cartridges are used (Strady et al., 2007). Concentrations were then measured by ICP-MS (Thermo X7) and were continuously quality checked by parallel analysis of certified international reference waters (CASS-4; SLRS-4).

Net flux estimates

Net fluxes were estimated by extrapolating the dilution line in the high salinity range to obtain a theoretical dissolved V concentration ($[X]_0$) at S=0 (Boyle et al., 1974; 1982), as follows:

$$F_{net}=Q_t * [X]_0$$

with, *Qt* daily river discharge.

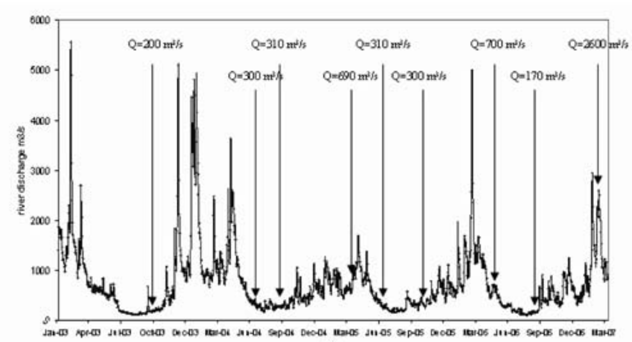

Figure1. Riverine water discharge (Garonne and Dordogne, m^3/s) from January 2003 to March 2007 and sampling periods.

Results

Dissolved V concentrations varied from 0.89 µg/l to 2.76 µg/l (Fig. 2a). The observed concentration levels were rather similar in both, the freshwater and the marine endmember, whatever the hydrological situation. In general, dissolved V concentrations off the Gironde estuary corresponded to typical North Atlantic Coastal Ocean values (~1,18 µg/l, CASS-4; Fig. 2a). Between these two endmembers, dissolved V concentrations followed (conservative) or not (non-conservative) the theoretical dilution lines, depending on the hydrological situation. Especially during low discharge situations, pronounced addition of dissolved V was observed in the low- to mid-salinity range (Fig. 2a).

Discussion

Distributions of dissolved V along the salinity gradient suggest addition of dissolved V to both surface and bottom waters (Fig. 2b). The amplitudes of the "bell-shaped" concentration curves (similar to those observed for Cd; Fig. 2a) along the salinity gradient reach values of up to nearly 3-fold higher than those expected for conservative mixing. This behaviour is clearly different from those reported for the Rhine, Scheldt (Van der Sloot, 1985) and

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Tamar estuaries (Van den Berg et al., 1991), where dissolved V behaviour was unstable at low salinity and conservative in the mid to high salinity range. On the Louisiana Shelf, V is removed from the dissolved phase, when O_2-depletion occurs (Shiller and Mao (1999). However, V addition in both, surface and bottom water of the Gironde estuary suggests that V dissolution prevails over sequestration (Fig. 2b), even in bottom water of the MTZ, which may be strongly O_2-depleted during low discharge (Robert et al., 2004; Audry et al., 2006.). The close relationship between dissolved PO_4^{3-} and V observed in the Gironde estuary (Fig. 2c) suggests that V addition may be attributed to intense OM degradation in the MTZ rather than complexation/desorption processes. This is coherent with V release from OM in the soft mud and consolidated sediment of the Gironde estuary (Audry et al. 2006). The dissolved V daily net fluxes exported to the coastal ocean (daily net fluxes) ranged from 58-125 kg/d, whereas average dissolved V gross fluxes varied from 18-106 kg/d. During the studied situations, estuarine addition roughly contributed 5-50 kg/d (i.e. up to 50%) to dissolved V net fluxes. Further studies are necessary to characterize mechanisms of V recycling in the estuarine environment.

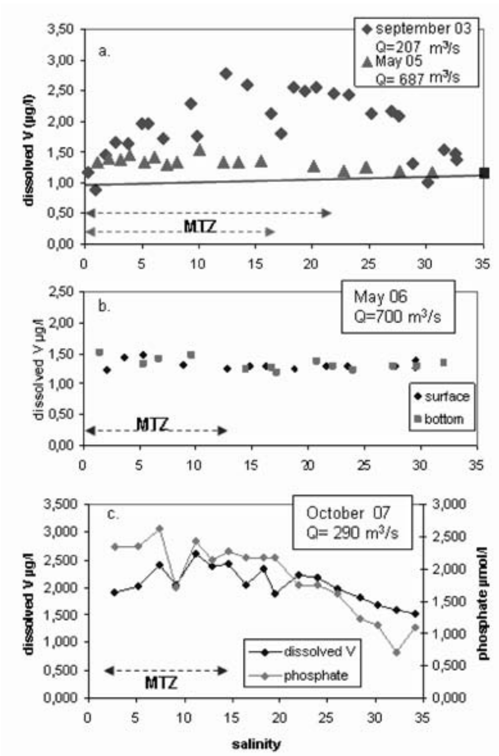

Figure 2. Distributions of dissolved V along the salinity gradient of the Gironde estuary; a) additive behaviour observed at low and medium fluvial water discharge. The black line represents the theoretical dilution line; b) distribution of dissolved V in surface and bottom water during intermediate water discharge; c) relation between dissolved V and phosphate for low water discharge. MTZ: Maximum Turbidity Zone.

Conclusion

The first data on the distribution of dissolved V in the Gironde estuary suggest non-conservative, additive behaviour along the salinity gradient, probably due to V release from OM.

References

Allen, G.P., Sauzay, G., Castaing, P. et Jouanneau, J.M. 1977. transport and deposition of suspended sediments in the Gironde estuary, France. In “estuarine processes”, M. Wiley (Ed). Academic press, New York: 63-81.

Audry S., Schäfer J., Blanc G., Bossy C., and Lavaux G., 2004. Anthropogenic components of heavy metals (Cd, Zn, Cu, Pb) budgets in the Lot-Garonne fluvial system (France). Applied Geochemistry, 19: 769-786.

Audry, S., Blanc, G., Schäfer J., Chaillou, G., Robert, S. 2006. Early diagenesis of trace metals (Cd, Cu, Co, Ni, U, Mo, and V) in the freshwater reaches of a macrotidal estuary. Geochimica et Cosmochimica Acta 70 (9), pp. 2264-2282

Auger, Y., Bodineau, L., Leclercq, S., Wartel, M., 1999. Some aspects of vanadium and chromium chemistry in the English Channel. Continental Shelf Research 19 (15-16), pp. 2003-2018.

Blanc, G., Lapaquellerie, Y., Maillet, N., Anschutz, P., 1999. a cadmium budget for the Lot-Garonne fluvial system (France). Hydrobiologia 410, 331-341.

Boyle, E.A., Collier, R., dangler, A.T., Edmond, J.M., Ng, A.C., Stallard, R.F., 1974. On the chemical mass-balance in estuaries. Geochim. Cosmochim. Acta 38, 1719-1728.

Boyle, E.A., Huested, S.S., Grant, B., 1982. The chemical mass-balance of the Amazon plume. II. Copper, nickel and cadmium. Deep-Sea Res. 29, 1355-1364.

Emerson, S.R., Huested, S.S, 1991. Ocean anoxia and the concentrations of molybdenum and vanadium in seawater. Marine Chemistry 34 (3-4), pp. 177-196.

Latouche, C., 1988. Cadmium pollution in the Gironde estuary /La pollution en cadmium de l’estuaire de la Gironde. Bulletin - Institut de Geologie du Bassin d’Aquitaine 44, pp. 15-21.

Patterson, C.C, Settle, D.M. 1976. The reduction of orders of magnitude errors in lead analyses of biological materials and natural waters by evaluating and controlling the extent and sources of industrial lead contamination introduced during sample collecting, handling, and analysis. National bureau of standards special publication, 422, 321-351.

Robert, S., Blanc, G., Schäfer J., Lavaux, G., Abril, G., 2004. Metal mobilization in the Gironde Estuary (France): The role of the soft mud layer in the maximum turbidity zone. Marine chemistry, 87, 1-2, pp1-13.

RNO - Réseau National d’Observation (French Mussel Watch Programme) ; www.ifremer.fr/lerlr/surveillance/rno.htm

Sadiq, M., 1988. Thermodynamic solubility relationships of inorganic vanadium in the marine environment. Marine Chemistry 23 (1-2), pp. 87-96.

Schäfer, J., Blanc, G., Lapaquellerie, Y., Maillet, N., Maneux, E. et Etcheber, H. 2002. Ten year observation of the Gironde tributary fluvial system: fluxes of suspended matter, particulate organic carbon and cadmium. Marine Chemistry. 79: 229-242.

Shiller, A.M., Boyle, E.A., 1987. dissolved vanadium in rivers and estuaries. Earth and Planetary Science Letters 86, 214-224.

Shiller, A.M., Mao, L., 1999. Dissolved vanadium on the Louisiana Shelf: Effect of oxygen depletion. Continental Shelf Research 19 (8), pp. 1007-1020.

Strady, E., Masson, M., Dabrin, A., Furusho, Y., Henry, J.Y., Schäfer J. et Blanc G., 2007. Détermination de V, Co, Ni, Cu, Mo, Cd et U dissous dans l’eau de mer ar extraction en phase solide au moyen de cartouches d’extraction de métaux. Application à l’estuaire de la Gironde. Poster, conférence Spectr’Atom, Pau, France.

Van Den Berg, C.M.G., Khan, S.H., Daly, P.J., Riley, J.P., Turner, D.R., 1991. An electrochemical study of Ni, Sb, Se, Sn, U and V in the estuary of the Tamar. Estuarine, Coastal & Shelf Science 33 (3), pp. 309-322.

Van der Sloot, H.A., Hoede, D., Wijkstra, J., 1985. Anionic species of V, As, Se, Mo, Sb, Te and W in the Scheldt and Rhine estuaries and the Southern Bight (North Sea). Estuarine, Coastal and Shelf Science 21 (5), pp. 633-651.

Wehrli, B., Stumm, W., 1989. Vanadyl in natural waters: adsorption and hydrolysis promote oxygenation. Geochimica et Cosmochimica Acta 53, 69-77.

Silver behaviour along the salinity gradient of the Gironde Estuary: Reactivity and Bioaccumulation in Eel (*Anguilla anguilla*)

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Introduction

The Gironde estuary (Fig. 1) is known for historical metallic pollution mainly due to geology, former ore treatment and agricultural activities (Audry et al., 2004; Masson et al., 2006). Cadmium has long been considered as the major pollutant but many other, less studied metals also show important anomalies (e.g. Hg, As and Ag; Schäfer et al., 2006; Masson et al., 2007). Although Ag is known to be a geochemical tracer of urban wastewater inputs (Sanudo-Wilhelmy and Flegal, 1992), Ag in the Gironde Estuary may probably be derived from ore-deposits and -treatment in the upstream watershed (Schäfer and Blanc, 2002). Data on dissolved Ag concentrations in natural freshwater and in estuaries are scarce, but typical dissolved Ag concentrations are in the low to sub-ng/l range (Sanudo-Wilhelmy et al., 1996; Wen et al., 1997). Silver is highly toxic to aquatic organisms and may be easily bio-accumulated (Luoma et al., 1995; Pedroso et al., 2007). Previous work has shown that Ag concentrations in bivalves of the Gironde Estuary are amongst the highest measured along the French coast (Chiffoleau et al., 2005), but no data exists on Ag levels in fish. The European Eel (*Anguilla anguilla*) is in the centre of important ecological and economical interest due to endangered stock and its particular ecology (benthic, long-lived and high-lipid requirement for reproduction) affected by pollution (e.g. Pierron et al., 2007).

The objective of the present work is to document for the first time Ag concentration levels and behaviour in the salinity gradient of the highly turbid, macrotidal Gironde Estuary. Furthermore, a potential impact of estuarine Ag dissolution on bioaccumulation in European eels is discussed.

Methods

Water and Suspended Particulate Matter (SPM) were sampled in surface water along the salinity gradient of the Gironde estuary on board the RV "Côtes de la Manche" (INSU) during low discharge (310 m^3/s). Yellow eels (*Anguilla anguilla*) were fished with the RV "Esturial" (CEMAGREF) in distinct, representative zones of the Gironde estuary (Bordeaux, Pauillac, Cônac and Saint Vivien) and in the Garonne (Golfech) and Dordogne (Tuillières) Rivers (5 individuals/zone; Fig. 1). Key organs (e.g. liver, kidney, muscle and gills) were sampled separately for metal analyses.

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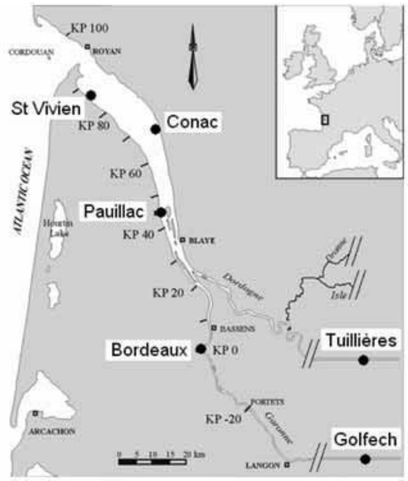

Figure 1. Map of the Gironde estuary and its major affluents: the Dordogne and the Garonne River systems.

Aliquots of dry, homogeneized SPM were analysed for POC using a carbon/sulphur analyser (LECO, CS-125). SPM were digested by a tri-acid solution (HNO_3, HCl, HF) in closed reactors (e.g. Masson et al., 2006). Eel liver tissues were digested in 3 ml HNO_3 (14 M, suprapure; Pierron et al., 2007). Digestates were analyzed by ICP-MS (X7, THERMO). The analytical quality was continuously monitored by parallel analyses of international certified reference materials (SRM 1640; SLEW-3; MESS-2; DORM-2). The obtained results were consistently within the certified ranges and precision was better than 6% (rsd). Prior to analysis by ICP-MS, dissolved (<0.2 µm) Ag was preconcentrated and separated from the matrix using liquid/solid extraction (DigiSep TE 05 cartridges; SCP Science). Accuracy, (standard addition) was 93±6% and precision was 6% (rsd) at the 10 ng/l level.

Results and discussion

During the sampling cruise, the maximum turbidity zone was located in the low- to mid-salinity range with SPM concentrations in surface water of up to 2850 mg/l (Fig. 2). Dissolved Ag concentrations ranged from 0.02 to 1.6 ng/l with a clear increase in the salinity gradient ($0 \leq S \leq 33$) and a decrease towards the marine endmember ($S > 33$; Fig. 2). Increasing dissolved Ag concentrations with salinity are attributed to non-conservative behaviour (addition) due to complexation with chloride (Wen et al., 1997; Barriada et al., 2007). The lowest values compared to both fluvial and estuarine Ag concentrations occurred in the MTZ ($0 \leq S \leq 3$), suggesting that adsorption onto particles (colloids) prevails over formation of dissolved AgCl(aq) (Barriada et al. 2007). Dilution of Ag-rich estuarine waters by low-Ag seawater is only visible at very high salinities (Fig. 2). As the amount

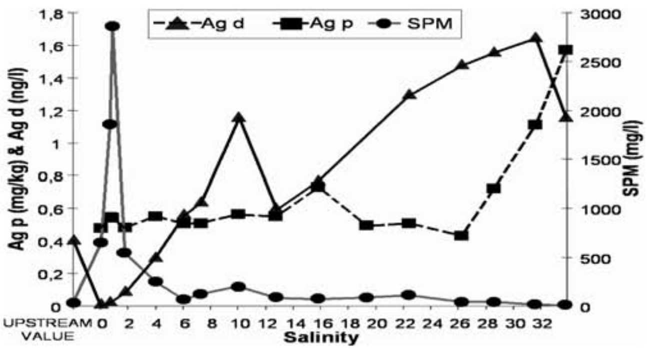

Figure 2. Particulate silver (Ag p), dissolved silver (Ag d) and suspended particulate matter (SPM) along the Gironde estuary salinity gradient.

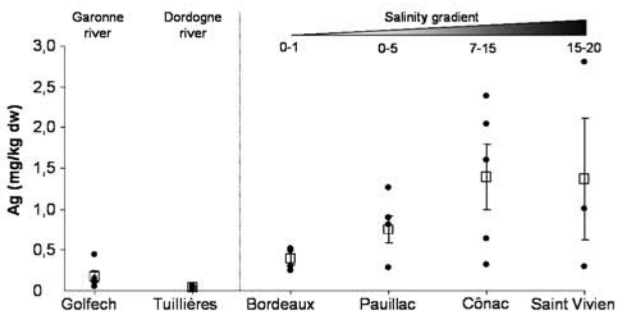

Figure 3. Silver concentrations in eel liver (ind./site, square : mean±SE)

of Ag dissolved is small compared to the total amount of Ag present, these changes in distribution do not affect particulate Ag concentrations: Particulate Ag concentrations were rather constant (~0.5 mg/kg;) in the salinity gradient, except for high salinity (S>26), where values reached up to 1.6 mg/kg (Fig. 2). Increasing particulate Ag concentrations near the estuarine mouth coincide with increasing POC values (from 1.6% to ~5%). This may reflect Ag assimilation/adsorption onto phytoplancton (diatoms?), as primary production in the Gironde estuary mainly occurs in this low-turbidity zone (Irigoien and Castel, 1997). This is coherent with "nutrient-like" behaviour of Ag in the open-ocean water-column (Zhang et al., 2001; Barriada et al., 2007).

Silver concentrations in eel liver ranged from 0.01 to 2.8 mg/kg (d.w.), with clearly higher values in brackish water than in freshwater (Fig. 3, Mann-Whitney, $p<0.05$). In the estuary, mean Ag concentrations were 2-8 fold and 11-40 fold higher than in the Garonne and Dordogne Rivers, respectively. The corresponding accumulation factors (Ag in liver (fw)/Ag dissolved) of 200.000 to 8.000.000 (Figs. 2, 3) are at maximum in the low salinity range (Bordeaux; Fig. 1). This is consistent with dominance of Ag^+ and AgCl(aq), i.e. respectively the most toxic and bioavailable inorganic Ag species, for $0 \leq S \leq 3$ (Reinfelder and Chang, 1999). Dissolved Ag speciation seems to play an important role in bioaccumulation in eel. Lower accumulation factors at higher salinity, where $AgCl_x^{\ y}$ (x= 2;3,4; y= 1-, 2-, -3) species are dominant (Barriada et al., 2007) suggest that bioavailability of Ag might be at maximum at low salinity. However, Ag concentrations in eel liver seem to reflect exposition, i.e. dissolved Ag concentrations along the salinity gradient.

Conclusions

Important Ag addition to the dissolved phase throughout nearly the whole salinity range and salinity-dependent bioaccumulation factors suggest maximum toxicity potential at low salinity. Understanding Ag behaviour in turbid estuaries needs to include redox gradients, OM degradation, bottom water, species analysis, the trophic chain, etc.

Acknowledgements

This work was supported by the ANR « Vulnérabilité, Milieu et Climat » and the SMIDDEST. We thank the crews of the RV "Côtes de la Manche" (INSU) and "Esturial" (CEMAGREF) and H. Derriennic for technical support.

References

Audry S., Schäfer J., Blanc G., Bossy C., Lavaux G., 2004. Anthropogenic components of heavy metal budgets in the Lot-Garonne fluvial system (France). *Appl. Geochem.* 19:769-786.

Barriada J.L., Tappin A.D., Evans H.E., Achterberg E.P, 2007. Dissolved silver measurements in seawater. *Trends in Anal. Chem.* 26:809-817.

Chiffoleau J.F., Auger D., Roux N., Rozuel E., Santini A., 2005. Distribution of silver in mussels and oysters along the French coasts: Data from the national monitoring program. *Mar. Pollut. Bull.* 50:1719-1723.

Irigoien X. and Castel J., 1997. Light limitation and distribution of chlorophyll pigments in a highly turbid estuary: the Gironde estuary (SW France). *Est., Coastal and Shelf Sci.* 44:507-517.

Luoma S.N., Ho Y.B., Bryan G.W., 1995. Fate, bioavailability and toxicity of Ag in estuarine environments. *Mar. Pollut. Bull.* 31:44-54.

Masson M., Blanc G., Schäfer J., 2006. Geochemical signals and source contributions to heavy metal (Cd, Zn, Pb, Cu) fluxes into the Gironde Estuary *via* its major tributaries. *Sci. Tot. Environ.* 370:133-146.

Masson M., Schäfer J., Blanc G., Anschutz P., 2007. Seasonal variations and annual fluxes of arsenic in the Garonne, Dordogne and Isle Rivers, France. *Sci. Tot. Environ.* 373:196-207.

Pedroso M.S., Pinho G.L.L., Rodrigues S.C., Bianchini A., 2007. Mechanism of acute silver toxicity in the euryhaline copepod *Acartia tonsa*. *Aquat. Toxicol.* 82:173-180.

Pierron F., Baudrimont M., Bossy A., Bourdineaud J-P., Brethes D., Elie P., Massabuau J-C., 2007. Impairment of lipid storage by cadmium in the European eel (*Anguilla anguilla*). *Aquatic Toxicol.* 81:304–311.

Sanudo-Wilhelmy S.A. and Flegal A.R., 1992. Anthropogenic silver in the southern California Bight: a new tracer of sewage in coastal waters. *Environ. Sci. Technol.* 26:2147-2151.

Sanudo-Wilhelmy S.A., Rivera-Duarte I., Flegal A.R., 1996. Distribution of colloidal trace metals in the San Francisco Bay estuary. *Geochim. Cosmochim. Acta* 60:4933-4944.

Schäfer J. and Blanc G., 2002. Relationship between ore deposits in river catchments and geochemistry of suspended particulate matter from six rivers in southwest France. *Sci. Tot. Environ.* 298:103-118.

Schäfer J., Blanc G., Audry S, Cossa D, Bossy C., 2006. Mercury in the Lot-Garonne River system (France): Sources, fluxes and anthropogenic component. *Appl. Geochem.* 21:515-527.

Reinfelder J.R., Chang S.I., 1999. Speciation and microalgal bio-availability of inorganic silver. *Environ. Sci. Tecnol.* 33:1860-1863.

Wen L-S., Santschi P.H., Gill G.A., Paternostro C.L, Lehman R.D., 1997. Colloidal and particulate silver in river and estuarine water of Texas. *Environ. Sci. Technol.* 31:723-731.

Zhang Y., Amakawa H., Nozaki Y., 2001. Oceanic profiles of dissolved silver: precise measurements in the basins of western North Pacific, Sea of Okhotsk, and the Japan Sea. *Mar. Chem.* 75:151-163.

Spatial distribution and sources of copper in sediments of the Gironde Estuary: a GIS-based approach.

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Introduction

Estuaries constitute the interface between continent and ocean, where numerous physical and biogeochemical processes take place. Various coastal ecosystems are significantly impacted by contaminant inputs and reactivity in estuaries (Claisse et al., 1989, Baudrimont et al., 2005, Audry et al., 2006).

The Gironde estuary (625 km², southwest France), affected by important historical polymetallic pollution due to former mining and ore-treatment activities, delivers 1.5 Mt y^{-1} of continental fine sediments to the Bay of Biscay (Jouanneau et al., 1999). Dissolved and particulate metal inputs (Cd, Zn, Cu, Pb) into the estuary via its major tributaries reflect different major sources in the watershed (e.g. ore deposits and mines, agriculture; Grousset et al., 1999; Schäfer and Blanc, 2002). For example, increasing riverborne Cu concentrations and Cu/Pb ratios from upstream to downstream were attributed to vineyard treatment, which strongly contributes (~50%; Masson et al. 2006) to annual particulate Cu fluxes into the estuary.

Fluvial sediments, especially in reservoirs, have been shown to represent important secondary metal sources due to natural and anthropogenic resuspension (flood events, dredging; Coynel et al., 2007). Important transformation processes in the estuarine geochemical gradients and related mass balances have revealed the potential role and the lack of knowledge on Cu stocks in the estuarine sediment (Audry et al. in press).

The present work aims to document the concentration levels and the spatial distribution of Cu in surface sediments of the Gironde estuary. For this, a preliminary database of metal concentrations was integrated in a GIS (Geographic Information System; ArcView®) and analyzed using geostatistics. This approach aims to optimize futur sampling strategies in order to (i) better understand the estuarine Cu cycle (ii) identify potential intra-estuarine sources and (iii) produce a reliable tool for sustainable management.

Methods

Sampling

From 1998 to 2007, 270 samples of surface sediments (0-10 cm) of the Gironde Estuary were retrieved onboard the RV "Côtes de la Manche" (INSU) using a box corer (Figure 1).

The grain size distribution of each sample was analyzed from fresh aliquots with a Laser Malvern Mastersizer (64 channels from 0.06 to 878 µm). Aliquots of the sediments were sieved <63 µm, using PP sieves.

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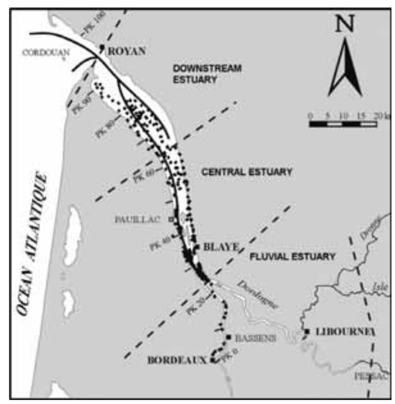
Chemical analyses were performed after total digestion of dry, homogeneized (agate mortar) sediment aliquots (30 mg) by a tri-acid solution (HNO_3, HCl, HF) in acid-cleaned closed reactors (e.g. Schäfer et al. 2002). Trace elements (Cu, Th) were measured by ICP-MS (Elan 5000, Perkin-Elmer and X7, THERMO). The analytical quality was continuously monitored by parallel analyses of international certified reference sediments (BCR 320, IAEA 405, NCS DC78301). The obtained results were consistently within the certified ranges and precision was better than 10 % (rsd). Detection limits were 0.023 $mg.kg^{-1}$ for Cu and 0.003 $mg.kg^{-1}$ for Th.

Figure 1. Position of the sampling sites.



Interpolation methods, based on geostatistical analysis allowed generating a continuous distribution pattern of Cu concentrations in sediments of yet unsampled areas. Variograms were developed to estimate the degree of continuity between data points, as follows:

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} \left[Z(x_i) - Z(x_i + h) \right]^2$$

where N(h) is the number of data pairs separed by a distance h and Z is the value of the point xi.

Results and discussion

The median grain size (MGS) tended to decrease from upstream to downstream (Table 1).

Table 1. Distribution parameters (minimum, maximum, median =50%, 5-10-25-75-95 centiles) of particulate Cu concentrations ($mg.kg^{-1}$) in surface sediment samples.

	Min	5%	25%	50%	75%	95%	Max	MGS
Whole estuary	1	2	14	25	31	37	42	-
Fluvial estuary	3	4	24	27	31	35	38	38
Central estuary	2	3	15	25	30	37	39	20
Downstream estuary	1	1	4	27	32	37	42	16

Particulate Cu concentations in surface sediments were highly variable (1.03-42.2 mg.kg^{-1}) through the estuary, without distinct differences in the different parts of the estuary (Table 1).

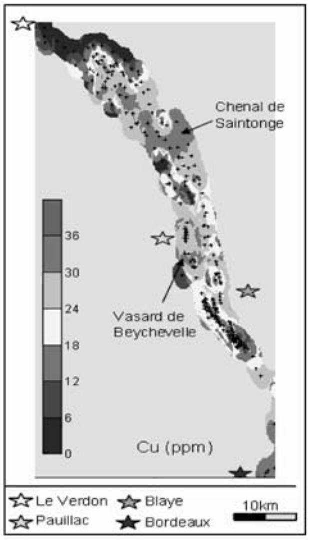


Figure 2. Spatial distribution of Cu (mg.kg^{-1})

Based on these 270 samples, the spatial distribution of particulate Cu in surface sediments suggests the existence of distinct zones with higher concentrations (Figure 2). These local differences were mainly explained by variations in grain size distribution: median grain sizes and total Cu concentrations were negatively correlated (r = - 0.93). Sieving is a commonly applied technique to control grain size effects in river sediment and soils (e.g. Horowitz, 1991). However, sieving (<63 μm) of the Gironde sediments only partially corrected the observed artefact: the <63 μm fraction still showed a clear dependence of Cu concentrations on grain size.

Normalization of Cu concentrations by Th concentrations (2-14 mg.kg^{-1}) allowed correcting for such grain size effects (Coynel et al, 2007). After Th-normalization, distinct zones with Cu anomalies were identified in the central and downstream reaches of the estuary. These anomalies may probably not be explained by fluvial inputs via the Garonne and Dordogne Rivers, suggesting the existence of intra-estuarine sources. According to observations in the fluvial watershed (Masson et al, 2006), important vine producing areas along the estuary might contribute to Cu anomalies in the estuarine sediments. This is coherent with results obtained for sediments in several small tributaries and canals adjacent to the estuary, draining vine producing areas (e.g. up to 100 mg.kg^{-1}).

Further work is going on to (i) increase spatial resolution of Cu concentrations in surface sediments, (ii) identify intra-estuarine sources and (iii) establish a historical record of Cu inputs into the Gironde estuary.

Conclusions

The first high resolution GIS-based map of Cu concentrations in the surface sediments of the Gironde estuary has shown important dependence of total particulate Cu concentrations on grain size. Sieving <63 μm did not completely compensate this effect. Thorium-normalization of Cu (metal) concentrations is efficient for the correction of grain size effects in estuarine sediments. The Th-normalized data suggests the existence of intra-estuarine sources that may clearly influence Cu concentrations in the central and downstream reaches of the Gironde estuary.

Acknowledgements

The authors thank the following colleagues for their contributions to field and laboratory work: C. Bossy, G. Lavaux, J.P. Lissalde, G. Chabaud, B. Clavé, and F. Scholz. The grain size anlyses were performed by the team "sédimentologie" UMR CNRS 5805 EPOC. This work was supported by grants from 'le Ministère de la Recherche', 'l'Agence de l'Eau Adour-Garonne' and the 'Région Aquitaine'. We thank the crew of the RV "Côtes de la Manche" (INSU) and the CIRMAT Committee.

References

Audry, S., Blanc, G., Schäfer, J., Chaillou G., Robert, S ; 2006. Early diagenesis of trace metals (Cd, Cu, Co, Ni, U, Mo, and V) in the freshwater reaches of a macrotidal estuary. Geochimica et Cosmochimica Acta 70, 2264–2282.

Audry, S., Blanc G., Schäfer, J., Guérin, F., Masson, M., Robert, S. Budgets of Mn, Cd and Cu in the macrotidal Gironde estuary (SW France). Marine Chemistry, In Press.

Baudrimont, M., Schäfer, J., Marie, V., Maury-Brachet, R., Bossy, C., Boudou, A., Blanc, G., 2005. Geochemical survey and metal bioaccumulation of three bivalve species (*Crassostrea gigas*, *Cerastoderma edule* and *Ruditapes philippinarum*) in the Nord Medoc salt marshes (Gironde estuary, France). Science of the Total Environment 337, 265– 280.

Claisse, D., 1989. Chemical contamination of French coasts : The Results of a Ten Years Mussel Watch. Marine Pollution Bulletin, 20, 523-528.

Coynel, A., Schäfer, J., Blanc, G., Bossy, C., 2007. Scenario of particulate trace metal and metalloid transport during a major flood event inferred from transient geochemical signals. Applied Geochemistry, 22 ,821-836.

Grousset, F.E., Jouanneau, J.M., Castaing, P., Lavaux, G., Latouche, C., 1999. A 70 year Record of Contamination from Industrial Activity Along the Garonne River and its Tributaries (SW France). Estuarine, Coastal and Shelf Science, 48, 401-414.

Horowitz, A.J., 1991. A primer on sediment-trace element chemistry. Chelsea, Lewis Publishing Co, 2nd edition, 136pp.

Jouanneau, J.M., Castaing, P., Crousset, F., Buat-Menard, P., Pedemay, P., 1999. Recording and chronology of a cadmium contamination by 137Cs in the Gironde estuary (SW France) C. R. Acad. Sci. Paris, Earth & Planetary Sciences, 329, 265-270.

Masson, M., Blanc, G., Schäfer, J., 2006. Geochemical signals and source contributions to heavy metal (Cd, Zn, Pb, Cu) fluxes into the Gironde Estuary via its major tributaries. Science of the Total Environment, 370, 133–146.

Schäfer, J., Blanc, G., 2002. Relationship between ore deposits in river catchments and geochemistry of suspended particulate matter from six rivers in southwest France. Science of The Total Environment. 298, 103-118.

Schäfer, J., Blanc, G., Lapaquellerie, Y., Maillet, N., Maneux, E., Etcheber, H., 2002. Ten-year observation of the Gironde tributary fluvial system: fluxes of suspended matter, particulate organic carbon and cadmium. Marine Chemistry. 79, 229–242.

Screening of PAH contamination in the Arcachon Bay.

Alexia Crespo[a], Hélène Budzinski*[a], Aurélia Moreau[a] and Karyn Le Menach[a]

Introduction

Arcachon bay is a middle-closed lagoon on the Atlantic coast of France, with strong ecological, fauna, and flora relevance; this is the 1st area producer of seed oyster in Europe, and the 3rd one of oyster in France. Quality assessment of the biotope of these benthic organisms becomes highly topical; actually shellfish farming have experienced some crisis (algal phycotoxines, chemical pollutions…), which have enhanced a lack of knowledge on the quality of this biotope.

PAHs are highly toxic pollutants, with carcinogenic properties for some of them, appointed as priority substances by the US-EPA. These organic compounds are highly lipophilic and have a strong affinity for particulate and organic matter in the water column, and for fatty tissues such as bivalve mantles. These characteristics make PAH studies a relevant part in the quality assessment of this lagoon.

PAHs are widespread and ubiquitous compounds, mainly released into the environment by pyrolitic processes involved in ship/car activity, home heating…Furthermore two huge oil spills have hit the Atlantic coast in the last decade (tankers Erika (1999) and Prestige (2002)), appreciable sources of petrogenic PAHs. Arcachon bay undergoes an increased anthropogenic pressure since the beginning of the century; as an exemple, pleasure boats increase around 200 unities during a year (around 25,000 registred- and 7500 anchored- boats).

The aim of this work was to document the environmental quality of Arcachon bay by assessing upper and deeper sediment PAH contamination and by identifying their sources. Because of their high hydrophobia, PAHs released into the environment are trapped to the sediment; sediments represent also a key compartment allowing to assess "historical contamination" and to get fingerprints of the chronic pollution.

Methods

Area sampling

Arcachon Bay is a 155 km² lagoon characterized by large intertidal sand and mud flats (74 %). Water masses are influenced by oceanic (semi-diurnal tide; 200-450 m^3/tidal cycle) and continental (1 x 10^6 m^3/year) inputs. Water renewal times are around 10 days (high flow) and 24 days (low flow).

Because of shell parks, marine vegetation and continental water flow decrease, the bottom of the lagoon and channels are continously silting up.

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Sediment collections

Archived sediments were used in a first step in order to draw a reference mapping of the PAH contamination in the bay; upper layer sediments (0-10 cm) of channels, cores (2 m) of five harbours (2001/2002, ORQUE) and beach sands (2003, after Prestige oil spill) were studied (Figure 1).

New collections have been realized in 2006/2007 and were focused mainly on inner-bay mud flat sediments, harbours and tributaries (figure 1).

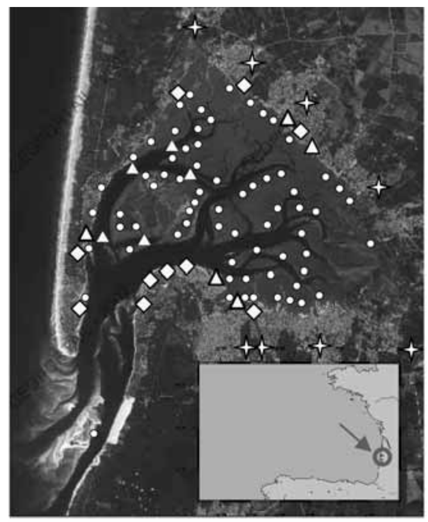

Figure 1: Sediments samples collected in 2001/2002 (triangle-shaped, harbour cores and superficial channels), 2003 (diamond-shaped) and 2007 (round-shaped, mud flats; star-shaped, tributaries).

Sediments were collected in aluminium containers and stored at -20°C until they were freeze dryied and sieved at 2 mm. PAHs were extracted with dichloromehtane by micro-wave assisted extraction (Maxidigest, PROLABO); the extracts were then purified with alumina and silica column and concentrated prior to GC-MS analysis (Letellier, 1998). 26 parent PAHs were quantified by the use of internal standards, and relative abondances of mono-, di-, tri- and tetra-alkylated PAHs were determined. PAH stable carbon isotope compositions (m/z=44, 45, 46) were determined in addition for some samples using gas chromatography coupled to isotope ratio mass spectometer (GC-IRMS).

Results and discussion

Overview on PAH contamination levels

Table 1 summarizes data obtained for sediment samples collected in 2001/2002, 2003 and 2006. PAH contamination on Arcachon bay is moderate. However some spots present higher levels (La Teste harbour, Courbey Channel, Bourg river). In these spots, concentrations of some compounds (benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene) exceed values of Effect Range Low (ERL; adverse effects can be observed occasionally) defined by Long et al. (1995).

Table 1. Sediment PAH contamination in the Arcachon Bay.

Area Sampling	Sediment PAH concentration (µg/g dw)	
Harbours		*Category and capacity of Harbours*
Arcachon	4.9	Pleasure Boats ; 2400
La teste	77.6	Fishering Boats
La Vigne	2.3	Pleasure Boats ; 300
Le Betey	5.0	Pleasure Boats ; 151
Arès	5.5	Fishering Boats
Fontainevieille	3.0	Pleasure Boats ; 180
Channels		
Ile	0.01-3.80	Sands to sandy-muds
Courbey	0.02-8.8	
Piquey	0.01-1.50	
Arès	0.02-2.30	
Beaches		
Arguin	0.003	Sands
Petit Nice	0.05	
La Chapelle	0.001	
Mimbeau	0.1	
Lanton	0.1	
Tributaries		
Craste de Nézer	0.4	Sandy-muds
Canal des Landes	0.5	
Bourg	3.1	
Leyre	0.5	
Lanton	0.01	
Betey	0.9	
Canal des Etangs	0.1	

Identification of sources

Molecular and isotopic markers have been used in order to distinguish pyrolitic sources from petrogenic ones. Figure 2 describes isomer ratios (Phe/An, Fluo/Pyr, C1-Chrys/Chrys and C1-Phe/Phe) determined in harbour, channel and tributary samples.

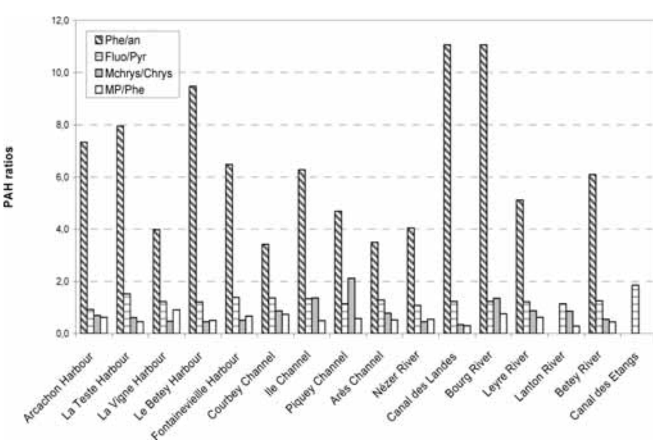

Figure 2. Use of isomer ratios for the identification of PAH sources in sediments of harbours, channels and tributaries.

These ratios show that PAH contamination is mainly due to pyrolitic processes; however, some petrogenic traces can be observed in two rivers (Canal des Landes, Bourg River; Phe/An >10) and in some layers of harbour cores (data not shown).

Individual PAH stable carbon isotope compositions of some layers of a harbour core are presented in Figure 3.

$\delta\ ^{13}C$ (‰)

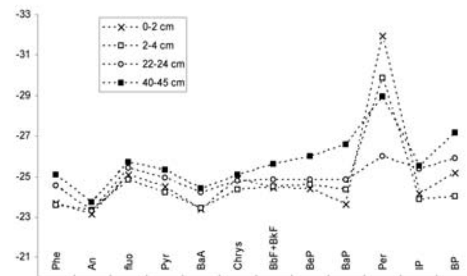

Figure 3. Individual PAH stable carbon isotope ratio analysis on harbour cores (4 layers of La Teste core are presented here).

These data show that most of the PAHs have stable carbon isotope near to -25 ‰, confirming pyrolitic origins (O'Malley et al., 1994). But perylene presents distinct ratio and is clearly depleted in ^{13}C ($\delta\ ^{13}C$ between 29 and 32 ‰), suggesting that it is issued from a different origin. It may be issued from microbial reworking of organic matter (Kim et al., 2008).

Acknowledgements

The authors thank IFREMER (LER/Arcachon) for their advices and help, and ORQUE for providing channel and harbour samples (2001/2002).

References

Kim, M., Kennicutt II, M.C., Qian, Y., 2008. Source characterization usiong compound composition and stable isotope ratio of PAHs in sediments from lakes, harbor, and shipping waterway. Science of The TotalEnvironment,389,367-377.

Letellier, M., H. Budzinski, J. Bellocq, J. Connan, 1999. Focused microwave-assisted extraction of polycyclic aromatic hydrocarbons and alkanes from sediments and source rocks. *Organic geochemistry*, 30: 1353-1365.

Long , E.R., MacDonald, D.D, Smith, S.L., Calder, F.D., 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Envrion. Management*, 19, 81-97.

O'Malley, V.P., Abrajano, T.A., Hellou, J., 1994. Determination of the $^{13}C/^{12}C$ ratios of individual PAH from environmental samples: can PAH sources be apportioned. *Organic Geochemistry* 21 (6/7), 809–822.

Wang, Z., Fingas, M., Shu, Y.Y., Sigouin, L., Landriault, M., Lambert, P., 1999. Quantitative Characterization of PAHs in Burn Residue and Soot Samples and Differentiation of Pyrogenic PAHs from Petrogenic PAHs-The 1994 Mobile Burn Study. *Environ. Sci. Technol*.33,3100-3109.

It is possible to classify different trace metal distribution in molluscs along the Bay of Biscay?

Luis Bartolomé,*[a] Juan Carlos Raposo [a], Patricia Navarro [a], Manu Soto,[b] Olatz Zuloaga,[a] and Nestor Etxebarria [a]

Introduction

Marine organisms can take up contaminants from bottom sediments, suspended particulate material, water-column and food-sources (Varanasi et al., 1992; Livingstone, 1993). The incorporation rate depends not only on the availability of the contaminants, but also on several biotic and abiotic factors. In this context, biomonitoring constitutes a good alternative or complement to chemical systems for pollution assessment. Mussels (*Mytilus galloprovincialis*) and limpets (*Patella vulgata*) are very suitable for biomonitoring of the sea environment (Khadim, 1990). Despite the importance of the previous results, few studies of the heavy metal contents in mussel and limpet tissues have been carried out to date in the Bay of Biscay (Puente et al., 1996, Soto and Marigomez, 1997, Besada et al., 2002, Franco et al., 2002). The main aim of this work was to classify different areas along the Bay of Biscay taking into account their metal content and distribution in molluscs by means of principal component analysis (PCA). In addition, temporal analysis of the results were carried out according to the Mann-Kendall correlation coefficient (Hollander et al., 1999)..

Methods

Data matrix

The sampling points were located in the northwest Iberian Peninsula, from Galicia to the Basque Country (Figure 1) for mussels and in the Basque coast from Kobaron to Jaizkibel for limpets. Individuals were collected from February 2004 to April 2006.

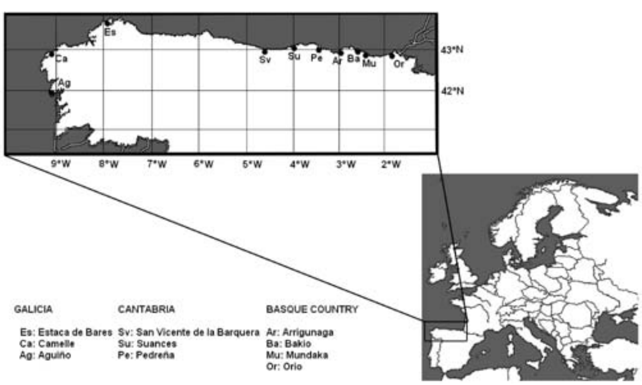

Figure 1. Map of the Gulf of Biscay showing the 10 sampling sites for mussels.

Mussels were collected from the same sampling point, immersed 100 mm of river-bed surface, rinsed with the natural water, introduced into plastic bags and frozen until sample preparation. Limpets were collected, identified, rinsed with natural water, wrapped in tinfoil, placed in a plastic bag and frozen until analisys. Frozen mussel and limpet samples were freeze-dried at 0.1 mbar and – 48ºC in a Cryodos T-50 (Telstar, Barcelona, Spain) system. Samples were ground in a Pulverisette 6 ball mill (Fristch, Quebec, Canada) and kept in the refrigerator at 4ºC until analysis. Then, 0.2 g of this material was accurately weighed and transferred into the extraction vessel together with 15 mL HNO_3 (7.0% v/v). The extraction vessel was placed in the microwave oven and the digestion program was run (power = 450 W, time = 18 min, magnetic stirring). All the acid extracts were filtered through Millex HV PVDF 0.45μm filters (Millipore, Carrigtwohill, Co. Cork, Ireland) and diluted to 25 mL with Milli Q water. All samples and standards were prepared in 1% HNO_3 medium before measurement by ICP-MS. This analytical procedure was optimized based on a previous work (Navarro et al., 2006).

Results and discussion

The PCA seemed to be useful to group different areas along the Bay of Biscay according to their spatial position. Each group was characterized by one or various metals (Figure 2). After this study a deep analysis of the samples was performed and it could be clearly seen how samples from some locations were clustered (Figure 3). In some cases (Arrigunaga, Suances, Estaca de Bares) the stations were related with a singular metal distribution (Cd and Mn, Pb and Co respectively) and, in this way, a classification of the Bay of Biscay in terms of metal content and distribution could be accomplished. The same treatment was carried out with the samples of each geographical location and a closer structure of the data can be observed.

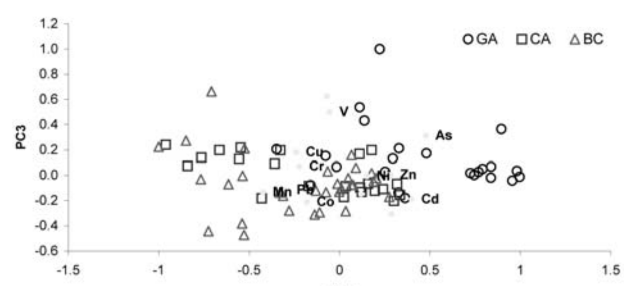

Figure 2. Principal Components Analysis plots: (PC2/PC3) with the different sampling regions: Galicia (Ga), Cantabria (Ca) and the Basque Country (BC).

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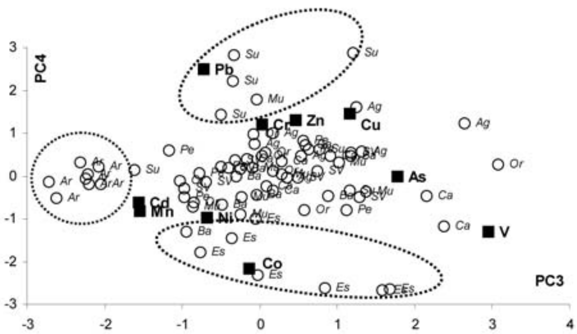

Figure 3. Principal Components Analysis plot: (PC3/PC4) with each sampling stations.

Acknowledgements

This work has been financially supported by the Basque Government through the ETORTEK-IMPRES project.

References

Besada V., Fumega J. and Vaamonde A., 2002. Temporal trends of Cd, Cu, Hg, Pb and Zn in mussel (Mytilus galloprovincialis) from the Spanish North-atlantic coast 1991-1999. Sci. Total Environ., 288: 239-253.

Franco J., Borja A., Solaun O. and Pérez V., 2002. Heavy metals in mollusc from the Basque country (Northen Spain): results from an 11-years monitoring programme. Mar. Pollut. Bull., 44: 956-976.

Hollander M., Myles Wolfe D.A. and Douglas A., 1999. Non-parametric statistical methods. John Willey and Sons Inc., New York.

Khadim M.A., 1990. Methodologies for monitoring the genetic effects of mutagens and carcinogens accumulated in the body of marine mussels. Rev. Aquat. Sci., 2: 83–107.

Livingstone D.R., 1993. Biotechnology and pollution monitoring: use of molecular biomarkers in the aquatic environment. J. Chem. Technol. Biot., 57: 195– 211.

Navarro P., Raposo J.C., Arana G. and Etxebarria N., 2006. Optimisation of microwave assisted digestion of sediments and determination of Sn and Hg. Anal. Chim. Acta, 566: 37-44.

Puente X., Villares R., Carral E. and Carballeira A., 1996. Nacreous shell of Mytillus galloprovincialis as a biomonitor of heavy metal pollution in Galicia (NW Spain). Sci. Total Environ., 183: 205-211.

Soto M. and Marigomez I. 1997. Metal bioavailability assessment in “Mussel-Watch” programmes by automated image analyisis of BSD in digestive cell lysosomes. Mar. Ecol. Prog. Ser. 156: 141-150.

Varanasi U., Stein J.E., Reichert W.I., Tilbury K.L., Krahn M.M. and Chan S.L., 1992. Chlorinated and aromatic hydrocarbons in bottom sediments, fish and marine mammals in US coastal waters: laboratory and field studies of metabolism and accumulation. In: Walker C.H. and Livingstone D.R. (Eds.), Persistent pollutants in marine ecosystems. SETAC Special Publication. Pergamon Press, Oxford, pp. 83–115.

Screening of PAHs, PCBs, MeHg$^+$ and Butyltins in sediments and oysters (*Crassostrea sps.*) in the estuary of Urdaibai

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Polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), methylmercury (MeHg$^+$) and butyltins (BTs, mono-, di- and trisubstituted) were monitored in the estuary of Urdaibai (Gulf of Biscay) in sediments and oysters (*Crassostrea sps.*) collected from January 2006 to June 2007 every three months.

In the case of of PAHs were in the range of 856-3495 µg/Kg 264-1789 µg/Kg for sediments and biota, respectively. In the case of PCBs the concentrations ranges between 58-220 µg/Kg 50-250 µg/Kg for sediments and biota, respectively. Finally, in the case of organometallic species, they were only measurable in biota samples and concentrations between 75-200 µg/Kg 400-1300 µg/Kg were observed for MeHg$^+$ and BTs, respectively.

No correlation between the total organic carbon (TOC) and the lipid content of sediments and biota, respectively, and the concntrations of organic and organometallic species was found and, thus, no normalization of the concentrations was performed.

Discussion on the possible contamination sources and possible cycles of the analytes in the estuary was performed.

Introduction

The Water Framework Directive (WFD, 2000/60) is probably the most important international legislation introduced for many years in the water sample field. This Directive considers the water management in a wide manner, looking for the prevention of any future deterioration of water bodies, as well as protecting and improving the state of marine ecosystems, in order to obtain “a good state” of water bodies. Therefore, it is very likely that its implementation will have its consequences in terms of the intensification of monitoring activities and an increase in the control of pollutants (Coquery *et al.*, 2005). The 16th article of the directive establishes a list of 33 priority chemical substances that represent a significant risk for and through the aquatic media in the European Union. Most of the analytes in the list are organic pollutants (hydrocarbons, organochlorine compounds, organic solvents, pesticides and chlorophenol), although four toxic metals (mercury, nickel, cadmium and lead) and one organometallic compound (tributyltin, TBT).

According to the WFD, the good state of the aquatic bodies is obtained when the concentrations of the priority substances in water, sediments and biota are below the established Environmental Quality Standards (EQSs), which have only been fixed for water. All the Member States should implement management plans in their river basins, which include monitoring programmes.

The estuary of Urdaibai (Bay of Biscay, northern Spain), and almost the whole basin of the Oka river, is a natural Unesco reserve of the biosphere since 1984. This estuary is a unique habitat for many species (birds, fishes, amphibious, etc.) and in addition to the ecological richness there are urban inputs, especially from the village of Gernika (20,000 inhabitants), and industrial, fisheries and leisure activities that have to be considered (Madariaga, 1995). As a consequence of those features, considerable efforts are taken in order to monitor and minimise any anthropogenic harm on the environment.

In this work polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), methylmercury (MeHg$^+$) and butyltins (BTs, mono-, di- and trisubstituted) were monitored in the estuary of Urdaibai (Gulf of Biscay) in sediments and oysters (*Crassostrea sps.*) collected from January 2006 to June 2007 every three months.

Methods

Samples were collected from 6 stations along the estuary: Gernika (2 locations), Arteaga, Kanala, Murueta and Sukarrieta. From the stations located in Gernika only sediments were taken since no oysters are found in these locations. All the sampling was done at low tide.

Sediment samples were collected manually from the superficial sediment, stored in pre-cleaned flasks (10% (v/v) nitric acid bath for 24 hours and dried at 110°C overnight, 1 mL of formaldehyde 4% was added to avoid bacterial growing. Oyster samples were collected close to the water line, rinsed with natural water and introduced into plastic bags. All the samples were transported in cooled boxes to the laboratory.

Sediment samples were frozen (-20°C) and freeze-dried at low temperatures (-46/-52°C) and pressures (0.17/0.22 mbar) in a Cryodos-50 apparatus (Telstar, Spain). Freeze-dried samples were sieved at different particle sizes (PS) (PS < 63 µm, 63 µm < PS < 250 µm and PS > 250 µm). Only the smallest two fractions were analysed. Samples were kept in the fridge at 4ºC until analysis.

The individual oysters were dissected with a clean scalpel blade to separate the soft tissues from the shells. Around twenty individuals were dissected out, frozen, homogenised and freeze-dried as explained above. Freeze-dried samples were ground in a ball mill and kept in the fridge at 4ºC until analysis.

The analysis of PAHs and PCBs in sediments and biota

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and organometallic species in biota were performed according to different procedures optimised before in our laboratories (Bartolomé *et al.*, 2005; Navarro *et al.*, 2006; Zabaljauregui *et al.* 2007).

Results and Discussion

Concentrations in the range of 856-3495 μg/Kg 856-3495 μg/Kg were found for PAHs and PCBs in sediments. In the case of biota the concentrations ranged between 264-1789 μg/Kg 50-250 μg/Kg for PAHs and PCBs, respectively. Finally, in the case of organometallic species, they were only measurable in biota samples and concentrations between 75-200 μg/Kg 400-1300 μg/Kg were observed for $MeHg^+$ and BTs, respectively.

In the case of sediments no significant correlation was found between the total organic carbon (TOC) and concentartions of PAHs (R^2=-0.02) and PCBs (R^2=0.05). Similarly, no significant correlations were found between the concentrations of organometallic and organic species and the lipid content. Thus, in none of those cases normalization of the concentrations was performed.

In the case of both biota and sediment samples, most samples presented a combustion source for PAHs (see Figure 1) and PCBs with 4 to 6 chlorine atoms were the most abundant. In general, tributyltin (TBT) was the most abundant BT in biota, followed by dibutyltin (DBT) and monobutyltin (MBT).

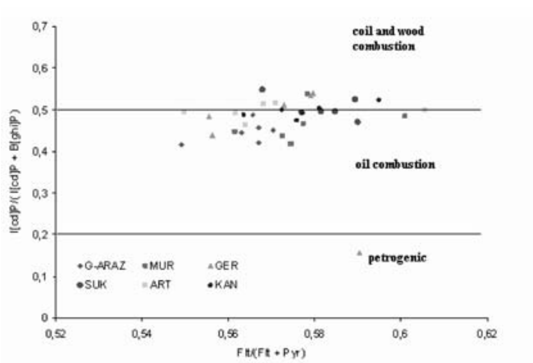

Figure 1 I[cd]P/(I[cd]P+B[ghi]P) vs Flt/(Flt+Pyr) for the determination of PAH source in sediments.

In the case of sediment samples, ERL (effects range low) and ERM (effects range medium) values established by the NOAA (National and Oceanic and Atmospheric Admisnistration) were used to discuss the quality of samples from Urdaibai. When total concentartions of PAHs were studied all sediment samples showed valued lower that ERL. However, when PAHs were divided in low (LPAHs) and high (HPAH) mass PAHsthe ERL values were exceeded in some samples. In the case of PCBs, all samples exceeded the ERL value established for this family (see Figure 2). In the case of biota sample, concentartions in the oysters of Urdaibai for PAHs and PCBs did not exceed the maximum values established by the NOAA in the “Mussel Watch project”. In the case of BT, the concentartions found in oyster of Urdaibai exceeded the NOAA citeria.

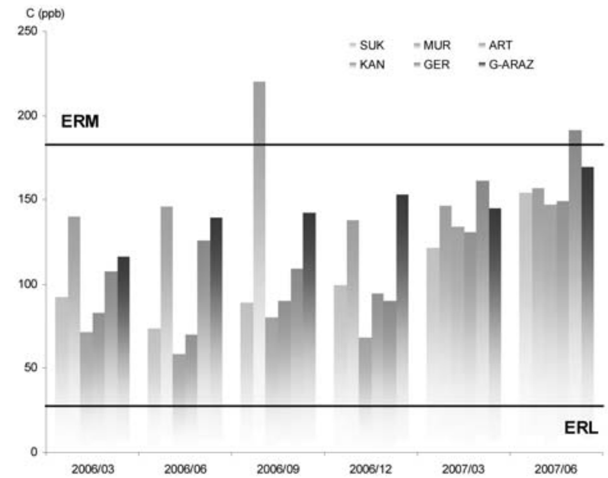

Figure 2 Comparison of the total concentration of PCBs versus the ERL and ERM values in sediments.

Acknowledgements

This project has been financially supported by the University of the Basque Country through the UNESCO 05/12 project.

References

Bartolomé L., Cortazar E., Raposo J.C., Usobiaga A., Zuloaga O., Etxebarria N., Fernández L.A., 2005. Simultaneous microwave-assisted extraction of polycyclic aromatic hydrocarbons, polychlorinated biphenyls, phthalate esters and nonylphenols in sediments. *Journal of Chromatography A* 1068:229-236.

Coquery M., Morin A., Bécue A., Lepot B., 2005. Priority substances of the Eurpean Water Framwork Directive: analytical challenges in monitoring water quality. *Tends in Analytical Chemistry*, 24:117-127.

Madariaga I., 1995. Photosynthetic characteristics of phytoplankton during the development of a summer bloom in the Urdaibai estuary, Bay of Biscay. *Estuarine and Coastal Shelf Science*, 40: 559-575.

Navarro P., Cortazar E., Bartolomé L., Deusto M., Raposo J.C., Zuloaga O., Arana G., Etxebarria N. 2006. Comparison of solid phase extraction and gel permeation chromatography for the clean-up of microwave-assisted biological extracts in the analysis of polycyclic aromatic hydrocarbons. *Journal of Chromatography A* 1128:10-16.

Zabaljauregui M., Delgado A., Usobiaga A., Zuloaga O., De Diego A., Madariaga J.M., 2007. Fast method for routine simultaneous analysis of methylmercury and butyltins in seafood. *Journal of Chromatography A* 1148:78-85.

Long-term morphological and stratigraphical evolutions of estuaries: Comparison between the Marennes-Oléron bay and the Arcachon lagoon

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Introduction

Estuaries are a sink for sediment and their infill represent a threat for human activities like shell farming, tourism, navigation and for their ecological importance in terms of habitat, nursery, productivity, water filtration and flood control. Hence the long-term sedimentary evolution of estuaries is of great interest. Estuaries are usually grouped into one of two types, wave-dominated and tide-dominated. In terms of geomorphology, tide-dominated estuaries show a typical funnel shape and elongated tidal sand bars in the estuary mouth area, like in the Marennes-Oléron Bay. Wave-dominated estuaries are characterized by a shore-parallel barrier and a shoal located in the estuary mouth area, like in the Arcachon Lagoon.

Numerous factors governs the sediment-fill of estuaries. They include natural factors (sea level variations, vertical crustal motions, sediment supply, climate and hydrodynamics processes including waves and tides) ; and also human activities (land reclamation, shell farming, dredging, etc…). Consequently it is difficult to differentiate the respective influence of each factors. One way to explore this issue is to compare estuaries that belong to the same basin. The purpose of this study is to compare two estuarine environments (the Marennes-Oléron Bay and the Arcachon Lagoon), belonging to the Bay of Biscay and that are close together, implying they have experienced similar sea-level changes, vertical crustal motions, and climate changes. Hence observed differences should result from hydrodynamics processes, sediment supply and human activities.

Methods

Methods deployed in this study consisted of bathymetry, seismic profiling and core sampling.

Bathymetry

Two successive bathymetric surveys were used to demonstrate the long-term morphological evolution of those estuarine environments. They were obtained in 1865 and 1993 for the Arcachon Lagoon (L'yvanc, 1995) and in 1824 (Bertin et al., 2005) and 2003 for the Marennes-Oléron Bay.

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Seismic Profiling

New seismic surveys (MOBIDYC4 in 2003, MOB in 2005 and LSTULR6 in 2006 for the Marennes-Oléron Bay and ARCA1, 2 and 3 in 2006 and 2007 for the Arcachon Lagoon) using a very high resolution profiler (IKB Seistec) were conducted to image the detailed stratigraphy of those estuaries and to make correlations with vibracore results.

Coring

Cores were collected along seismic profiles in the case of the Marennes-Oléron Bay (MOBIDYC3 and MOBIDYC5 respectively in 2002 and 2006). Cores used for the Arcachon Lagoon were collected before seismic profiling (Féniès, 1984), hence in this case, seismic profiles were shot along core positions. Correlation between seismic and sedimentological data was done on the basis of a depth-to-time conversion of the core datasets (Billeaud et al., 2005).

Results

A positive and a negative sedimentary budget

Bathymetric evolutions whithin the Marennes-Oléron Bay between 1824 and 2003 clearly show a positive sediment budget estimated to + 75.10^6 m^3; as bathymetric evolutions within the Arcachon Lagoon show a negative sediment budget estimated to - 11.10^6 m^3. In terms of bathymetric evolutions, the Marennes-Oléron Bay can be subdivided in two main domains: (1) a northern domain where sediment accretion occurs in both the intertidal (mud and mixed sand-and-mud flats; sandbanks) and subtidal (sandy and muddy tidal channels) areas; (2) a southern domain where sediment accretion mainly occurs within inter tidal areas (sand and mixed sand-and-mud flats) as erosion occurs within tidal channels. Bathymetric evolutions in the Arcachon Lagoon show that sediment gain mainly occurs within inter tidal areas and in northwest-southeast oriented channels; as erosion occurs in tidal channels located close to the tidal inlet.

Two surprisingly different stratigraphical organisations

Seismic profiles combined with cores show that the upper sediment-fill of the Marennes-Oléron Bay is dominated by (1) a few meters-thick mud drape, deposited since 1000 yr BP over sandy or mixed-sand-and-mud sediment bodies (2) sand banks. This mud drape is believed to record an increase in suspended matter mainly due to deforestation during the midle age period, and expulsion of suspended matter from nearby estuaries, in response to both their natural filling and land reclamation (Billeaud et al; 2005 ; Chaumillon et al., 2004). In the Arcachon

Lagoon, the upper sediment-fill is dominated by tidal channel-fills associated with a mixed sand-and-mud drape deposited mainly deposited since 2500 yr BP. This sediment-fill records a counter clockwise rotation of tidal channels in response the closure of the Arcachon Lagoon following the Cap Ferret Sandspit development (Féniès, 1984 ; Faugères et al., 1986).

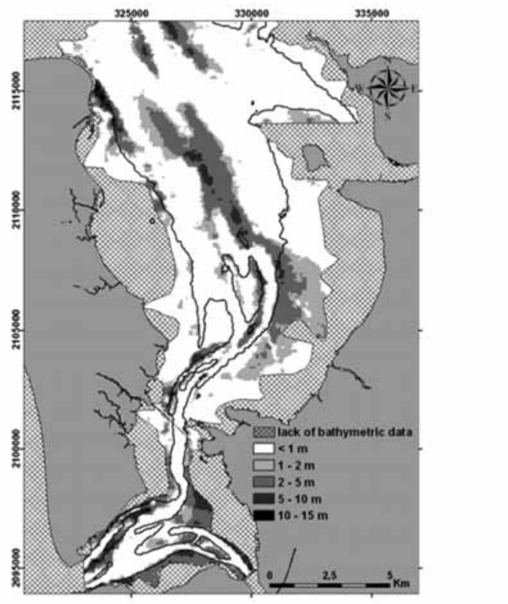

Figure 1 – Sediment gain map between 1824 and 2004 in the Marennes-Oléron Bay. The 0 m contour line contour (in black) has been superimposed.

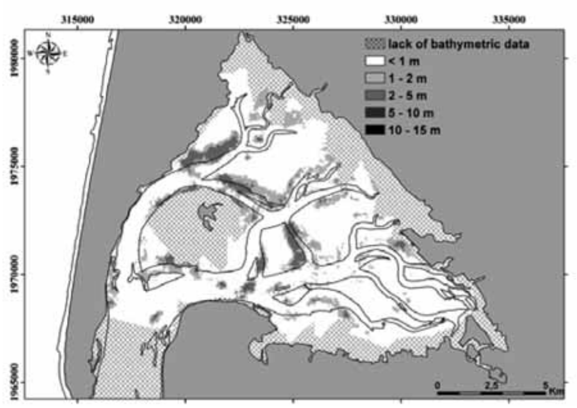

Figure 2 – Sediment gain map between 1824 and 2004 in the Arcachon Lagoon. The 0 m contour line (in black) has been superimposed.

Discussion

This study evidences strong differences in terms of both bathymetric evolutions and stratigraphical organisation for two close estuarine environments belonging to the Bay of Biscay. Stratigraphical differences between the Marennes-Oléron Bay and the Arcachon Lagoon can be mainly explained by differences in terms of sediment supply and hydrodynamics. Suspended matter supply in the Marennes-Oléron Bay is more important because this bay receives sediments from both local rivers and the Gironde estuary (Castaing 1981). Hence the Marennes-Oléron Bay has been largely influenced by deforestation and expulsion of suspended matter in response to estuaries infill. In the case of Arcachon Lagoon , waves and related littoral drift are more important and have induced a rapid closure of this lagoon that has induced a drastic change of the tidal channel framework (Féniès, 1984; Faugères et al., 1096).

Sedimentary budget for the last centuries show that the Marennes-Oléron Bay experienced a rapid sediment-fill Bay as the Arcachon Lagoon seemed to be in equilibrium. Such differences can be explained by morphological and human impact differences. In terms of morphology, the Marennes-Oléron Bay is a tide-dominated estuary as the Arcachon Lagoon is wave dominated estuary. Consequently, the connections with the open ocean are larger in the case of the Marennes-Oléron Bay compared to the Arcachon Lagoon. This leads to larger marine sediment supply to the Marennes-Oléron and larger sediment infill. The rapid sediment-fill of the Marennes-Oléron Bay can also be explained by a larger influence of human activities. Hence shell farms that lead to an increase in sedimentation rate (Sornin, 1981) corresponds to 19% of the total surface area of the in the Marennes-Oléron Bay as it only corresponds to 6% the total surface area of the Arcachon Lagoon.

Acknowledgements

This study has been partly supported by the Programme National Environement Côtier (PNEC) entilted “Chantier littoral Atlantique”. We thank IFREMER and SHOM to provide us bathymetric data.

References

Bertin X., Chaumillon E., Sottolichio, A. and Pedreros, A. 2005. Tidal inlet response to sediment infilling of the associated bay and possible implications of human activities: The Marennes-Oléron Bay and Maumusson Inlet, France. Continental Shelf Research, Volume 25, Issue 9, 1115-1131.

Billeaud, I., Chaumillon, E. & Weber, O., 2005. Correlation between VHR seismic profiles and cores evidences a major environmental change recorded in a macrotidal bay. Geomarine letters, 25, 1-10.

Castaing, P., 1981. Le transfert à l’océan des suspension estuariennes. Cas de la Gironde. Unpublished Thesis, Univ. Bordeaux I, France, 530 pp.

Chaumillon, E., Tessier, B., Weber, N., Tesson, M., & Bertin, X.., 2004. Buried Sandbodies within Present-Day Estuaries (Atlantic Coast of France) Revealed by Very High Resolution Seismic Surveys. Marine Geology, 211, 189-214.

Faugères, J.-C., Cuignon, R., Féniès, H., and Gayet, J., 1986. Caractères et facteurs d’un comblement littoral à l’Holocène supérieur : passage d’un domaine estuarien à un domaine lagunaire (bassin d’Arcachon, France). Bull. Inst. Géol. Bassin d’Aquitaine, Bordeaux, n°39, 95-116.

L’hyavanc, J., 1995. Evolution bathymétrique et morphologique du Bassin d’Arcachon. Rapport interne IFREMER pour l’etude intégrée du Bassin d’Arcachon. 82 p.

Sornin, J.M., 1981. Processus sédimentaires et biodéposition liés à différents modes de conchyliculture-Baie de Cancale, Anse de l’Aiguillon et Bassin de Marennes-Oléron. Unpublished Ph.D. Thesis, University of Nantes, France.

A high marsh transfer function for sea-level reconstructions in the southern Bay of Biscay.

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Introduction

Current concerns regarding global sea-level rise associated with anthropogenic warming of the atmosphere and oceans and its impacts on coastal resources have increased the interest on past sea-level changes. The mean global rate of sea-level (RSL) rise has been estimated at ~1.8 mm yr^{-1} for the last century (Holgate, 2007). Since 1993, satellite altimetry data provide estimates of ~3 mm yr^{-1} (Leuliette *et al*., 2004). It is not clear yet whether the recent sea-level acceleration represents a change in the long-term trend or reflects decadal variability (Bindoff *et al*., 2007). Various authors estimate that sea level reached modern rates approximately at 1850 (Douglas, 2001), around the end of the 19th century (Jevrejeva *et al*., 2006), during the 1920s (Peltier and Tushingham, 1989), or 1935 (Church and White, 2006). Some studies have even proposed decelerations within the 20th century (Woodworth, 1990). Instrumental records of sea-level change are generally too short and provide insufficient spatial coverage to give definitive answers to this debate.

Recent geological-based research offers great potential to supplement the temporal and spatial global database of instrumental (tide-gauge) observations of sea-level change. Proxy records from salt marshes around the North Atlantic Ocean have provided the first indications that modern rates of sea-level rise (last ~100 years) in this region may be more rapid than the rate of rise in preceding centuries, and that the timing of this acceleration may be indicative of a link with human-induced climate change (Gehrels *et al*., 2005; 2006). So far, these high resolution sea-level reconstructions have only come from the western and northern margins of the North Atlantic. Because multi-decadal patterns of sea-level change are spatially highly variable across the globe, it is important to obtain comparable sea-level reconstructions from other regions. This study aims to provide high-resolution sea-level data from the eastern Atlantic to examine the issue of recent changes in the RSL rise. The model here proposed will increase the precision of the sea-level reconstructions and it will improve the time resolution for the last 200 years based on foraminiferal transfer functions from high marsh sediments.

Marshes in Basque coast are few and fragmentary. They are restricted to the inner parts of the small estuaries that sporadically interrupt the continuous cliffs that characterize this coastal area. Marsh reclamation for agricultural and disease-eradication purposes was initiated in the 17th century, and was particularly intense since the second half of the 19th century. However, during the last few decades agriculture has been in decline and previous cultivated areas have been abandoned. The lack of dyke maintenance has allowed tidal estuarine water to invade these once artificially isolated areas and, consequently, halophytic vegetation is rapidly recolonizing them. All study sites come from estuaries (Barbadun, Plentzia and Urdaibai) with similar mesotidal ranges (2.5 m).

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Materials and Methods

We collected 73 surface sediment samples and six 50cm-sediment cores for micropalaeontological analysis in the Muskiz, Isuskiza, Ostrada, Txipio, Mape and Axpe-Busturia marshes. Sampling sites were chosen as representative of different marsh subenvironments in terms of elevation above mean sea level and distance from the main estuarine channel, including different vegetated and unvegetated areas. We measured topographic elevation for all modern samples and cores and this information is presented relative to the local ordnance datum. Tidal inundation frequency at each study area was calculated and compared with the closest tide gauge, and elevations relative to Mean Higher High Water (MHHW) were standardized. Hence, the elevations are expressed as a standardized water level index (SWLI). Microfossil, geochemical, ^{210}Pb, and ^{137}Cs data have been obtained from these samples. Description of sample preparation and analysis is presented in Cearreta *et al*. (2002).

Results

Detrended Cannonical Correspondence Analysis of the training set with SWLI as the only environmental variable has produced a gradient length of 3.38. This indicates a unimodal nature of the foraminiferal abundance data with respect to SWLI. Thus, we used a unimodal-based method of regression and calibration, known as weighted averaging partial least squares (WA-PLS). The WA-PLS transfer function produces results for five components. The choice of component depends upon the prediction statistics (RMSEP and r^2) and the principle of parsimony, i.e. choosing the lowest that gives an acceptable model. Using component three, the relationship between observed and tidal foraminiferal-predicted elevation was very strong, a result that illustrated the robust performance of the WA-PLS transfer function (r^2_{jack}=0.76). These results indicated that reconstructions of former sea levels are possible ($RMSEP_{jack}$=12.5).

We have further explored possible models that reconstruct palaeomarsh surface elevation. Model 2 uses only foraminiferal species typical from marsh environments, while Model 3 uses samples above a standardized water-level index of 160, thus removing lower elevation samples. Model 2 performs significantly better (component 1; r^2_{jack} =0.81; RMSEP$_{jack}$=11.6) as a result of including only species that respond to elevation, reducing therefore the noise of the dataset. Model 3 has low RMSEP (component 3; 7.5) but also low r^2_{jack} (component 2; 0.75) because of the lower number of samples and the reduced length of the elevational gradient.

The precision of this transfer functions is comparable to other foraminifera-based transfer functions from the northern Atlantic Ocean. Following back transformation of the SWLI values, Models 1, 2 and 3 have a precision of ±0.19 m, ±0.18 m and ±0.11 m, respectively.

Discussion

Recent sedimentation trends (ca. 1850AD to present) typically employ shorter-lived radionuclides (^{210}Pb, ^{137}Cs). The activity of ^{210}Pb in each sediment layer declines with its age due to radioactive decay. Based on ^{210}Pb half-live (22.3 years), this technique is restricted to the last 120 years. ^{137}Cs and Pb concentrations are then used to increase the reliability of the age model generated by ^{210}Pb-calculated sedimentation rates. There is an excellent agreement between all three methods, and therefore, we have used their sedimentation rates-derived ages in the sea-level reconstruction. Preliminary results based on regression analysis through the mid-point of the reconstruction provides a general trend of 2.4±0.4 mm yr^{-1} for the period 1884-1997 with none or little variation during the 19th century. However, we have to consider the full vertical errors derived from the reconstruction, and therefore the error introduced into the calculated trend (±78 mm), and the restriction in the interpretation of the 19th century sea-level reconstruction derived from the low number of sea-level index points and their large temporal errors. On the other hand, the Santander tide gauge provides a trend of 2.18±0.41 mm yr^{-1} for the period 1944-2001, supporting our reconstruction. This is a very similar pattern to that of the tide-gauge record at Brest (France). These results seem to imply none or little variation of the sea-level during the 19th century in the Bay of Biscay with a sea-level rise of 22 ± 4 cm during the 20th century in the southeastern area.

The likely increase in the rate of sea-level rise at the change of centuries is roughly coincident with the temperature increase during the 20th century (Bindoff *et al*., 2007). This is also coincident with the onset of rapid recent sea-level rise reported for northeastern North America occurring between 1880 and 1920 (Donnelly *et al*., 2004). The similar timing for the onset of the recent sea-level rise at both sides of the (north)Atlantic Ocean signals the global significance of this sea-level acceleration. The different rates of sea-level rise detected could be related to the different characteristics of the water masses and the influence of the North Atlantic Oscillation (Gehrels *et al*., 2006).

Conclusions

Whilst accelerated rates of global relative sea-level rise are potentially one of the most devastating impacts of future climate change, our understanding of multi-decadal climate-ocean relationships is poor. This contribution seeks to address this knowledge gap by combining tide gauge and high-precision foraminifera-based transfer function reconstructions of RSL. We have produced three transfer functions with a precision of between 0.19 m and 0.11 m. We placed the foraminifera-based prediction of palaeomarsh elevation into a temporal framework through the ^{137}Cs, Pb concentrations, and ^{210}Pb-derived sediment accumulation rates. The resulting relative sea-level reconstructions imply a sea-level rise for the 20th century of 22 ± 4 cm, which is in general agreement with the local tide-gauge records and the long-term regional gauge from Brest. In a region where sea-level data are very scarce even for the second half of the 20th century, this study offers an alternative method to reconstruct former sea levels at centimetre-to-metre vertical resolution scale and decadal-to-centennial age resolution scale.

Acknowledgements

E. Leorri was supported by a postdoctoral grant from the Basque Government and by the Conseil Général of the Vendée (F). This work has been partially funded by the UNESCO06/08 and IT-332-07/GIU06-10 research contracts and it represents a contribution to IGCP project #495.

References

Bindoff, N.L. et al., 2007. Observations: Oceanic Climate Change and Sea Level. Solomon, S. et al. (eds). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC.* Cambridge University Press.

Cazenave, A. and Nerem, R.S., 2004. Present-day sea level change: Observations and causes, *Review of Geophysics,* 42: 1-20.

Cearreta, A., Irabien, M.J., Ulibarri, I., Yusta, I., Croudace, I.W., Cundy, A.B., 2002. Recent salt marsh development and natural regeneration of reclaimed areas in the Plentzia estuary, N. Spain. *Estuarine Coastal and Shelf Science,* 54: 863-886.

Church, J.A. and White, N.J., 2006. A 20th century acceleration in global sea-level rise. *Geophysical Research Letters,* 33, L01602.

Donnelly, J.P., Cleary, P., Newby, P. and Ettinger, R., 2004. Coupling instrumental and geological records of sea-level change: evidence from southern New England of an increase in the rate of sea-level rise in the late 19th century. *Geophysical Research Letters,* 31, L05203.

Douglas, B.C., 2001. Sea level change in the era of the recording tide gauge. Douglas, B.C., Kearney, M.S. and Leatherman, S.P. (eds.) *Sea Level Rise; History and Consequences*, Academic Press: 37-64.

Gehrels, W.R., Kirby, J.R., Prokoph, A., Newnham, R.M., Achterberg, E.P., Evans, E.H., Black, S., Scott, D.B., 2005. Onset of recent rapid sea-level rise in the western Atlantic Ocean. *Quaternary Science Reviews,* 24: 2083-2100.

Gehrels, W.R., Marshall, W.A., Gehrels, M.J., Larsen, G., Kirby, J.R., Eiriksson, J., Heinemeier, J. and Shimmield, T., 2006. Rapid sea-level rise in the North Atlantic Ocean since the first half of the 19th century. *The Holocene,* 16: 948-964.

Holgate, S.J., 2007. On the decadal rates of sea level change during the twentieth century, *Geophysical Research Letters,* 34, L01602.

Jevrejeva, S., Grinsted, A., Moore, J.C. and Holgate, S., 2006. Nonlinear trends and multiyear cycles in sea level records. *Journal of Geophysical Research-Oceans,* 111: C09012.

Leuliette, E., Nerem, R. and Mitchum, G., 2004. Calibration of TOPEX/Poseidon and Jason altimeter data to construct a continuous record of mean sea level change. *Marine Geodinamics,* 27, 79-94.

Peltier, W.R., Tushingham, A.M., 1989. Global sea level rise and the greenhouse effect: might they be connected. *Science,* 244: 806-810.

Woodworth, P.L., 1990. A search for accelerations in records of European mean sea level. *International Journal of Climatology*, 10: 129-143.

Late Quaternary (MIS 1-3) environmental change in the S Bay of Biscay evidenced by benthic microfaunas of the basque shelf

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Introduction

Palaeoceanographic studies are largely based on the characterisation of water masses both in modern and fossil settlements. A modern approach to achieve this is by using microorganisms as foraminifers and ostracods to characterise the ecological ecosystems of the sediments afected by these oceanic water masses (Murray, 1991; Cronin et al., 2002). These studies, completed with stable isotope analyses of the calcitic carapaces, evidence paleoceanographic events thus providing a good basis to estimate climatic changes in the geological past. The study of recent sediments of the basque shelf (Jouanneau et al., 1999, 2007) provided with a big set of samples with a rich microfauna of foraminifers and ostracods which are used in this work to show environmental modifications in the southern Bay of Biscay during the late Quaternary. We follow models of application of these microorganisms to palaeoceanography and palaeoclimatology of the N-Atlantic (Murray, 1991; Van der Zwaan et al., 1999; Cronin et al., 1999, 2000, 2002) and more particularly of the Bay of Biscay (Fontanier et al., 2002, 2006; Laprida et al., 2002; Pascual et al., in press).

Samples of this study (133 surface and another 77 core samples) were obtained from two cores of 2.5m length located in the inner shelf (KS 05-10, 114m water depth) and the outer shelf (KS 05-05, 249m wd, Jouanneau et al., 2007, and this volume). Samples were processed for sedimentological and micropalaeontological analyses. Sedimentological features of these sediments are completed with X-ray analyses. Also, the POC (Particulate Organic Carbon) and the sedimentation rate estimation by $^{210}Pb_{exc}$ are described in Jouanneau et al. (in press). Oxygen and carbon stable isotopic analyses ($\delta^{18}O$ and $\delta^{13}C$) have been performed with the recent and fossil studied microfauna, trying to find a characteristic signal of benthonic and planktic environments in this shelf. Multivariate analysis (Cluster, DCA) have been used to show main trends in faunal and geochemical distributions.

Results

Recent distributions of benthic foraminifers and ostracods in the Basque shelf (Pascual et al., in press) are used as modern analoges to interpret major palaeoceanographic events in this region. Benthic foraminifer assemblages in this shelf are represented by 167 species dominated by the hyaline tests (R 69%; M 16%; T 15%). Characteristic assemblage is formed by *Brizalina spathulata, Bulimina marginata, Casssidulina laevigata, Hyalinea balthica, Lobatula lobatula, Rosalina globularis, Textularia sagittula and Uvigerina peregrina*. Only the 1.6% of the studied specimens belong to the biocenoses. The benthic ostracods are represented in this shelf by more than a hundred species, with assemblages dominated by *Lindisfarnia guttata, Costa edwardsii, Pterygocythereis ceratoptera* and *P. jonesii*. We found changes in these assemblages correlative to depth and type of sediment.

Taking into account the type of microfaunal assemblages coupled with average values of environmental parameters ($CaCO_3$, POC, silt/clay, hypoxic indicators) six facies are present in this shelf: the outer fringe (100-150 m depth), the mud patch, the inner fringe (60-80 m wd), the eastern fringe, the w-outer fringe (90-130 m wd) and the inner fringe (<60 m wd).

The occurrence of ecological exotic species in the sediments of this shelf can be indicative of environmental inputs. Thus, ostracods characteristic of lakes of the basque area found in the marine sediments evidence the basque rivers inputs in the shelf. High percentages of these continental indicators in the shelf can be interpreted as an increase of the fluviatile supply and thus, of the increased humidity in the past. Also, the occurrence of species characteristic of deeper, bathyal waters, is indicative of upwelling processes in the outer shelf, as evidenced in the San Sebastian canyon area.

The palaeoecological interpretation is based upon the aforementionned proxies. Firstly, the ecological type of both foraminifers and ostracods are good markers of a particular water mass, in this case the central N-Atlantic water. Quantification of the assemblages, performed with faunal indices and multivariate analyses, shows noticeable variation caused by environmental modifications of the benthic ecosystems, which were in turn induced by oceanographic and climatic changes. We used as faunal indices: diversity, planktic/benthic foraminifer ratio, nF (number of benthic forams), nO (number of ostracods). The used stable isotope indices, $\delta^{18}O$ and $\delta^{13}C$ of both benthic and planktonic foraminifers provide us with geochemical inprints of bottom and surficial waters, respectively.

By comparing the observed faunal and geochemical changes with the calendar calibrated ages obtained through the studied cores, we present a record of the MIS 3 (c. 40.000 years) to Recent main events in the Basque shelf. This record evidences as well palaeoclimatic events as the onset of the Last

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Glacial Maximum, and the Hypsithermal warm period and the Neoglacial cold period of the Holocene in the southern Bay of Biscay.

Acknowledgements

This work has benefited of the financial support of Spanish Ministry of Education and Science (project CGL2004-02987) and the University of the Basque Country (ref. GIU/49).

References

Cronin, T., Demartino, D.M., Dwyer, G.S., Rodriguez-Lazaro, J. 1999. Deep-Sea Ostracode species diversity: response to Late Quaternary Climate Change. *Marine Micropaleontology*, 37 (3/4): 231-249.

Cronin, T., Dwyer, G., Baker, P.A., Rodriguez Lazaro, J., Demartino, D.M., 2000. Orbital and suborbital variability in North Atlantic bottom water temperature obtained from deep-sea Ostracode Mg/Ca ratios. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 162: 45-57.

Cronin, T.M., I. Boomer, G. Dwyer, J. Rodriguez-Lazaro 2002. Ostracoda and Paleoceanography. *The Ostracoda: Applications In Quaternary Research*, American Geophysical Union (AGU), Geophysical Monograph 131: 99-119.

Dwyer, G.S., Cronin, T.M., Baker, P.A.,Rodriguez-Lazaro, J. 2000. Changes in North Atlantic deep-sea temperature during climatic fluctuations of the last 25,000 years based on ostracode Mg/Ca ratios.*Geochemistry, Geophysics, Geosystems*, Vol. 1, 17 pp. 2000gc000046. (AGU Electronic Journal: http://G-cubed.org/).

Fontanier, C., Jorissen, F.J., Licari, L., Alexandre, A., Anschutz, P., Carbonel, P., 2002. Live benthic foraminiferal faunas from the Bay of Biscay: faunal density, composition, and microhabitats. *Deep-Sea Research*, Part I, 49, 751-785.

Fontanier, C., Mackensen, A., Jorissen, F.J., Anschutz, P., Licari, L. and Griveaud, C., 2006. Stable oxygen and carbon isotopes of live benthic foraminifra from the Bay of Biscay: Microhabitat impact and seasonal variability. *Marine Micropaleontology*, 58: 159-183.

Holmes J.A., Chivas, A.R., 2002. The Ostracoda. Applications in Quaternary Research. *American Geophysical Union*, Washington, DC.

Jouanneau, J.M., Weber, O., Cremer, M., Castaing, P., 1999. Fine-grained sediment budget on the continental margin of the Bay of Biscay. *Deep-Sea Research II,* Spec.Issue, 46 (10), 2205-2220.

Jouanneau, J-M. Weber, O., Champilou, N., Cirac, P., Muxica, I., Borja, A., Pascual, A., Rodriguez-Lazaro, J., Donard, O. Recent sedimentary study of the shelf of the Basque country**.** *Journal Marine System* (in press).

Laprida, C., Azpilikueta, M., Carbonel, P., 2002. Dinámica de los ostrácodos mediterráneos en el Golfo de Vizcaya, Océano Atlántico Nororiental. *Revista Española de Micropaleontología*, 34, 201-213.

Murray, J., W., 1991. *Ecology and Palaeoecology of Benthic Foraminifera*. Longman Scientific & Technical, Essex, England.

Pascual, A., Rodriguez-Lazaro, J., Martin, M., Jouanneau, J-M. Weber, O. A survey of the benthic microfauna (Foraminifera, Ostracoda) on the Basque Shelf (Southern Bay of Biscay). *Journal Marine System* (in press).

Rodriguez-Lazaro, J., Cronin, T., 1999. Quaternary glacial and deglacial *Krithe* (Ostracoda) in the thermocline of the Little Bahama Bank (NW Atlantic): palaeoceanographic implications. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 152 (3-4), 339-364.

Van der Zwaan, G.J., Duijnstee, I.A.P., den Dulk, M., Ernst, S.R., Jannink, N.T., Kouwenhoven, T.J., 1999. Benthic foraminifers: proxies or problems? A review of paleoecological concepts. *Earth Science Reviews*, 46, 213-236.

Facies, granulometry, morphoscopy and exoscopy of south Armorican continental shelf sediments (inner shelf)

Guilhem Estournès*[a], David Menier[a], François Guillocheau[b]

Introduction

Pleistocene sedimentary wedge have been observed all along the west french coast. On south armorican shelf, the connection between this pleistocene sediments and the present sedimentary wedge in term of sediments movement is quite unknown. Reconstitution of sediments history in term of transfert and residence in several kind environments of deposition allows to track these sediments during eventual transport and then to polarize zones of supply. This reconstitution is possible through several sedimentological technics as facies analysis, morphoscopic, exoscopic and granulometric studies.

Vibrodrilling campain led by "La Société Rennaise des Dragages" in May 2006, produced new sedimentological data. Aera of interest is located 12 Km south eastward of Groix Island and 9 Km north estward of Quiberon Peninsula, in offshore. 23 cores have been sampled 30 m deep and have a maximal size of 1.50 m. They are constituted of detritic deposits that show various granulometric range (from silts to peebles) with important fauna contents (bivalves shells, sea-urchins shells, sponge spicules). These dark grey beds are easily recognizable due to their color and contrast with ochre and yellow shoreface sands of the top of the cores.

What is more, 18 samples of present sandy sea floor surface have been collected in April 2007 by scuba divers from 3 beaches of Morbihan (Britany, France) to 25 m deep to characterize the connection degree between coast and inner shelf (-30 m) in term of sediments movements.

Methods

Morphoscopic, exoscopic and granulometric studies have been led on samples of material (6 cores and all sea-floor samples) to reconstruct deposits environments succession crossed by sediments. Samples have been observed through binocular microscope and scanning electronic microscope (S.E.M). Quartz grains surface shows features herited from the differents environments of deposition that these sediments cross during their transport. These features result of physico-chimic conditions that occured in the differents environments. Mecanic features are intergranular impact tracks as conchoïdal fratcures, straight grooves. Chemical features are deep surface etching and dissolution picking. Cores have been described with facies sedimentological methods in order to obtain the last deposits environment for each sequence and to stratigraphicaly correlate cores at the scale of the studied zone. Granulometric studies on several levels of these cores and on all sea-floor samples have been lead to characterize the effects of present hydrodynamic condition on sediments grains.

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Results

Cores show individualized facies, grouped in sequences present from the base upward:

- Peebles of gneiss and granules from tidal dominated bay (facies S1).
- Medium to fine sands, sometimes with thin pieces of shells relative to a bay environment (facies S2 and S3) and shelly interbeds described as storm washovers in a calm bay environment (facies T).
- Coarse grains to granules, with bioclastic contents from marine shoreface domain (facies S4) and characterized by ocher and yellow coloration. This bed is limited downward by a swell erosion surface.

This succession reveals a landward stepping of the facies.

The binocular microscope observation shows a high ratio of « émoussés luisants » grains (more than 80 % of grains) which is caracteristic of marine influence. Observation with S.E.M shows that the majority of quartz grains presents dissolution features generaly produced in marin domain and diagenetic silica recristaliaztion thin layer. It indicates a long time of residence in this environment. Intergranular impacts, herited from anterior transports, are very smooth and intense dissolution etching spread out from these tracks.

Sea-floor samples show granulometric evolution in relation to hydrodynamic conditions. Between beaches and -10/-15 m in depth, sediments show a granulometric selection produce by high hydrodynamic conditions. Below this limit, sediments are less sorted and localy, the presence of a shaly thin layer indicates a drop of hydrodynamic conditions.

Discussion

This landward stepping pattern probably results from the last marine transgression during quaternary age which began -18000 years ago (Pleistocene). Relative sea level was approximatively at -120 m, and rise during the global warming and ice cap thawning which cover the north of Europe during the last glacial period (Weschelien). At the end of this marine transgression (8000 years B.P), relative sea level was positioned -25 m lower than today. These deposits represent a Holocene transgressive fossil wedge constituted of bay facies preserved during the rise of sea level. The intense dissolution on quartz grains surface indicate a long time of residence in marine environment and motionlessness of fossil sediments since the end of the trangressive period.

Hydrodynamic condition appears to be too low to move sediments below -15 m deep during fair weather periods. No clues of continental or coastal supplies have been observed on this grains through granulometric studies. All this data indicate that the studied zone is disconnected from the current coast zone in term of sediment alimentation.

References

ALLEN J. R. L. 1979. A model for the interpretation of wave ripple-marks using their wavelength, textural composition, and shape. Journal of the Geological Society of London, 136: 673-682.

ALLEN P. A. 1981. Some guidelines in reconstructing ancient sea conditions from wave ripplemarks. Marine Geology, 43: M59-M67.

BOS P. and QUELENNEC R.E. 1988. Etude de l'évolution du littoral nord ouest du Morbihan entre Guidel et la Trinité-sur-Mer., B.R.G.M.

CHASSE C. and GLEMAREC M. 1976. ATLAS DU LITTORAL FRANCAIS (Atlas des fonds meubles du plateau continental du Golfe de Gascogne) - Cartes biosédimentaires.

DIEM B. 1985. Analytical method for estimating paleowave climate and water depth from wave ripple marks. Sedimentology, 32: 705-720.

FRIHY O. E. and STANLEY D.J. 1987. Quartz grain surface textures and depositional interpretations, Nile Delta region, Egypt. Marine Geology, 77: p 247-255.

GUILLOCHEAU F., BRAULT N., THOMAS E., BARBARAND., BONNET., BOURQUIN S., ESTEOULE-CHOUX J., GUENNOC P., MENIER D., NERAUDEAU D., PROUST J.-N. and WYNS R. 2003. Histoire géologique du Massif Armoricain depuis 140 Ma (Crétacé-Actuel). Bulletin d'information des géologues du bassin de Paris, 40: 13-28.

HJULSTROM F. 1935. Studies of the morphological activity of rivers as illustrated by the river Fyris. Bull. Geol. Inst. Univ. Uppsala, 25: 221–527.

KRINSLEY D. H. and DOORNKAMP J.C. 1973. Atlas of quartz sand surface textures. Cambridge University Press, 91 pp.

LE RIBAULT L. 1977. L'Exoscopie des Quartz. Masson, 150 pp.

MIGNOT C. 1989. Etude sédimentologique du site de l'Epi de Plouhinec à l'entrée de la rivière d'Etel - Amenagement possible de l'embouchure., Direction Départementale de l'Equipement - Service maritime - Subdivision de Lorient-Maritime.

PINOT J.P. 1974. Le pré-continent breton, entre Penmarc'h, Belle-île et l'escarpement continental, étude géomorphologique., Lannion, 256 pp.

VANNEY J-R. 1977. Géomorphologie de la marge continentale sud-armoricaine., S.E.D.E.S, Paris.

VOLMAT M. 1931. Les extractions de sables à l'embouchure de la rivière d'Etel et leur influence sur l'état de l'embouchure et sur le port d'Etel.

Reactive compounds from water column to buried sediment: Role of early diagenesis

Aurélia Mouret*[a], Pierre Anschutz[a], Pierre Cirac[a], Hervé Gillet[a] and Jonathan Deborde[a]

Introduction

The main objective of the program FORCLIM is to improve significantly the interpretation of fossil foraminifera signals, as a proxy for hydrological changes in the North Atlantic ocean. In this context, it is necessary to know and quantify the transformations of sediments due to diagenesis.

The studied area is the southeastern part of the Bay of Biscay on the slope of the Aquitaine margin between the canyons of Capbreton and Cap Ferret (Fig.1). Multitube corer has been used for ten years (OXYBENT and FORAMPROX programs) to sample at selected stations the first twenty centimetres of sediment with bottom water for analyses in terms of early diagenetic geochemistry, radionuclide chemistry (Hyacinthe et al., 2001; Anschutz et al., 2002; Chaillou et al., 2002, 2003, 2006) and benthic foraminifera fauna (Fontanier et al., 2002, 2003, 2005, 2006).

A kullenberg corer was used during the PROSECAN IV cruise (May 2007) at one of the FORCLIM stations, in order to go further in terms of diagenetic processes.

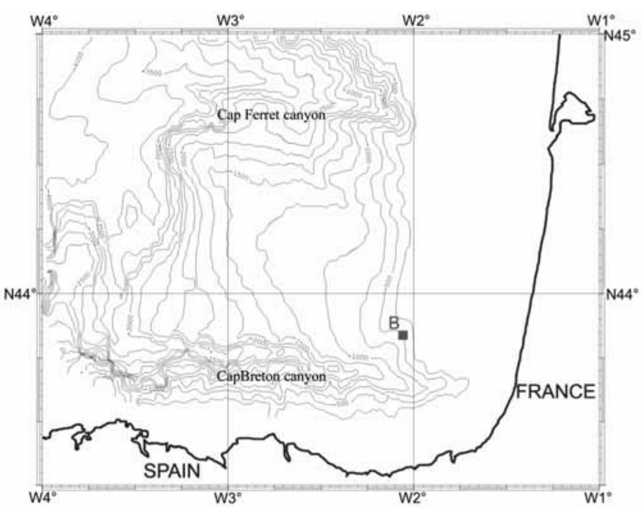

Figure 1. Map of the south-eastern part of the Bay of Biscay showing the location of the sampled station.

Methods

A core (KGB07) of 3.2 meters long was collected at the station B (550m) (Fig.1). It was sliced every twenty centimetres in thin horizontal sections of 2 cm, 3 cm below and 4 cm at the bottom of the core. For each level, a sub-sample was immediately sealed in a pre-weighted vial, and frozen for further determination of porosity, and analyses of solid fraction. Another sub-sample was centrifuged under inert N_2-atmosphere at 5000 rpm for 15 min in order to collect pore waters. Two aliquots of water were filtered (0.2 µm cellulose acetate syringe filter) and frozen at -25°C for nutrient analyses, and another aliquot was filtered and acidified with ultrapure HNO_3 for dissolved Mn and Fe analyses.

Results and Discussion

With kullenberg corer, the first centimetres of sediment are lost. By comparing profiles of ammonium, dissolved Mn and Mn-oxides with multitube profiles, we estimate that only 5 or 6 centimetres have been lost (Fig.2). Thus we can adjust the depth of the core.

The porosity values are 0.85 close to the interface and decrease rapidly until fifty centimetres. Deeper the decrease is slower. Porosity allows the calculation of the stock of particles integrated the whole-length of the core. $^{210}Pb_{xs}$ and Mn method (Mouret et al., in preparation) have been used to determine a mass accumulation rate between 79.5 - 54 mg cm^{-2} yr^{-1}. Using this parameter and the stock of particles, we can estimate an age of about 5000 years at the bottom of the core.

The rapid decrease of dissolved Mn (Fig.2) is due to the use of Mn^{2+} for the formation of a secondary solid phase, probably a carbonate phase. There is no peak of dissolved Mn deeper, because there is no source of Mn, like Mn-oxides (Fig.2). The lack of fossilized Mn-oxides and constant particulate Fe concentrations (Fig.2) suggest that the sedimentation remained steady during 5000 years.

The particulate organic carbon profile shows a rapid decrease in the twenty first centimetres, then the decrease is slower (Fig.2). The reason is that the more labile organic matter is mineralized in the first centimetres and the organic matter, which is still available deeper, is refractory and harder to mineralize.

The sulfate profile shows a linear decrease with depth (Fig.2). This decrease is certainly due to sulfate reduction. The flux of sulfates in pore waters can be calculated, assuming transport by molecular diffusion, from the concentration gradients according to Fick's first law. We obtain a sulfate flux of 3 µmol cm^{-2} yr^{-1}. We can estimate carbon mineralized by this flux with the equation of sulfate reduction:

$$CH_3COOH + SO_4^{2-} \rightarrow 2HCO_3^- + H_2S + 2H_2O \quad (1)$$

We obtained a value of 0.36 g C cm^{-2} for 5000 years. The quantity of POC integrated on the whole-length of the core for

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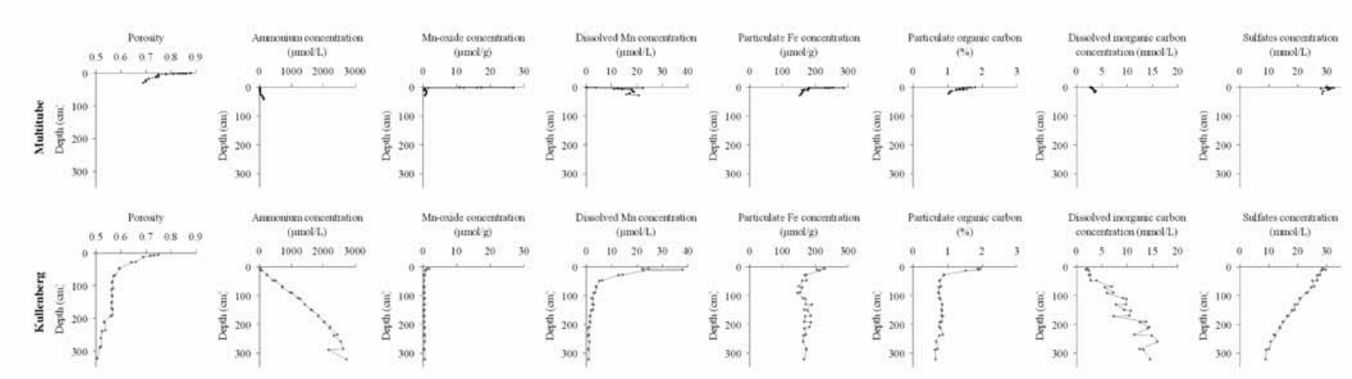

Figure 2. Profiles of porosity, ammonium, dissolved Mn, Mn-oxides, particulate Fe, particulate organic carbon, dissolved inorganic carbon and sulfates of the core KGB07 and one example of multitube cores at the station B.

a section of 1 cm² represents 3.5 g. Thus the sulfate reduction uses only 10% of the content of POC. This calculation could explain the low decrease of POC content at depth.

The dissolved inorganic carbon increase with depth, but the profile is disturbed (Fig.2). One explanation may be the use of alkalinity for carbonate formation. This hypothesis should be confirmed with calcium measurements in porewaters. These parameters are important to understand the $CaCO_3$ system in sediments. Dead foraminifera undergo partial dissolution or can also be coated with secondary carbonates, depending on $CaCO_3$ saturation. These dissolutions and/or coating must be determined in order to know how they modify the recorded signal for paleoceanographers.

Acknowledgements

This work is a contribution of the ANR FORCLIM.

References

Anschutz P., Jorissen F. J., Chaillou G., Abu-Zied R., and Fontanier C. (2002) Recent turbidite deposition in the eastern Atlantic: Early diagenesis and biotic recovery. *Journal of Marine Research* **60**(6), 835-854.

Chaillou G., Anschutz P., Lavaux G., and Blanc G. (2006) Rare earth elements in the modern sediments of the Bay of Biscay (France). *Marine Chemistry* **100**(1-2), 39-52.

Chaillou G., Anschutz P., Lavaux G., Schäfer J., and Blanc G. (2002) The distribution of Mo, U, and Cd in relation to major redox species in muddy sediments of the Bay of Biscay. *Marine Chemistry* **80**(1), 41-59.

Chaillou G., Schäfer J., Anschutz P., Lavaux G., and Blanc G. (2003) The behaviour of arsenic in muddy sediments of the Bay of Biscay (France). *Geochimica Cosmochimica Acta* **67**(16), 2993-3003.

Fontanier C., Jorissen F., Anschutz P., and Chaillou G. (2006) Seasonal variability of benthic foraminiferal faunas at 1000 M depth in the Bay of Biscay. *Journal of Foraminiferal Research* **36**(1), 61-76.

Fontanier C., Jorissen F. J., Chaillou G., Anschutz P., Gremare A., and Griveaud C. (2005) Live foraminiferal faunas from a 2800 m deep lower canyon station from the Bay of Biscay: Faunal response to focusing of refractory organic matter.

Fontanier C., Jorissen F. J., Chaillou G., David C., Anschutz P., and Lafon V. (2003) Seasonal and interannual variability of benthic foraminiferal faunas at 550 m depth in the Bay of Biscay. *Deep-Sea Research Part I: Oceanographic Research Papers* **50**(4), 457-494.

Fontanier C., Jorissen F. J., Licari L., Alexandre A., Anschutz P., and Carbonel P. (2002) Live benthic foraminiferal faunas from the Bay of Biscay: Faunal density, composition, and microhabitats. *Deep-Sea Research Part I: Oceanographic Research Papers* **49**(4), 751-785.

Hyacinthe C., Anschutz P., Carbonel P., Jouanneau J.-M., and Jorissen F. J. (2001) Early diagenetic processes in the muddy sediments of the bay of biscay. *Marine Geology* **177**(1-2), 111-128.

Particle fluxes and recent sediment accumulation on the Aquitanian margin of Bay of Biscay

Sabine Schmidt*[a], Hélène Howa[b], Aurelia Mouret[a], Neven Lončarić[b], Fabien Lombard[c], Pierre Anschutz[a] and Laurent Labeyrie[c]

Introduction

The present work is a contribution to the program ANR Forclim (2006-2008); main objective is to improve significantly the interpretation of fossil foraminifera signals, as a proxy for hydrological changes in the North Atlantic ocean. A specific task of this program is to characterize the geochemical and sedimentary environment of foraminifera growth in the water column and at the water-sediment interface. The studied area is the Aquitanian margin, in the south-eastern part of the Bay of Biscay. Rivers and coastal runoff discharge large quantities of suspended particulate matter onto the continental shelf of the Bay of Biscay, with subsequent dispersion of suspended particles through shef-slope exchange (Durrieu de Madron et al., 1999). From the ECOFER study, the role of the Cap-Ferret canyon as an active pathway of shelf-slope exchange of SPM was well establised (Heussner et al., 1999). To better understand particle transport processes on the Aquitanian margin, we focus on the slope of the Aquitanian margin between the canyons of Capbreton and Cap Ferret (Fig. 1).

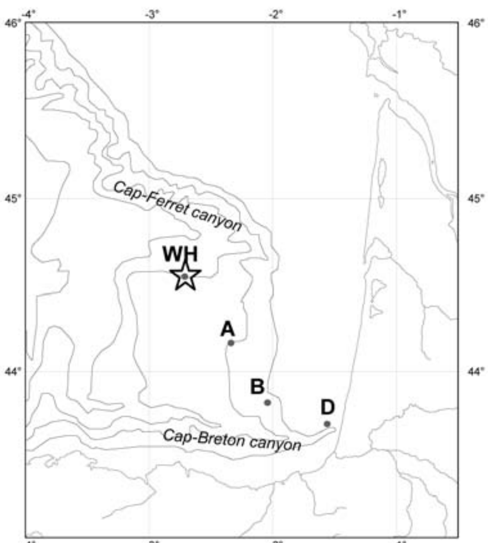

Figure 1 Map showing the sites of the sediment trap mooring (star) and of interface cores on the Aquitanian margin (S.-E. Bay of Biscaye)

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This work presents the particulate mass flux and ^{210}Pb determined from two time-series sediment traps deployed at the main FORCLIM site (WH) and from interface cores taken along a detph transect (D, B, A, WH). The comparison of mass fluxes between the water column and the seabed provides new insight in the particle dispersion on this margin.

Methods

During the ‘‘Côte de la Manche’’ cruise PECH01 in June 2006, a long-term mooring with two sediment traps (PPS5 TECHNICAP; sampling area 1 m^2) was deployed on the plateau des Landes (Fig. 1, 44°32N, 2°43W, 2000 m water depth). Traps were deployed at a depth of respectively 800 m and 1700 m, with sampling intervals of 12 days. The 24 collecting cups were filled with filtered seawater previously collected at depth and poisoned with NaN_3. The mooring was recovered in April 2007 during the cruise PECH03. After recovery, the samples were splitted into half aliquots. One half was used to determine mass fluxes. Thereafter this fraction was used to measure ^{210}Pb and ^{226}Ra using a low background, high-efficiency, well-shaped-detector (Schmidt et al., 2002). Standards used for the calibration of the γ detector are IAEA standards (RGU-1, RGTh-1). Excess ^{210}Pb data were calculated by subtracting the activity supported by its parent isotope, ^{226}Ra, from the total activity in the sediment.

In addition, during the cruise PECH01, interface sediments were collected using a multicorer along a transect between 140 and 2000 m water depth. Immediately after core retrieval, tubes were carefully extruded with sediment taken at 0.5 cm interval from 0 to 2 cm, and 1 cm interval below. In the laboratory, dry bulk density (DBB) was measured by determining the weight after drying (60°C) of a known volume of wet sediment. Following this procedure, ^{210}Pb and ^{226}Ra activities were measured as described previoulsy. Based on the CF:CS method (constant flux and constant sediment accumulation rate) (Robbins et al., 1975), the regression of $^{210}Pb_{xs}$ against cumulative mass allowed to calculate a mass accumulation rate (MAR).

Sea surface temperature (SST) and chlorophyll a concentrations were analised using remote sensing data.

Results

The total particulate mass flux, registered by the sediment trap at site WH, varied between 19 and 116 mg m^{-2} d^{-1} at 800-m depth and between 34 and 812 mg m^{-2} d^{-1} at 1700-m depth (Figure 2). Particule flux was much higher at the location of the deeper trap. In addition, the deeper trap recorded large and abrupt mass flux variations, especially in winter and early spring. $^{210}Pb_{xs}$ specific activities of settling particles range between 110 and 254 dpm g^{-1}, with a higher variability in the deeper trap.

In surface sediments, profiles of $^{210}Pb_{xs}$ present the classical exponential decrease with depth (only a mixed layer for site D); MAR derived from these profiles decrease, as expected, with depth: 0.095 g cm^{-2} d^{-1} (site B, 500 m), 0.053 g cm^{-2} d^{-1} (site A, 1000 m) and 0.025 g cm^{-2} d^{-1} (site WH, 2000 m).

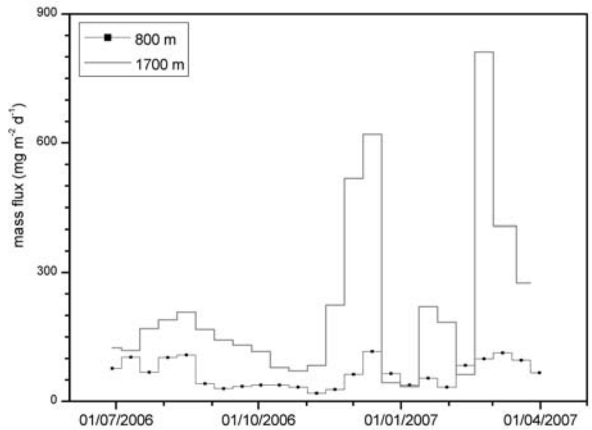

Figure 2 Time-series variation of the particulate mass flux at site WH.

Discussion

Mean mass fluxes at 800 m and 1700 m depth at site WH are respectivly 82 and 272 g m^{-2} y^{-1} (Fig. 3) which are about 1–20 times the values reported at equivalent depths over the Goban Spur and Meriadzek Terrace at the northern margin of the Bay of Biscay (47–50°N, 16-91 g m^{-2} yr^{-1}) (van Weering et al., 1998) and over the north-western Iberian Margin (41–44°N, 30-50 g m^{-2} yr^{-1}) (Schmidt et al., 2002). The ^{210}Pb budget, as determined by the ratio of measured fluxes to the rate of ^{210}Pb production in the water column above the trap, implies temporary high lateral input, as observed in the Cap-Ferret canyon (Radakovitch et al., 1999). Biological activity does not appear the main factor driving mass flux

Although a gradual decrease of mass accumulation rates along the transect (Fig. 3), particle deposition on mid-slope is high and comparable to the mean particle fluxes recorded in the deeper trap. Such high deposition rates have been already reported for the southern Middle Atlantic Bight or the Ikinanawa Trough by example (Biscaye and Anderson, 1994; Oguri et al., 2003), where lateral transport plays an important role in particle accumulation. This indicates that the mid-slope of the Aquitanian margin is an efficient depocenter.

Conclusions

Present-day sedimentation on the Aquitanian slope was assessed using ^{210}Pb and mass fluxes. Sedimentation intensity (particulate fluxes, mass accumulation rates) supports the occurrence of significant advection of sediments, even at the deepest site. Although such mass transfer affects mostly fine particle fraction, Brunner et Biscaye (2003) report events of resuspension and transport of foraminifers on the Southern Middle Atlantic. Regarding the objective of the program FORCLIM, these advection processes must be considered when interpreting fluxes of foraminifers.

Acknowledgements

This work is a contribution to the ANR FORCLIM. The Region Aquitaine, the Ministère de la Recherche (ACI ARTTE) and the Université Bordeaux 1 founded the acquisition of the γ spectrometer.

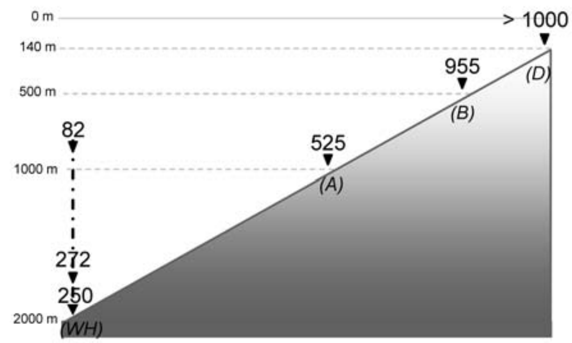

Figure 3 Schematic illustration of mass accumulation rates (in g m^{-2} y^{-1}) along the Aquitanian slope transect. Note that distances between sites are not respected.

References

Biscaye, P.E., Anderson, R.F., 1994. Fluxes of particulate matter on the slope of the southern Middle Atlantic Bight: SEEP-II. Deep-Sea Research II, 41: 459–509.

Brunner, C.A., Biscaye, P.E., 2003. Production and resuspension of planktonic foraminifers at the shelf break of the Southern Middle Atlantic Bight. *Deep Sea Research I*, 50, 247-268.

Durrieu de Madron, X., Castaing, P., Nyffeler, F., Courp, Th., 1999. Slope transport of suspended particulate matter on the Aquitanian margin of the Bay of Biscay. Deep Sea Research II, 46: 2003-2027.

Heussner S., Durrieu de Madron X., Radakovitch O., Beaufort L., Biscaye P.E., Carbonne J., Delsaut N., Etcheber H., Monaco A., 1999. Spatial and temporal patterns of downward particle fluxes on the continental slope of the Bay of Biscay (northeastern Atlantic). Deep-Sea Research II, 46: 2101-2146.

Oguri, K., Matsumoto, E., Yamada, M., Saito, , 2003. Sediment accumulation rates and budgets of depositing particles of the East China Sea. *Deep-Sea Research II*, 50: 513-528.

Radakovitch, O., Heussner, S., 1999. Fluxes and budget of ^{210}Pb on the continental margin of the Bay of Biscay (northeastern Atlantic). Deep-Sea Research II 46: 2175–2203.

Robbins, J., Edgington, D.N., 1975. Determination of recent sedimentation rates in Lake Michigan using ^{210}Pb and ^{137}Cs. *Geochimica Cosmochimica Acta*, 39: 285-304.

Schmidt, S., van Weering, Tj.C.E., Reyss, J.-L., van Beek, P., 2002. Seasonal deposition and reworking at the sediment-water interface on the north-western Iberian Margin. Progress in Oceanography, 52: 331-348.

van Weering, Tj.C.E., Hall, I.R., de Stigter, H.C., McCave, I.N., Thomsen, L., 1998. Recent sediments, sediment accumulation and carbon burial at Goban Spur, N.W. European Continental Margin (47–50°N). Progress In Oceanography 42: 5-35.

Video observation of a rapid post-storm accretionnary beach state transition on the Aquitanian coast.

Almar Rafael*[a], Castelle Bruno[a], Sénéchal Nadia[a], Bonneton Philippe[a]

Introduction

Wave-dominated beaches are continuously shaped by temporally variable forcings of tide and waves. The sequential morphologic state mode of Wright & Short (1984) has been widely used to predict temporal and spatial evolution of beaches under varying incident waves. Beaches have been divided into the dissipative, intermediate and reflective states, the intermediate beaches being further divided into four sub-states. Immediately below the dissipative state is the Longshore Bar and Trough (LBT) morphology, then the Rhythmic Bar and Beach (RBB) morphology, next Transverse Bar and Rip (TBR) morphology and finally the Low Tide Terrace (LTT) morphology. While beach state transitions have been observed in the field by various authors, there are only little attempts to quantify both beach volume and accretion/erosion rates associated with these beach state transitions. Indeed, in-situ high frequency observations of the nearshore topography are often limited to short periods of measurements. Therefore, key events in beach state transitions can be missed, limiting our understanding of beach morphodynamics on time scales of days to months.

Recently, the development of permanent video systems (ARGUS,CAM-ERA) made possible continuous observation of a beach. Inversion methods using wave dispersion (Stockdon and Holman, 2000), energy (Aarninkhof, 2003) and shoreline detection during a tidal cycle (Aarninkhof, 2003) have shown good results in estimating the beach topography. Such a video system has been recently implemented at the double-barred Biscarrosse beach, representative of most of the Aquitanian Coast beaches, which is located about 30 km southard of the Arcachon Lagoon. The tide is of meso-macro type with non-significant tide-induced currents in comparison with wave-induced currents. Wave forcing is highly energetic, with predominance of W-NW swells (Butel et al., 2002). As recently highlighted in Castelle et al.(2007), substantial knowledge gaps remain on the inner bar dynamics, which can go through all the states within the intermediate classification.

The present study is focuses on the 21 August – 17 September period which is characterised by a four week post-storm period with very low energy waves and fair weather conditions. Observation of a TBR-LTT beach state transition and quantification of accretion are presented and used to investigate the inner bar dynamics.

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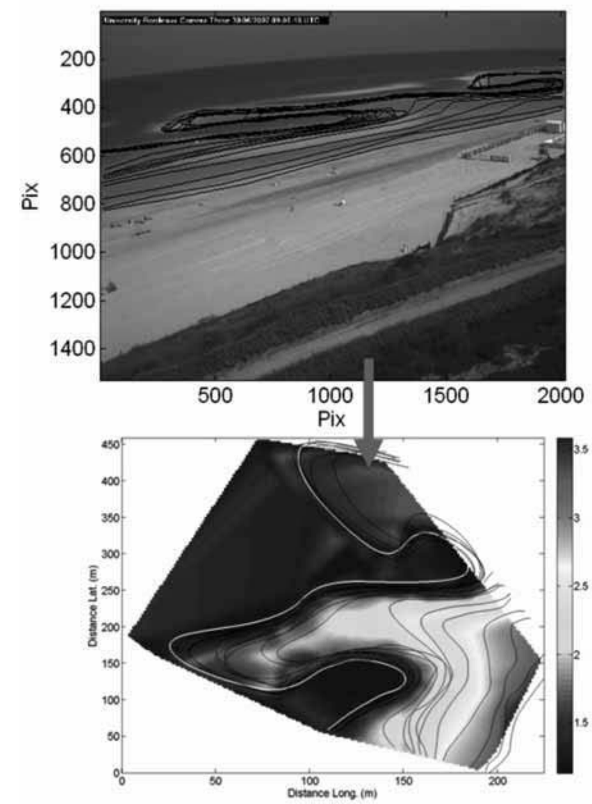

Figure 1 Example of inner bar morphology computed from video imagery . Top panel: shoreline detection at different tide levels (pixel coordinates). Bottom panel: interpolated topography from water levels (real coordinates).

Method

A permanent video system has been installed at Biscarrosse beach in April 2007. The system Cam-Era (NZ) is equipped with 5 High Resolution cameras for an overall view-field of 2 km. Acquisition rate is 4 images per hour and 3 types of image are archived. The first type is an instant image, the second one is time-averaged image (over 10 minutes) and the third type is a timestack at a specific section (2 Hz over 10 minutes). Instant images are used to control the image quality. Time-averaged images reveal the sandbar position and morphology, the shoreline and timestacks allow wave celerity estimation.

Beach topography is estimated by tracking the shoreline during a tidal cycle (Coco et al., 2005), each alongshore shoreline position detection being associated to an iso-level of the beach. To reconstruct the topography, all daily shorelines (X,Y,Zlevel) are used and are interpolated to compute the three-dimensional beach topography and the resulting beach volume. Detections are automatic and manually checked with possible deletion when abnormal. In the present study, we only used one camera and focused our study only on an alongshore distance corresponding to one wavelength of the inner bar (400 m). Figure 1 shows an example of computed intertidal beach morphology using this method.

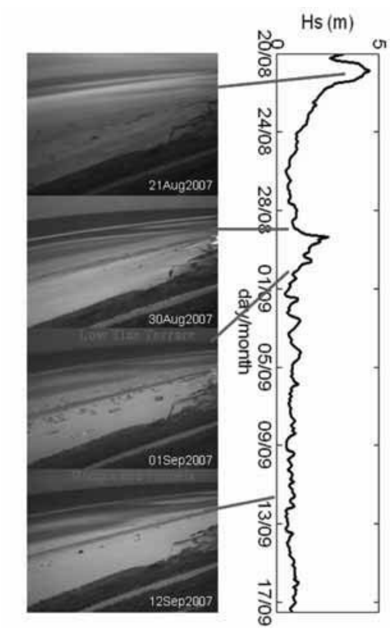

Figure 2. Evolution of the beach together with time series of offshore significant wave height Hs(m).

Preliminary results

During the study period, morphologies have been compared with the classification of Wright & Short (1984). Image analysis shows that the beach evolved rapidly from a TBR morphology to a well-developed LTT morphology. Figure 2 shows a time series of the offshore significant wave height during this period, together with four time-averaged images of the study area, each one selected at low tide. This figure shows that within the 10 day of low wave energy period immediately following the storm (with Hs up to 4.5 m), the deep channel of the TBR morphology rapidly infilled. This was associated with a high accretion rate of upper intertidal domain and the formation of a shallow alongshore runnel and, eventually (30 August, Fig. 2), the formation of a Low Tide Terrace morphology according the conceptual beach state transition of Wright and Short (1984, Figure 3). Precedent studies (Castelle et al., 2007) suggested that this transition generally occurred after at least 10 days. From early September to the end of the study period, the beach did not evolve that much, with a weak accretion rate of the upper part of the beach and the formation of a high berm. At the end of the study period, the beach even seems to reach a quasi-equilibrium.

Computations of beach topography and resulting quantification of accretion rates of the intertidal domain are currently in progress. This will provide detailed information about this intermediate beach state transition.

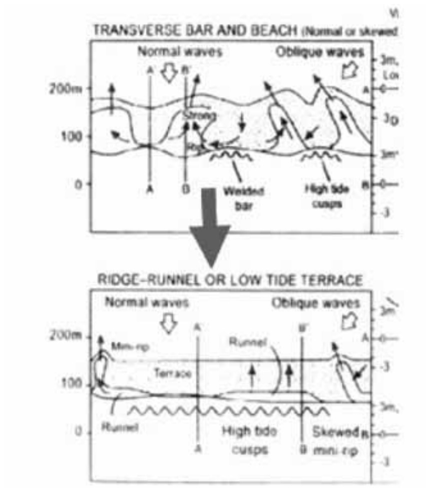

Figure 3. Conceptual beach state transition from a Transverse Bar and Rip morphology to a Low Tide Terrace morphology (Wrigth & Short, 1984)

Conclusions and Discussion

Video observation of the post storm period shows an obvious and rapid transition from a TBR morphology to a LTT morphology following the classification of Wright & Short (1984). This accretionnary event shows that the beach does not need a long time to rebuild after a storm. This shows that high frequency beach observation is required to fully understand the Aquitanian Coast beach dynamics. The non-linearity of the beach response to the wave forcing is clearly highlighted with this study with a rapid accretion followed by quasi-equilibrium. At the time of writing this paper, data analysis is in progress and beach volume evolution will be shortly quantified.

Further improvements of the method need to be undertaken. For instance, in this study we neglected the wind effect (Aarninkhof, 2003) and used a simple formula (Bowen et al., 1968) to estimate the wave-induced setup. More complex numerical modelling would significantly the improve setup estimation and, therefore, beach volume estimation. The position of the shoreline is also sometimes difficult to track in poor lighting conditions, storms, and for complex configuration of the shoreline, which needs to be fixed.

References

Aarninkhof, S., 2003. Nearshore bathymetry derived from Video Imagery. Delft University Thesis, November 2003.

Bowen, A.J., D.L. Inman and V.P. Simmons, 1968. Wave 'setup' and 'setdown', *Journal of Geophysical Research*, **73**, 2569–2577.

Butel, R., H. Dupuis, P. Bonneton, P., 2002. Spatial variability of wave conditions on the French Atlantic coast using in-situ data. *Journal of Coastal Research*, Special Issue 36, 96-108

Castelle B., P. Bonneton, H. Dupuis H, N. Sénéchal, 2007. Double bar beach dynamics on the high-energy meso-macrotidal French Aquitanian Coast : a review. *Marine Geology*, 245, 141-159.

Coco, G., K.R. Bryan, M.O. Green, B.G. Ruessink, I.L. Turner, I.M.J. Van Enckevort, 2005, Video observations of shoreline and sandbar coupled dynamics. In Proc. of Coasts and Ports 2005, Adelaide, 471-476.

Stockdon H.F., R.A. Holman R.A., 2000. Estimation of Wave Phase Speed and Nearshore Bathymetry from Video Imagery. *Journal of Geophysical Research*. 105, 22015-22033.

Wright, L.D., A.D. Short, A., 1984. Morphodynamic variability of surf zone and beaches : a synthesis. *Marine Geology*, 56, 93-118.

Wind waves and fine sediment resuspension and deposition in the intertidal mudflats of a mesotidal lagoon (Arcachon, France)

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Introduction

In intertidal areas protected from oceanic swell, wind waves often play a key role on sediment dynamics, as they can be the only forcing able to generate significant erosion of surficial sediments. In these zones, under fair weather conditions, tidal currents are too weak to generate resuspension, and residual fluxes induce flat accretion (Le Hir et al., 2000 ; Janssen-Stelder, 2000 ; Christie et al., 2001).

The Arcachon lagoon is a mesotidal embayment of the french atlantic coast. 74% of its total area is occupied by intertidal flats, protected from the oceanic swell by the Cap Ferret Spit. Sediment on the flats are fine grained, covered by zostera noltii in wide areas. There is little evidence on sedimentary balance, excepted from bathymetric charts comparisons showing average trends of accretion of the order of 10 cm/century (L'Yavanc, 1995). However, this secular trend shades short-term processes related to resuspension/desposition cycles induced by critical shear stress on the bottom. Moreover, there is little knowledge on the effect of wind on local waves and its specific effect on sediment transport (excepted Gassiat, 1989). Thus, the aim of this study is to evaluate wind waves generation as well as its action on surficial sediments in the intertidal flats.

Methods

A preliminary set of time series have been obtained through field experiments carried out in during the winter, i.e. the most favourable period for strong winds, expecially western winds associated with atlantic low pressures. Experiments consisted of continous high-frequency recording of water level, bed level, velocity currents and suspended sediment concentration provided by respectively ultrasonic Altus altimeters (Verney et al., 2006), ADV velocimeters and OBS turbidimeters. Instruments were deployed together in three intertidal stations of the esatern edge of the lagoon, where accretion is supposed to be the highest.

A first attempt carried out in march 2005 in the absence of any significant wind provided good estimations of residual sediment fluxes induced by tidal currents over a fortnightly tidal cycle (Susperregui, 2005). A second successful deployment was performed between december 2006 and february 2007. At this occasion, five supplementary altimeters were deployed in the central area of the lagoon, giving a better spatialized information of generation and propagation of wind waves over the entire surface of the bay.

Results

Collected data showed that western winds higher than 8 m/s can generate wind waves of more than 10 cm high with periods of 2 s. They also gave evidence of an increase of the wave height when tidal currents and wind are in the same direction.

Interesting features of wind wave generation were obtained on december 8th. Western wind speed reached 20 m/s, generating waves of more than 40 cm, with periods between 4 and 5 s. The fetch effect is suggested by the evolution of wave parameters during the tidal cycle, as signficant height (Hs) and period (T) increase with the tide level and reach maximum values at High Tide. Also, there is a west-east gradient, with highest waves near the east edge, where the fetch distance is the largest.

In terms of sediment response, the altimeters recorded significant erosion during the windy episod of Dec 8th (figure 1). As an example, Station 01 shows important remobilisation of surficial sediment, with no clear trend to erosion or accretion. This station corresponds to a central location where surficial sediment is a sand-mud mixture leading to formation of ripples. Stations 03 and 04 are situated on a muddy bed in the eastern part of the lagoon. They show a more clear erosion, as the bed level (given by the distance from the aoucstic probe in mm) increases for about 10 mm. Before and after this windy episod, the bed shows relative stability.

In terms of forcing, bottom shear stress generated by wind waves is 10 times higher than shear stress generated by tidal currents (figure 2). Tidal currents generate maximum bottom shear stress of 0,5 N/m2 and resuspension of several mg/l, but wind waves cause more significant erosion and bed remobilisation, with a shear stress of 3-4 N/m2. Figure 2 shows that suspended sediment concentration under wind wave action is in the order of 250 mg/l, whereas the bed experiences erosion of about 1 cm. After the windy episod, under fair weather conditions, the bed tends to recover its initial level, as tidal currents allow residual fluxes from the channel towards the inner part of the flat.

The overall results of these preliminary experiments show that short term bed changes under currents and wave action are at the same order of long-term historic changes in the Arcachon lagoon. They also confirm that in sheltered areas, wind waves are an efficient factor to equilibrate the regular action of tidal currents that tend to promote the sedimentary accretion of the flat. Morphodynamic models in development must take into account for wind forcing, at least in order to predict a more realistic bottom shear stress and subsequent erosion rate.

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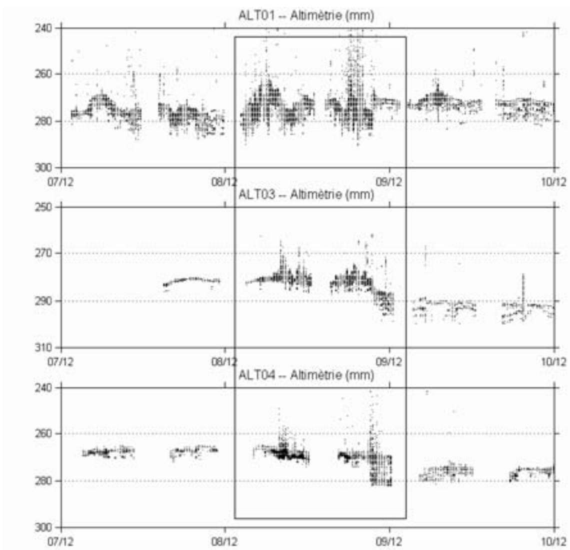

Figure 1 Bed level recorded by the acoustic altimeters at three stations of the Arcachon lagoon. See text for details

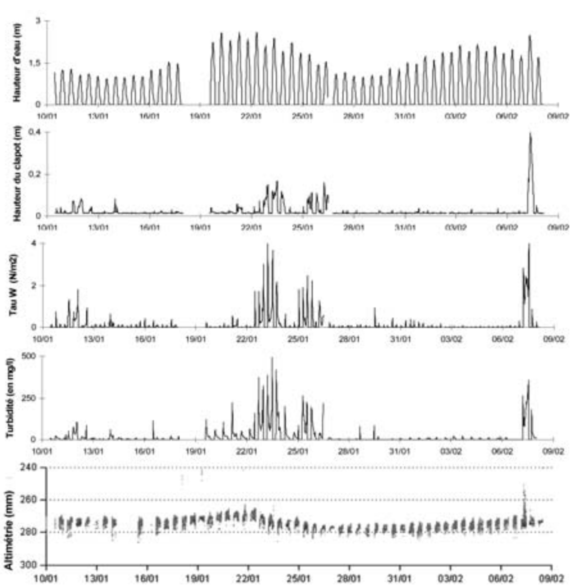

Figure 2 Time series of hydrodynamic forcing and sedimentary response at Le Teich tidal flat. See text for details

Acknowledgements

This work is part of the PNEC Project funded by CNRS-INSU.

References

Christie M.C., Dyer K.R., Turner P., 2001. Observations of long and short-term variations in the bed elevation of a macro-tidal mudflat. In : Coastal and Estuarine Fine Sediment Processes; McAnally, W.H., Mehta, A.J. (Eds.). *Proceedings in Marine Science*. Elsevier Science, Amsterdam, 323–342.

Gassiat L., 1989. Hydrodynamique et évolution sédimentaire d'un système lagune-fleche littorale. *PhD Thesis*, Université Bordeaux 1, 228 p.

Janssen-Stelder B., 2000. The effect of different hydrodynamic conditions on the morphodynamics of a tidal mudflat in the Dutch Wadden Sea. *Continental Shelf Research 20*, 1461–1479

L'Yavanc, J., 1995. Evolutions bathymétriques et morphologiques du Bassin d'Arcachon. Rapport interne, Ifremer DEL/95-12.

Le Hir P., Roberts W., Cazaillet O., Christie M., Bassoullet P., 2000. Characterization of intertidal flat hydrodynamics. *Continental Shelf Research*, 20, 1433-1459.

Susperregui A.S., 2005. Hydrodynamique sédimentaire des estrans vaseux du Bassin d'Arcachon. Rapport de stage de master 2, Université Bordeaux 1, 20 p.

Verney R., Deloffre J., Brun-Cotan JC., Lafite R., 2006. The effect of wave-induced turbulence on intertidal mudflats : Impact of boat traffic and wind. *Continental Shelf Research, 27*, 594-61

Sedimentation on the southern margin of the Bay of Biscay (Basque Country) over the last 40 000 years BP

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Introduction

Since 2003, several geosciences research missions have been performed in southern Bay of Biscay both in capbreton canyon and the shelf in order to recognise the main geomorphological features of the seafloor. The main focus of this research is reconstruct the late glacial and Holocene history of coupled ocean-terrestrial interactions in the Bay of Biscay and to understand the impact of these connections on regional and global climate on time scales of centuries to millennia. Furthermore, we aim to establish the time period when the mud patch settles down, to determine their spatial distribution along the continental shelf and to distinguished the mechanisms controlling the deposition of fine-grained material in this region. Two cores of 2.5 m length sampled both on the shelf mud patch at 114m depth (KS05 10) and on the upper slope at 249 m depth (KS05 05) have been selected for our purpose.

Results and discussion

Chronological framework has been established from 15 14C datings on shelly material. On the shelf, the core sedimentation corresponds to the Holocene period (9044 +- 60 yrs BP Cal at the bottom of KS 05 10) whereas the sedimentation record on the upper slope is up to 40 000 yrs BP with an intermediate value of 28087 +- 100 yrs BP Cal at 1.65 m depth in the core KS 05 05 including the maximum glacial and deglaciation periods (Figure 1).

The grain size data obtained from each centimetric sub samples for the 2 cores vary between 20 to 30 µm whatever their location. It can reach 60 µm in the high carbonate content levels.

On the shelf the stable organic matter content during Holocene period could been explained by a constant supply probably coming from Oria river as observed from the ostracoda fauna species distribution in the surficial sediment.

Conversely on the slope, strong variations are observed in the OM content with a minimum at 0.62 m depth level fitted to the maximum glacial period (18 000 BP Cal dating). During the deglaciation phase, the OM content increases from 0.6 to 2.6%.

The microfaunal study is going on. Nevertheless the presence of fauna linked with the rising of cold waters through secondary canyons located on the southern flank of the Capbreton canyon let think to another source of material coming from deeper zone.

A direct correlation between marine (dinocysts and planktic foraminifera faunas) and terrestrial proxies (pollen) will be performed in the 2 cores, in order to understand the nature, significance and causes of natural climate oscillations over the last 40 000 yr in the southern bay Biscay.

A high resolution pollen analysis of the last 25 000 yr will be carried out to complete the detailed history of vegetation changes in western France.

Core presents an exceptional high sedimentation rate providing detailed centennial/millennial-scale climate variability in terrestrial and marine realms for the entire Holocene. Nevertheless no anthropogenic signal like trace metal has been found neither on top nor within the shelf core contrary to previous results obtained on interface box-cores. This indicates the absence of the upper part of deposit on account of coring process.

Conclusions

1. The shelf sedimentation seems to be substantial with an Holocene record of 2.5 m deposits in thickness. It is environment principally controlled by the terrigeneous supply off basque rivers even if some biological seawards tracers could be recognize.
2. The upper slope is a transfer zone where the sedimentation of the last 40000 yrs BP is condensed in 2.5 m thickness deposits. The main sedimentary deposit is clearly located in the Capbreton canyon acting as a sink
3. The nature of the sediment does not vary in grain size suggesting homogeneous inputs except for MO and carbonate contents that react with time in relation with climate oscillations and sea level variations.
4. This muddy deposit up to 7 m thick seems to be continuous beyond the shelf break. Then it could be considered like a potential source for the Capbreton canyon feeding.

Acknowledgements

This work was partially supported by INSU Thanks to the crews of "Côtes de la Manche" to D.,Poirier and G. Chabaud for their technical support.

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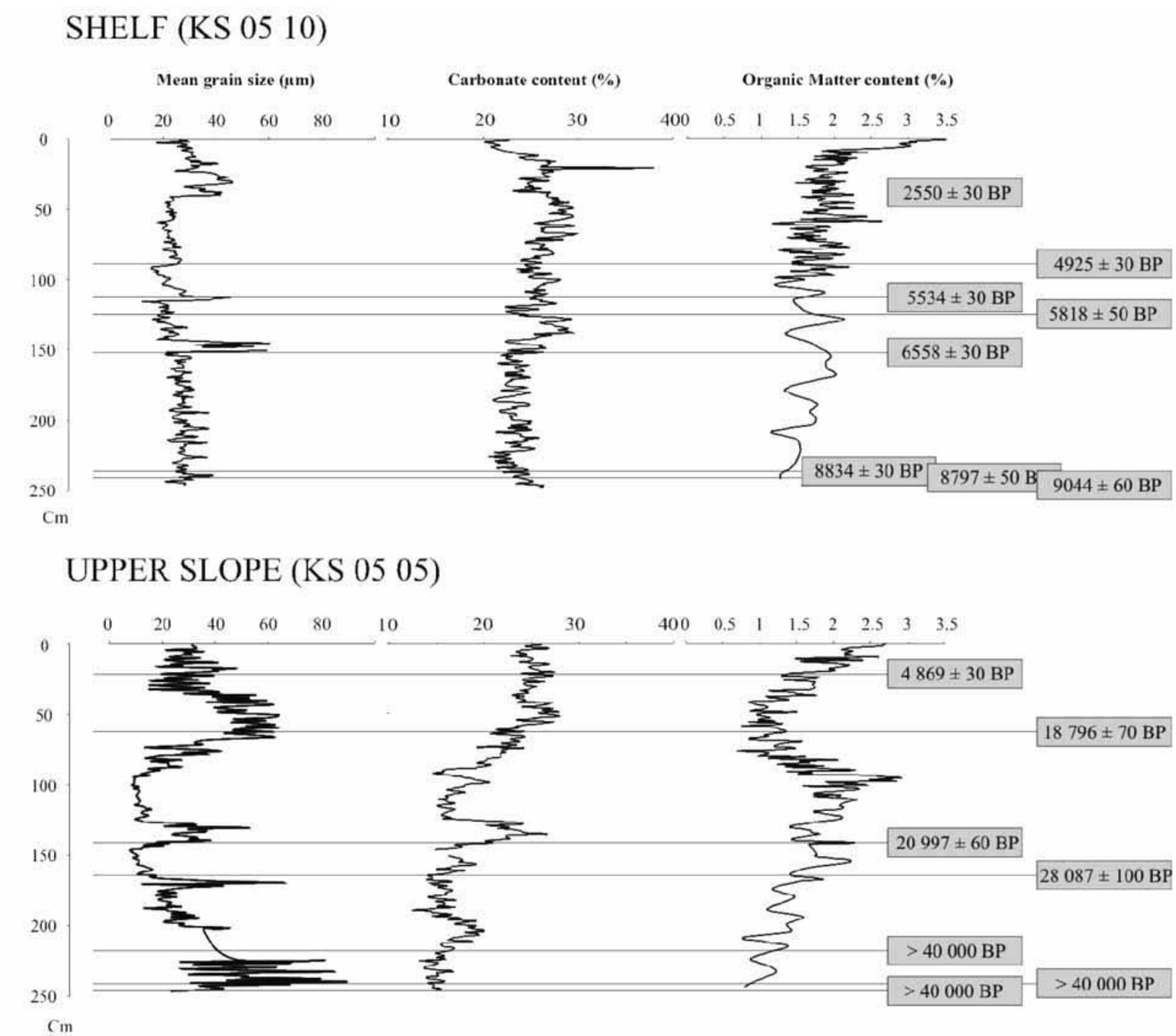

Figure 1. Vertical variations of mean grain size, carbonate content and organic matter content in the two cores

References

Bareille, G., D. Amouroux, O. Weber, J-M Jouanneau, O. F.X. Donard, 2007. Geochemistry of sediment trace metals from both the urban Adour estuary and a mud-patch developed in the south part of the continental shelf of the Bay of Biscay *EGU meeting*, Vienna 15-20 april, abstract and poster.

Gaudin, M, T. Mulder, P. Cirac, S. Berné, P. Imbert, 2006.Past and present sedimentary activity in the Capbreton Canyon, southern Bay of Biscay. *Geo-Mar Lett.* 26, 331_345.

Jouanneau, J-M , O.Weber, N. Champilou, P.Cirac, I. Muxica, A. Borja, A. Pascual, J. Rodriguez-Lazaro, O.Donard. Recent sedimentary study of the shelf of the Basque country. *Journal Marine System*, in press

Pascual, A., J. Rodriguez-Lazaro, M. Martin, J-M Jouanneau, O. Weber Pollution in the Basque Shelf evidenced by the benthic microfauna (Foraminifers, Ostracods) *Journal Marine System*, in press

Rey, J.J., T. Medialdea, 1989. Los sedimentos cuaternarios superficiales del margen continental español. *Publicaciones especiales del Instituto español de oceanografia*, 3.

Uriarte, A., M. Collins, A. Cearreta, J. Bald, G. Evans, 2004. Sediment supply, transport and deposition: contemporary and Late Quaternary evolution. In: *Oceanography and marine environment of the Basque Country* (Eds A. Borja and M. Collins), pp. 97-131.

Preliminary data about planktonic foraminifera assemblages and Heinrich events record from Galicia continental slope

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Introduction

The GeoB 11035 gravity core was retrieved at 65 km of the western Galician coast, in the upper continental slope on board the R/V "Poseidon" during the cruise GALIOMAR in Augost-September 2006 at 2000 mbsl.

The main goals of this work are:

1) To characterise the planktonic foraminifera assemblages and to identify the main faunal events.

2) To detect the influence of icebergs discharge in the studied region.

3) To establish a preliminary chronostratigraphic framework of the studied core.

4) To interpret the paleoceanographic/paleoclimatic evolution of the region.

The hydrography of Galicia is governed by the North Atlantic subtropical gyre that, together with dominant shelf winds, determine the influence of a strong, seasonal and recurrent upwelling-downwelling dynamic (Varela et al., 2005). This area constitutes the northernmost limit of the North Atlantic upwelling system and the position of the studied core is close to the west limit of this upwelling system (Abrantes *et al.* 1991).

The circulation of surface waters is controlled by the Portugal Current that is a broad and slow branch of the North Atlantic Drift (NAD). Subsurface water is the Eastern North Atlantic Central Water (ENACW) which includes all mode waters formed eastward of the Mid-Atlantic Ridge (Varela *et al,* 2005). The ENACW is composed by two members, one warmer and saltier from subtropical origin ($ENACW_{st}$) and the other one colder and less saline from subpolar origin ($ENACW_{sp}$) (Harvey *et al.* 1982). The depth of that branch depends mainly of the winter intensity, but never more than 500 m. At current conditions, between 450 and 1100 m the Mediterranean Outflow Water (MOW) is present. Deeper, at around 1500 mbsl, the Labrador Sea Water (LSW) is bathing the slope, where core GeoB-11035 was retrieved. The bottom water, below 3000 m, is the North Atlantic Deep Water (NADW). Nowadays the influence of the Antarctic Bottom Water (AABW) is weak at these latitudes and it is strongly mixed, but during glacial times this water mass could influence the abyssal plain and the lower continental slope.

Over the last 50 ky five Heinrich events (HE) were found in the North Atlantic sedimentary record. These layers are composed by lithic fragments, ice rafted debris (IRD), which were deposited by the massive melting of icebergs delivered from the northern ice caps. These icebergs arrived to the Galician margin following the North Atlantic anticyclone polar surface circulation. Evidences of these events have been described at this latitude (Vidal *et al.* 1997,Abreu *et al.,* 2003) and even southwards, off to the San Vicente Cape (Lebreiro *et al*., 1996)

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Methods

In a preliminary analysis 40 samples were taken at 16 cm intervals covering the whole core (500 cm length). Samples were wet sieved using 150 μm and 63 μm mesh. The 150 μm fraction was split in order to obtain at least 300 specimens of planktonic foraminifera. A quantitative analysis of recorded planktonic foraminifera species were performed following the taxonomic criteria of Bé (1977) and Kennett and Srinivasan (1983). At the same time, other micropaleontological components and lithic grains were counted.

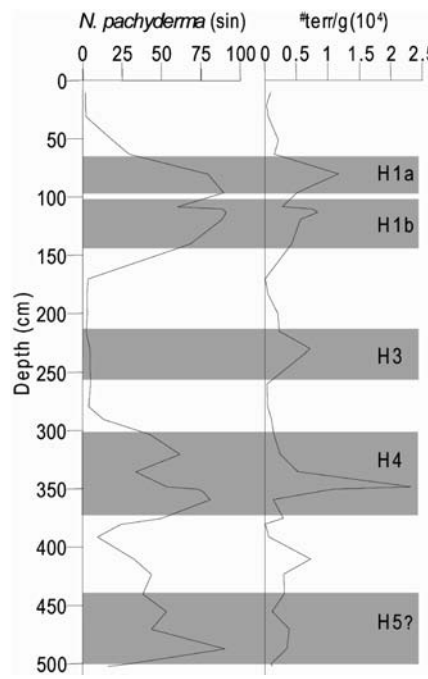

Figure 1: Correlation between *N. pachyderma* (sin) and terrigenous grains abundances.

Results and interpretation

Eighteen planktonic foraminifera species have been identified all of them belonging to this area (Duprat, 1983). In the whole set of samples only two species, *Neogloboquadrina pachyderma* (Ehrenberg) and *Globigerina bulloides* (d'Orbigny) account for more than 70% of the total assemblage, excepted the youngest 60 cm. Both species show a similar percentage in most part of samples, but at certain levels the left coiling forms of *N. pachydema* reach up to 90% of the assemblages (Figure 1). This typical polar form only reaches such a large abundance at mid latitudes of the northern hemisphere during Heinrich events, when cold polar waters invaded this region due to the massive melting of icebergs (Lebreiro et al., 1997; Zaragosi et al., 2001, 2006; de Abreu et al., 2003). A good correlation between peaks of *N. pachyderma* (sin.) and terrigenous grains is observed on figure 1. Because of that, levels characterised by high content of polar species and terrigenous particles can be certainly identified as Heinrich events.

According to the aforementionated data, the Holocene and four Heinrich events are clearly identified that we tentatively interpret as H1, H3, H4 and H5. This interpretation is based on three AMS ^{14}C analyses at levels at levels 58 cm, 135 cm, and 496 cm combined with a linear interpolation of ages using dated levels and the published ages of Heinrich events. These dates are shown on Table 1.

The two youngest peaks of *N. pachyderma* (sin) and lithic grains centred at around 95 cm and 115 cm have been correlated with H1a and H1b. The existence of a double peak during H1 has been documented by many authors in surrounding areas (Lebreiro *et al*., 1996, Cayre *et al*.,1999). The largest abundance of lithic grains recorded at 350 cm coinciding with a double peak of *N. pachyderma* (sin) let us to identify this event with H4, in agreement with the statements of Vautravers and Shackleton (2006). These authors found the strongest influence of icebergs discharge at a southern latitude than core GeoB 11035 at H4 times.

In the studied core, H3 is recorded only by a higher content of terrigenous components at 230 cm, but the percentage of the polar species does not show any increment. Relatively cold fauna dominates the plaktonic assemblages at this level (*N. pachyderma* (dex) and *G. bulloides*) as occurs in the most part of samples excepted samples from the upper 50 cm. The dominance of cold water species must be interpreted in the context of glacial conditions characterising the marine isotopic stage 2 (MIS 2).

The high percentage of *N. pachyderma* (sin) recorded towards the bottom of the core (488 cm) together with relatively low but significant abundance of lithic grains led us to hypothesise the occurrence of H5. A ^{14}C analysis done at 494 cm gives an age out of range but anyway older than 46600 yrs. This data support the interpretation about the presence of H5 which took place at around 50-54 kyrs. According to that, the bottom of the core would record the younger MIS 3.

H2 has not been recorded in the studied core. Probably it is due to the low resolution of sampling. Further analyses will let us a more detailed and precise interpretation of this core.

According the aforementioned data a preliminary chronostratigraphy of core GeoB 11035 can be established taking into account dated levels and the age of Heinrich events. These ages of control are shown on Table 1.

Depth (cm)	Event	Age (kyrs.)
50	Warm fauna	10.0
58	^{14}C	12.77±0.06
95	H1	13.0-16.0
135	^{14}C	17.54±0.26
215	H3	25.0-28.0
350	H4	35.0-38.0
488	H5	50.0-54.0
494	^{14}C	>46.0

Acknowledgements

Funding for this work was supported by the Xunta de Galicia projects PGIDIT05PXIB31201PR and *Análise das Evidencias e Impactos do Cambio Climático en Galicia* (Ref: CO-028-07).

References

Abrantes, F., 1991. Increased upwelling off Portugal during the last glaciation: diatom evidence.Marine Micropaleontology 17, 285–310.

Abreu, L. de, N. Shackleton, J. Schoënfeld, M. Hall, ,M. Chapman, 2003. Millennial-scale oceanic climate variability off the Western Iberian margin during the last two glacial periods. *Marine Geology.*, 196: 1-20.

Bé, A.W.H. 1977. An ecological, zoogeographic and taxonomic review of recent planktonic foraminifera. In: A. T. S. Ramsay (Ed.), *Oceanic Micropaleontology*, Academic Press, New York.1–100.

Cayre, O., Y. Lancelot, E. Vincent, 1999. Paleoceanographic reconsructions from planktonic foraminifera off the Iberian Margin: Temperature, salinity, and Heinrich events. *Paleoceanography,* 14:384-396.

Duprat, J 1983. Les Foraminiféres planctoniques du Quaternaire terminal d'un domaine péricontinental (Golfe de Gascogne, Cotes Ouest-Iberiques, Mer d'Alboran): Ecologie-Biostratigraphy, *Bulletin de l'Institut de Géologie du Bassin d'Aquitaine* 33, 71–150.

Harvey, J., 1982. θ–S relationship and water masses in the Eastern North Atlantic. Deep-Sea Res. 29, 1021– 1033

Kennet J.P. and Srinivasan M.S. 1983. Neogene planktonic foraminifera. A phylogenetic atlas.- Hutchinson Ross Publishing Company, Stroudsburg, Pennsylvania, 265 p.

Lebreiro, S.M., J.C. Moreno, I.N. McCave, and P.P.E. Weaver,1996. Evidence for Heinrich layers off Portugal(Tore Seamount:39ºN, 12ºW). *Marine Geology,* 131, 47-56.

Lebreiro, S.M., Moreno, J.C., Abrantes, F.F. & Pflaumann, U. 1997. Productivity and paleoceanographic implications on the Tore Seamount (Iberian Margin) during the last 225 kyr: Foraminiferal evidence. *Paleoceanography*, 12: 718-727

Vautravers, M.J. and N.J. Shackleton, 2006. Centennial-scale surface hydrology off Portugal during marine isotope stage 3 : Insights from planktonic foraminiferal fauna variability. *Paleoceanography*, 21(3) PA3004.

Varela, R.A., G. Rosón, J.L. Herrera, S. Torres-López, Á. Fernández-Romero, 2005. A general view of the hydrographic and dynamical patterns of the Rias Baixas adjacent sea area. *Journal of Marine. Systems*, 54: 97-113.

Vidal, L., L. Labeyrie, E. Cortijo, M. Arnold, J.C. Duplessy, E. Michel, S.Becqueì, T.C.E. Van Weering, 1997. Evidence for changes in the North Atlantic Deep Water linked to meltwater surges during the Heinrich events (1997) Earth and Planetary Science Letters, 146 (1-2): 13-27.

Zaragosi, S., F. Eynaud, C. Pujol, G.A. Auffret, J.L. Turon, T. Garlan. 2001. Initiation of the European deglaciation as recorded in the northwestern Bay of Biscay slope environments (Meriadzek Terrace and Trevelyan Escarpment): a multi-proxy approach. *Earth and Planet. Sci. Lett.*, 188. 493-507.

Zaragosi, S., J.F. Bourillet, F. Eynaud, S. Toucanne, B. Denhard, A. Van Toer, V. Lanfumey. 2006. The impact of the last European deglaciation on the deep-sea turbidite systems of the Celtic-Armorican margin (Bay of Biscay). *Geo-Marine Leters.*, 26. 317-329.

The impact of an intra-estuarine dam on sedimentation, sedimentary record and potential release of metals: the case of the Charente estuary

Aymeric Dabrin[a], Eric Maneux[a], Sabine Schmidt[a], Jörg Schäfer*[a] and Gérard Blanc[a]

Introduction

The Charente River (southwest France; Fig. 1), drains a watershead of about 10 000 km². The mean annual discharge of the Charente River at the Chaniers site, i.e. upstream from the tidal limit was 55 m^3/s during 2004-2007 (DDE, Charente Maritime). The Charente Estuary represents the main direct pathway of continental water and particles into the Marennes-Oléron Bay, the most important oyster production zone in Europe.

The Charente estuary displays a tidal range of up to 7 m, with the tidal influence reaching the city of Saintes (Fig. 1) and a pronounced maximum turbidity zone (MTZ). Suspended Particulate Matter (SPM) concentrations in the MTZ typically reach values >1 g/l in surface water. One particularity of the Charente Estuary is the presence of an intra-estuarine dam-system built in 1957 at Saint Savinien (Fig. 1). The system consists of two dams: One dam with fix height on the natural branch and one of variable height on an artificial bypass are used to control the water level in the upstream estuary (navigation). However, as the dam system is located in the tidal zone it has to be opened during high tide. During this periods, highly turbid water (MTZ) intrudes into the reaches upstream from the dam, inducing important sedimentation/resuspension cycles as function of dam management, tide and river discharge.

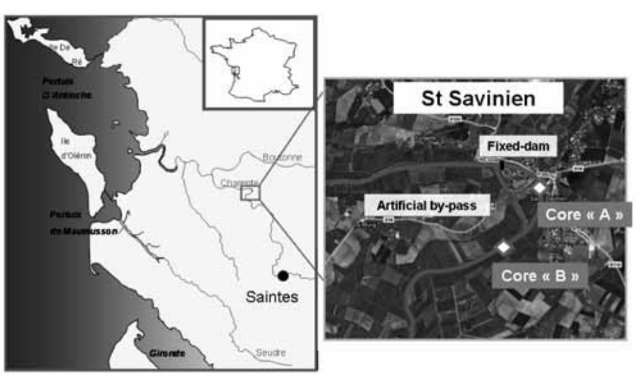

Figure 1. Localisation of the study area and the sediment cores.

Sediment accumulation upstream from the dam has strongly reduced the flow section contributing to flooding of the adjacent areas during high discharge events. The present study contributes to the assessment of the potential impact of dredging these sediments. In fact, fluvial-estuarine sediment may represent temporary sinks and important secondary metal sources to the coastal environment and particularly to the seafood production zones. Accordingly, this work aims to determine the sedimentation rates and the vertical trace metal distribution. The potential release of trace metals (particularly Cd) after dredging-induced re-suspension was assessed by desorption experiments and the major metal carrier phases (solid state partitioning) were identified by selective extractions.

Methods

In August 2005, two sediment cores were sampled upstream from the dam at Saint Savinien (Fig. 1). The core "A" (2.2 m length) was taken in the natural branch of the Charente River and the core "B" (4.8 m length) upstream from the dam in the bypass (derivation channel). The cores were immediately sliced with resolutions of 2 cm and 5 cm for the cores "A" and "B", respectively. Grain size distribution in each sample was determined by laser diffraction (Malvern Mastersizer). Sedimentation rates were estimated from ^{137}Cs and ^{210}Pb activities along the two cores.

Total element concentrations mineralization of trace metals was realised by tri-acid digestion in closed PP reactor (DigiTUBEs) according to a protocol described elsewhere (e.g. Schäfer et al. 2002, Audry et al. 2004 and Masson et al. 2007). Parallel selective extractions were performed to extract metals associated with four different operationally-defined solid fractions: exchangeable/carbonate, reactive Fe- and Mn-oxy/hydroxides, organic matter/sulphides and acid soluble. Although the choice of selective extracting chemicals is based on commonly applied sequential extraction schemes (e.g. Tessier et al., 1979), we applied a modified protocol (Audry et al., 2006) to avoid/reduce artefacts e.g. due to limited selectivity of the different extractants.

The obtained solutions were analyzed by ICP-MS (X7, THERMO) with external calibration. The analytical methods employed were continuously quality checked by analysis of certified reference sediments (IAEA 405, BCR 320). Accuracy was within 5% of the certified values and the analytical error (relative standard deviation) was generally better than 5% for concentrations ten times higher than detection limits.

Results and discussion

In western Europe, airborne ^{137}Cs was mainly introduced by "worldwide" nuclear tests in 1963-1965 and during the Tchernobyl accident in 1986. Radiocesium activities in both cores were constant with depth (Fig. 2), suggesting that

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sediments were deposited after 1986. Accordingly, minimum sedimentation rates were roughly estimated >11 cm/a and >25 cm/a for the cores "A" and "B", respectively. This is coherent with average sedimentation rates estimated from indirect dating with ^{210}Pb (Figure 2): 12cm/a (core "A") and 35cm/a for the core "B". Based on these average sedimentation rates, approximative sediment age in the bottoms of the cores was estimated (Core "A": 1992 and Core "B": 1994). Both cores covered the whole sediment column at the respective sites (i.e. from the water/sediment interface to the rocky bottom; confirmed by acoustic measurements, data not shown). These observations suggest complete erosion of the sediments accumulated between 1957 and 1992/94 during major ("once in a century") flood events in 1982 and 1994 (DDE Charente Maritime). Grain size distribution in both cores was very constant over depth with median grain sizes of 7.7±0.6 µm.

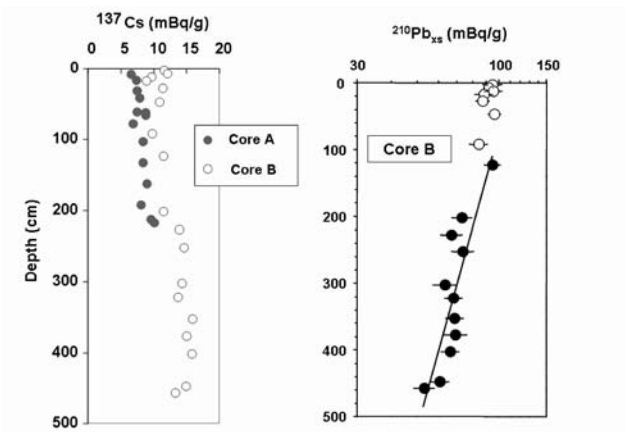

Figure 2. ^{137}Cs activity in the two cores and ^{210}Pb activity in the "B" core

Trace element profiles display constant Cu (19±2 mg/kg), As (21±2 mg/kg), Pb (59±5 mg/kg) and U (2±0.1 mg/kg) concentrations over depth in both cores. The observed concentration levels are similar to those in estuarine SPM rather than in fluvial particles, suggesting that the accumulated sediment is mainly derived from the estuary.

In contrast, Hg and Cd display different vertical distributions (Fig. 3), with relatively low and constant values in the upper sediment layers (<80 cm in core "A"; <200 cm in core "B"). Deeper in the sediment, a clear shift towards higher and more variable concentrations occurred. This important discontinuity probably reflects modified sedimentation mode and/or sediment origin after ~2003 (2002-2004). The relatively low Cd concentrations in the upper sediment layers might suggest an increased contribution of estuarine (i.e. partially Cd-depleted) particles under recent conditions.

Maximum concentrations of both, Cd and Hg occurred in the bottom layers of the two cores, eventually reflecting historical riverbed contamination. Further work is needed to better assess the historical evolution of geochemical signals in the Charente River sediments as a function of landuse, industrial evolution, etc.

Desorption experiments simulating the estuarine salinity and turbidity gradients, suggest important potential Cd release under estuarine conditions. Both, desorption experiments and selective extractions suggest that the Cd concentration in the residual fraction (= silicate-bound?) was 0.2-0.25 mg/kg. Accordingly, an important part of the metals accumulated in the Charente estuary sediments at St Savinien are carried by reactive phases. Natural and/or anthropogenic resuspension may potentially result in important metal remobilization during estuarine dissolution processes, increasing their potential bio-availability. For example, the amount of potentially desorbable Cd in the sediment behind the dam represents ~800 kg. For comparison, the estimated dissolved Cd flux transported by the Charente River in 2006 was 35 kg.

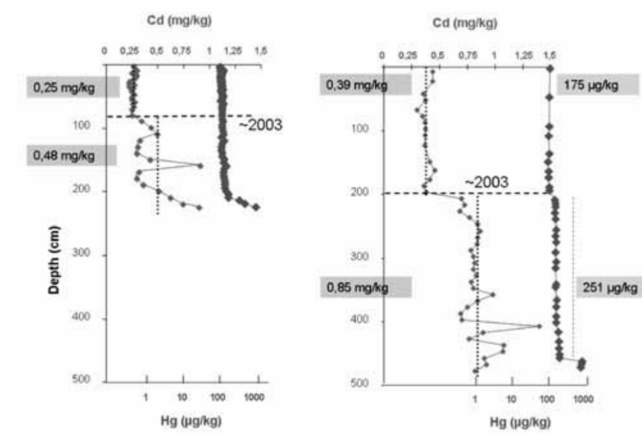

Figure 3. Cadmium and Hg concentrations in the two cores.

Acknowledgements

This study was supported by grants from EPTB Charente, Agence de l'Eau Adour Garonne, «Ministère de la Recherche» and «La Région Aquitaine». We gratefully acknowledge D. Tafforet for the field work support and the following colleagues for their contribution to field work and analytical support: S. Castelle, H. Derriennic, N. Girardot, M. Masson and G. Oggian.

References

Audry, S., G. Blanc, J. Schäfer, 2004. Cadmium transport in the Lot-Garonne River system (France) – temporal variability and a model for flux estimation, *The Science of The Total Environment*, 319:197-213.

Audry, S., G. Blanc, J. Schäfer, 2006. solid state partitioning of trace metals in suspended particulate matter from a river system affected by smelting-waste drainage, *The Science of The Total Environment,* 363: 216-236.

Masson, M., J. Schäfer, G.Blanc, P. Anschutz, 2007. Seasonal variations and annual fluxes of arsenic in the Garonne, Dordogne and Isle Rivers, France, *The Science of The Total Environment*, 373 :196-207.

Schäfer, J., G. Blanc, Y. Lapaquellerie, N. Maillet, E. Maneux, H. Etcheber, 2002. Ten-year-observation of the Gironde tributary fluvial system: fluxes of suspended matter, particulate organic carbon and cadmium, *Marine Chemistry*, 79: 229-242.

Tessier, A., P.G.C. Campbell, M. Bisson, 1979. Sequential extraction procedure for the speciation of particulate trace metals, *Analytical Chemistry*, 51: 844–851.

Sandy tidal sediments of the Aquitaine coast as biogeochemical reactors

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Introduction

Water that replaces pore space air of sandy sediment of Aquitaine tidal beaches during flood tide is coastal seawater. Water that leaves the pore space during ebb tide is transformed seawater, because of organic matter mineralization processes that occur during the the residence of water into the sediment. This observation has been made during a survey of pore water chemistry of tidal permeable sediment of the Aquitaine coast.

Sandy sediments of continental shelves and most beaches are often thought of as geochemical deserts because they are usually poor in organic matter and other reactive substances. Based on the belief that importance of sedimentary environment is proportional to its own stock of reactants and organic matter, sandy sediments are generally neglected (see discussion in Boudreau, 2001). Recent observations are fortunately changing this obsolete point of view: The property which makes sandy sediment different of muddy sediment is the permeability, which controls the transport of pore-waters, and consequently, the fluxes within, and out of the sediment. The advective transport of pore water, which is obvious during ebb and flood tide in sandy sediments of tidal zone, makes this environment particularly transient in term of saturation of water. Bacon et al. (1994) showed that permeable sediments can trap and decompose organic matter efficiently enough to totally consume organic matter. Aquitaine coastal beach sediments represent extreme case of advective transport of pore waters, due to very high permeability, waves and tides.

The present study focuses on analyses of dissolved biogenic compounds of surface seawater and pore waters at low tide on a dynamic sandy beach with a 4 m high tidal amplitude.

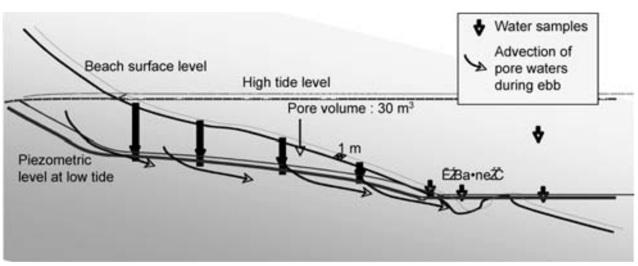

Figure 1. Schematic representation of a cross shore section and water sampling locations. Interstitial water samples were collected at low tide in holes at the level where sediment becomes saturated with pore water.

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Methods

To quantify biogeochemical reactions that take place in such environment, we collected pore waters at low tide on tidal cross shore transects, at the depth of water saturation zone (Fig. 1). We measured temperature, salinity, oxygen saturation state, and nutrient concentrations. These parameters were compared to the values measured in the seawater that enters the interstitial environment during flood. Cross shore topography and position of piezometric level at low tide was obtained from kinematics GPS measurements. Residence time of pore waters was estimated by a tracer approach, using dissolved silicate concentration and kinetics of quartz dissolution with seawater. Kinetics parameters were obtained from 20 days incubation of sediment with seawater, during which dissolved silicate concentration was monitored.

Figure 2. View of the Aquitaine coast at low tide, and water sampling location.

Results

Pore waters were collected close to the surface in the lower part of the beach, and at 2 m depth in the upper part. The volume of water that enters the pore space at each flood tide, and that is replaced by air at low tide represents about 30 m^3 at the Truc Vert beach, when considering an average tide amplitude, the cross shore extent of the tidal beach, and a longshore length of 1 m (Fig. 1). Oxygen saturation of seawater was close to 100%, whereas it was as low as 80% in pore waters. Concentrations of dissolved nutrients were higher in pore waters than in seawater. These results suggest that aerobic respiration occurred in sands.

Nutrient concentrations were the highest in pore waters collected in sediments of the lower beach, which suggests that pore waters were "older" than in the upper beach. Samples collected in seawater trapped at low tide by transverse rip and bar systems ("baïne") (Fig. 2) are characterised by dissolved nutrient enrichments, which suggests that "baïnes" accumulated pore waters that were extruded form the sand at low tide. Silica concentrations of up to 25 µM were measured in several baïnes along the Cap Ferret coast, whereas concentrations of only 5 µM were found in seawater. Sands incubation experiments indicated that dissolved silicate enrichment was the result of quartz dissolution during percolation of seawater through beach sediment. Dissolution kinetics obtained from incubation were comparable to results obtained from quartz dissolution (Dove, 1994). Therefore, dissolved silica concentrations can be used as a residence time tracer of interstitial waters in sandy sediments. We found that seawater that entered the sediment during flood tide remained between 6 hours to more than three days (1 to 7 tidal cycles) within the interstitial environment.

Oxygen deficit in interstitial waters, and nitrate and phosphate enrichments more or less matched with the stoichiometry of Redfield-type organic matter mineralization. For example, for a mean deficit of 38 µM of oxygen, we measured an increase of 5.7 and 0.26 µM of nitrate and phosphate, respectively. This suggests that origin of mineralized organic matter was plankton material that infiltrated into sediment with water during flood tide. Therefore, sandy tidal sediment of the Aquitaine coast is a biogeochemical reactor, which promotes or accelerates remineralization of coastal pelagic primary production.

Some pore water and baïne samples showed salinities lower than seawater salinity, which suggests that continental ground waters are drained as well during ebb tide. We observed a fairly good correlation between salinity and nitrate concentrations. For the Truc Vert beach, nitrate concentration of the 0 salinity end member is 60µM.

Conclusions

Water mass balance shows that at each tide 30 m^3 of water are evacuated towards the ocean for each longshore 1 meter. Our results suggest that it represents roughly 0.1 to 0.2 moles of nitrate and 0.005 to 0.01 moles of phosphate at each tide (again for a longshore section of 1 m). Considering the whole Aquitaine coast, this corresponds to a diffuse supply towards the coastal ocean of 25 000 to 50 000 mole of nitrate, and 1300 to 2600 mole of phosphorus per tidal cycle. This represents only 1 to 2% of nitrate and about 3 to 6% of phosphorus supplied by the Gironde estuary to the Bay of Biscay. However, it represents a diffusive, local, and permanent contribution that does not depend on runoff or currents. Therefore, it can represent close to the coast a major contribution of nutrients.

Acknowledgements

This is a contribution of the program PNEC – AT BENTIDAL

References

Bacon, M. P., R. A. Belastock and M. H. Bothner. 1994. ^{210}Pb balance and implications for particle transport on the continental shelf, U.S. Middle Atlantic Bight. Deep-Sea Research II, *41*, 511-535.

Boudreau, B. P., M. Huettel, S. Forster, R. A. Jahnke, A. McLachlan, J. J. Middelburg, P. Nielsen, F. Sansone, G. Taghon, W. Van Raaphorst, I. Webster, J. M. Weslawski, P. Wiberg and B. Sundby. 2001. Permeable marine sediments: overturning an old paradigm. EOS, *82*, 133-136.

Dove P.M. (1994) The dissolution kinetics od quartz in sodium chloride solutions at 25° to 300°C. Amer. J. Sci., 294, 665-712.

Sediment fluxes between the Marennes-Oléron bay and the adjacent shelf of the bay of Biscay: a numerical study.

Pierre Le Hir*[a] , Isabelle Brenon[b] , Jean-Yves Stanisière[c], Stéphane Kervella[c] and Patrice Walker[d]

Introduction

The Marennes-Oléron bay is a 10 km x 20 km semi-enclosed bay connected to the continental shelf of the bay of Biscay through two tidal inlets, the Antioche inlet, rather large, and the Maumusson inlet, very narrow (Figure 1). The bay is shallow and characterized by large intertidal flats occupied by the largest shellfish farms in Europe. Sediment is mixed in the area, with sand-dominated channels and muddy tidal flats. A comparison between ancient and recent bathymetric charts shows a sediment infilling during the last two centuries and a 20% decrease of the water volume together with a decrease of the Maumusson inlet cross-section (Bertin et al., 2005). For environmental and economic purposes, the question of a possible continuation of the trend becomes crucial, and the role of human activities as the oyster farming itself arises.

As an input for answering this question, the present study aims to describe the particulate fluxes in the area, and especially their variability according to different forcings, either natural (tides, winds, riverflow and waves) or artificial (shellfishing activities). For this purpose, a process-based mathematical model is used.

Methods

In order to simulate the simultaneous transport of sand and mud and to account for their possible interactions, for instance through consolidation processes, a new sediment transport software has been developped : it includes a circulation model, a sediment model and a specific procedure for wind-wave action based on SWAN simulations (Le Hir et al., 2007).

Circulation model

The depth-averaged version of the SiAM model is used (Brenon & Le Hir, 1999). The computational grid is cartesian but irregular (finite differences scheme). Real forcing conditions are considered: observed winds and Charente river flow, harmonic predictions of tide provided along the boundary by the CST-France model from the French Hydrographic and Oceanographic Department (SHOM). Water level and currents are respectively validated by means of SHOM data and ADCP measurements of the programme REPER.

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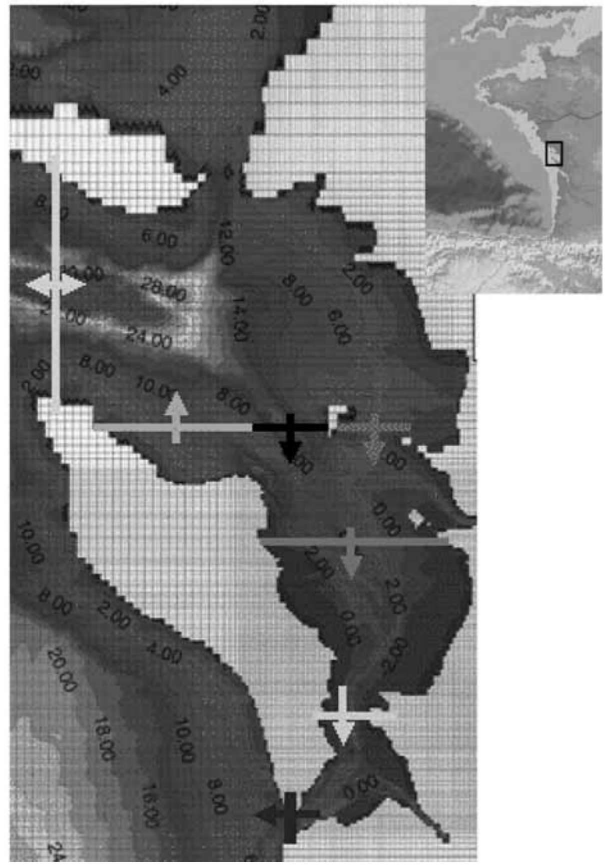

Figure 1. map of the study area, showing the model grid and sections where particulate fluxes are computed

Waves calculation

The SWAN model from Delft U.T. has been run for 12 representative scenarii of wind in the area and 7 typical water levels along a spring tide. Then a distribution of wave-induced bottom shear stresses can be computed at any moment, after a double interpolation (on wind intensity and tidal phase).

Sand/mud sediment model

The state variables of the model are different classes of primary particles, generally classified according to their size, and grouped in categories that are either transported as bedload or in suspension. The bed is described as thin layers characterized by a distribution of these classes. The number of layers and their thickness depend on erosion, deposition and consolidation processes. For sand/mud mixtures, the erosion law differentiates cohesive and non cohesive behaviours, according to the mud fraction. The consolidation module is based on the Gibson equation formulated for each class concentration, and modified to account for segregation. In the deposition module, new deposits may be managed in different ways (production of a new layer or mixing in the surficial layer) depending on the mud fraction and its relative concentration. Validation is achieved by means of turbidity measurements and local erosion/deposition observations.

Results

In a first step, the respective contributions of wave and current forcings on the bed are estimated by analysing statistics of the computed bottom shear stress during a 3 month simulation in winter (Figure 2). The dominance of waves (or current) proves to be dependent on the critical shear stress for erosion, which is lower for fine sand than for consolidated mud.

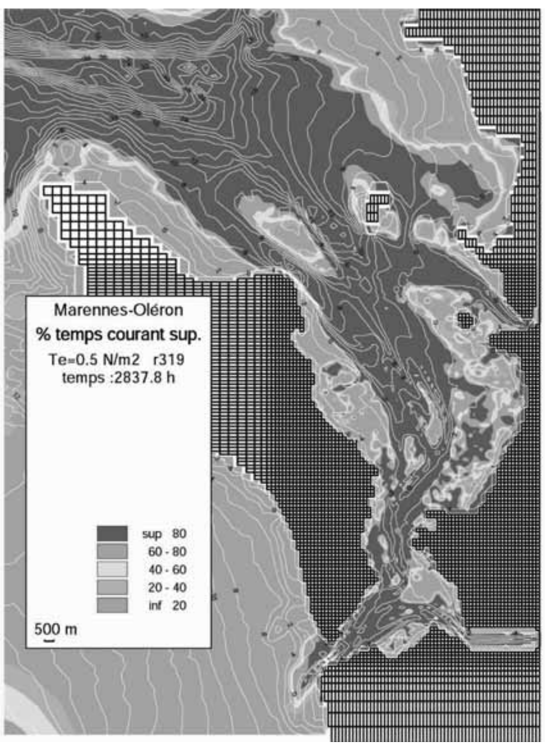

Figure 2. Distribution of wave-dominated or current-dominated shear stresses in excess of a critical stress of 0.5 Pa

Results of sand and mud transport are being presented in terms of erosion/deposition of each fraction after several months, and simulation of turbidity patterns for different forcing scenarii (tide, storms…). Possible changes of surficial sediment facies are shown. Then particulate fluxes through different cross-sections located on figure 1 are discussed (figure 3). Their variations can be related to the tidal amplitude (for sand and mud) or to meteorological events (for mud only). The erosion of the West-Gironde subtidal muddy area, nourished by the Gironde plume is shown to input the Marennes-Oléron bay during south-west storms.

Discussion

Many uncertainties are likely to modify results and sediment balance (boundary conditions, sediment behaviour…): a sensitivity analysis is presented. Last, the necessity to account for morphodynamical coupling is discussed.

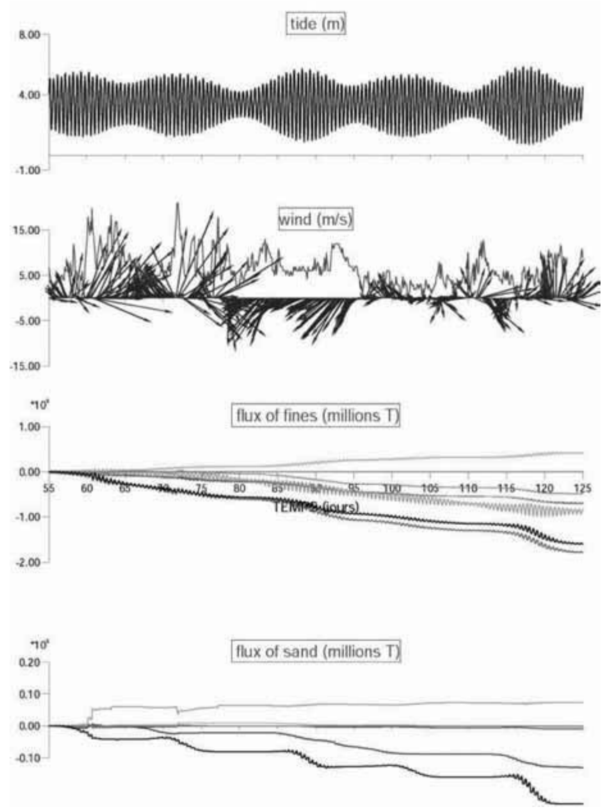

Figure 3. Simulated time evolution of sediment fluxes in relation with tide and wind forcings *(see figure 1 for location of fluxes, identified by their colour)*

Acknowledgements

This study has been partly supported by the french Programme National Environement Côtier (PNEC) entitled “Chantier littoral Atlantique” and by the Conseil Général Charente Maritime (contract N° 104213). ADCP measurements have been supported by the programme REPER from the Poitou-Charente region.

References

Bertin X., Chaumillon E., Sottolichio, A. and Pedreros, A. 2005. Tidal inlet response to sediment infilling of the associated bay and possible implications of human activities: The Marennes-Oléron Bay and Maumusson Inlet, France. Continental Shelf Research, Volume 25, Issue 9, 1115-1131.

Brenon I., Le Hir P., 1999. Modelling the turbidity maximum in the Seine estuary (France): identification of formation processes. Estuar. Coast. Shelf Sci. 49, 525-544.

Le Hir P., waeles B. and Cayocca F., 2007. Dynamics of sand and mud mixtures : a new modelling strategy. Proceedings of the Intercoh’07 conference, Brest, 25-28 sept.

Pockmarks on the southern margin of the Capbreton Canyon (south-eastern Bay of Biscay)

Hervé Gillet*[a], Pierre Cirac[a], Blandine Lagié[b]

Introduction

The Capbreton canyon is located in the southern parts of the Bay of Biscay along the offshore westward extension of the Pyrenean fordeep (Deregnaucourt and Boillot, 1982). This canyon, described in detail by Cirac et al. (2001), lies on the boundary between two major structural zones: the stable Aquitanian passive margin to the north, and the Basque–Cantabrian former active margin to the south. We describe here recently discovered pockmarks located on this last narrow margin, on the edge of the canyon, offshore Zumaia (Basque Country).

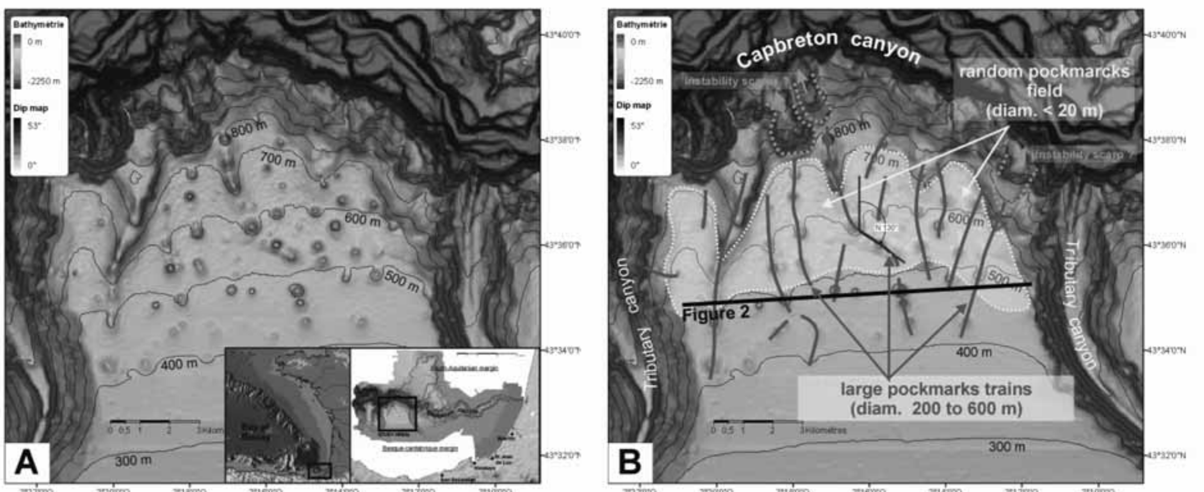

Figure 1. Multibeam bathymetric map (EM 300) of Costarrenkala interfluve on which the studied pockmarks are located. Grayscale corresponds to dip map of the area. A: raw data; B: interpreted map.

Pockmarks are cone-shaped circular or elliptical depressions that occur on the seafloor of most of the continental margins of the World. These features ranging from a few metres to several hundred meters in diameter are related to active or fossil fluid escape (in Gay et al., 2006; Hovland, 1984; King and MacLean, 1970). Because of the nature of the fluids expelled (CO2, CH4, H2S), the consequences of they expulsion (greenhouse effect, slope instability) and they economics interest, study of the pockmarks deals with fundamental and societal stakes.

Methods

The present work is based on a double approach combining bathymetric data (multibeam Simrad EM1000) with high-resolution seismic reflection data (Sparker). These geophysical data have been collected by Bordeaux 1 University during ITSAS 2 (2001) and PROSECAN 3 (2006) cruises. The analysis of seismic data followed a classical seismic stratigraphic procedure based on the analysis of the reflection ending and configuration. However, sharp stratigraphic calibration was not yet established for this area.

Results - Discussion

The Basque margin is incised by northward flowing tributaries of the Capbreton canyon. The pockmarks are concentrated on the Costarrenkala interfluve that separates two of these tributaries. The morpho-bathymetric analysis of the area leads to the following observations:

(1) The pockmarks lie on the middle part of the slope (4%) at water depth ranging from 400 to 800 m.

(2) A variety of pockmark features are observed including :

- Randomly distributed small pockmarks (diameter < 20 m)
- Large pockmarks (ranging from 200 to 600 m in diameter) linearly distributed (pockmarks trains) along axis of shallow morphologic troughs that reach down stream the Capbreton canyon.

(3)On of these pockmarks trains shows a N135° oriented segment, as shown by some segments of the Capbreton canyon

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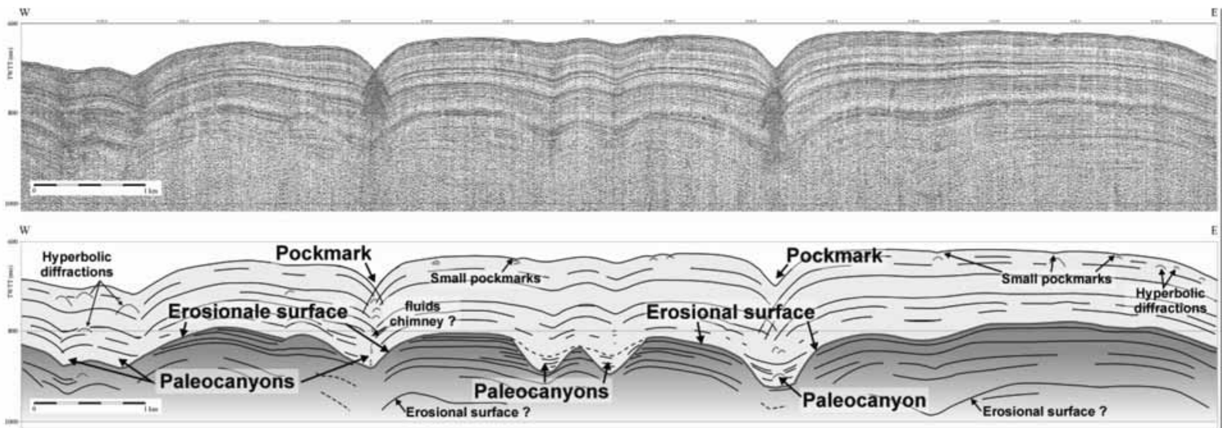

Figure 2 High resolution seismic data interpretation (Sparker). See Figure 1 for position.

and of it tributaries. Such orientation is interpreted as Pyrenean tectonic control.

(4) Some of these pockmarks trains are connected on the edge of the Capbreton Canyon to hemi-circular scarps suggesting relation between pockmarks and slope instabilities.

Morphobathymetric analysis underlines a close relationship between large pockmarks distribution and orientation of the erosional drains of the shelf break. On the one hand, pockmarks trains lie on axis of shallow troughs that could either correspond to just initialised erosional gullies or to moribund partially filled canyon. On the other hand, pockmarks trains and mature erosional canyons show the same tectonic control. Such observations can match with the two following hypothesis: (1) Pockmarks trains, alignments of which are tectonically controlled, coalesce into gullies, (2) Pockmarks trains grow above axis of partially buried canyons, indicating the escape of fluid from the canyons filling sediment, vertically upward to the seabed.

From the analysis of the HR seismic reflection we arrive at the following observation:

(1) The actual seabed pockmarks trains are located above axis of partially buried paleocanyons.

(2) A vertical seismic structure, underlined by hyperbolic diffractions, pull-down-effect and deflected reflector, is seen directly beneath some pockmarks. These structures may be chimneys corresponding to active or fossil upward fluid migration pathway.

(3) These chimneys connect down to the submarine erosional surface that define bottom of the paleocanyons.

These observations suggest that, in this area, the pockmarks are related to fluid escapes source of which are located in sedimentary filling of Capbreton canyon paleotributaries. In this hypothesis, fluid source could be related to degradation of organic matter preferentially trapped in the canyon during it filling.

Conclusions

Combined analysis of the bathymetric and seismic reflexion data shows that the large pockmarks alignments of the study area are related to upward escape of fluid coming from sediment filling of beneath buried canyon.

To complete the present work, origin of the randomly distributed small pockmarks, nature of the expelled fluids and active or fossil statute of these pockmarks have to be specified.

References

Cirac, P., Bourillet, J.-F., Griboulard, R. and Normand, A., 2001. Le canyon de Capbreton : nouvelles approches morphostructurales et morphosedimentaires. Premiers resultats de la campagne Itsas: Canyon of Capbreton: new morphostructural and morphosedimentary approaches. First results of the ITSAS cruise. Comptes Rendus de l'Académie des Sciences - Series IIA - Earth and Planetary Science 332(7), 447-455.

Deregnaucourt, D. and Boillot, G., 1982. Structure géologique du golfe de Gascogne. Bulletin du BRGM, Geologie de la France(3), 150-168.

Gay, A., Lopez, M., Cochonat, P., Seranne, M., Levache, D. and Sermondadaz, G., 2006. Isolated seafloor pockmarks linked to BSRs, fluid chimneys, polygonal faults and stacked Oligocene-Miocene turbiditic palaeochannels in the Lower Congo Basin. Marine Geology 226(1-2), 25-40.

Hovland, M., 1984. Gas-induced erosion features in the North Sea. Earth Surface Processes and Landforms 9(3), 209-228.

The Vilaine River estuary in the Bay of Biscay: Insight into geomorphologic controls on estuarine sedimentation

Camille Traini,*[a] David Menier[a,b] and Jean-noël Proust[b]

Introduction

Estuarine environments are among of the main critical interfaces at the boundary between land and sea. They receive most of the drainage waters coming from the land through the fluvial network and also intermittently shallow marine waters through tidal and wave processes. These dynamic interrelationships produce an exceptional diversity of environments. The nature and distribution of these environments are described into a few generic models like Zaitlin and Dalrymple (1992) and Ashley and Sheridan (1994) or end members like the Bay of Fundy etc. However the natural diversity is certainly underestimated and many case examples still need to be described and compared to each other.

The Vilaine estuary is located along the French Atlantic coast, in Southern Brittany (Fig.1). It is one of the poorly known French estuaries that was recently strongly impacted by human activity. Fish farming and tourism activities are well installed and a dam was built on the river in 1970 at 8 km from the outlet. Since this construction, fine particles coming from the ocean steadily accumulated in the estuary.

Our goals are here to describe the nature and architecture of the estuarine environments and to interpret their historical evolution through time with regards to forcing mechanisms (hydrodynamic and anthropogenic factors).

Figure1. Location map of the Vilaine estuary

Data / Methods

In the following we present results from field observations, aerial photographs analysis, electric tomography and sediment coring. Field studies focused on the coastline and wetlands bordering the estuary. The observations were conducted at a regular time space covering the full range of seasons and tidal regimes. Four series of orthophotographs (IGN National Geographic Institute) and a nautical chart (SHOM) were gathered covering years 1958, 1971, 1993 2000 and 1820 respectively. These aerial photographs were georeferenced and compiled under ArcMap© from the software

ArcGis and a synthetic map was constructed for each year by describing the main geomorphological zones like tidal flat, salt marsh, offshore bar etc. To estimate the depth of the bedrock and sediment thicknesses, electrical tomography was perfortned on salt marsh and tidal flat of the estuary. Direct current electrical profiles were achieved by using a multielectrode data acquisition system connected to cables with 64 electrode plugs (Nicollin et al, 2006). 5 m electrode spacing provides a total layout of 320 m long and the depth of investigation reach 20m. Data integrated in pseudo sections of apparent resistivity provide a preliminary electrical image of sediment thicknesses and geometries. Tomographic interpretations are groundtruthed by series of sediment cores. The cores were extracted with a Russian corer that consists of a one m-long, semi-cylindrical tube of and several one m-long, drill pipes.

Results

The Vilaine estuary drains a large catchment area of about 10 400 km² that represents one third of the Armorican massif. It receives 600 to 1000 mm of rain per year under a largely oceanic climate. The river flow is highly variable with only 2 m3/s in the 1989 slack waters, 1500 m3/s in the 1995 flood event and 80 m3/s in average. The river carries a sediment load of 0.1 million tons per year. It is a mixed suspended and bed load meandering river on most of its course flowing on a Palaeozoic magmatic and metamorphic hard rock basement but 8 km from the dam sediment accumulate onto the river bed partially filling the estuary. The estuary is affected by macrotidal, semi-diurnal, tidal regime with tidal currents reaching a maximum velocity of 2 knots in high spring tides. The most significant swells come from the NW.

Description

The Vilaine estuary sediments filled a 20m-deep, fault bounded asymmetric valley that can be divided into 6 main domains (Fig.2).

• Zone 1 (Vilaine channel) is comprised of the main channel of the Vilaine River. It exhibits a meandering stream that straightens progressively in a seaward direction and towards the 2km-wide outlet. The channel is between 4 and 6m deep. The draught is being maintained by dredging to ensure summer leasure and work boat traffic. This channel is bordered by important mussel farming.

• Zone 2 (Banc du Strado) is a muddy tidal flat made up of silty muds over 20m-thick. Mud deposition on the tidal flat occurs according to seasonal rhythms.

• Zone 3 (Pointe du Halguen) is a rocky area bypassed by

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sediment provided by the northward longshore drift;

• Zone 4 (Dunes de Ménard) is a lowland area infilled during the last centuries by marsh silty-mud preserved at the back of a ridge formed by compound storm washover fans lying on mixflat deposits. The ridge forms a narrow band of shelly sand or pebbles along the coastline while the mix tidal flat is made up of alternating layers of silty-mud, sand and pebbles. The mixflat deposits are over 20m-thick.

• Zone 5 (Betahon) is comprised of salt mashes preserved at the back of a barrier beach and cross cut by a small permanent river stream. The infilling of the back barrier area is over 22 m-thick and made up of a stack of tidal channels and salt marshes alternation.

• Zone 6 (Tréhudal, La Grée, Etier du Palud, Vieille Roche, Kerdavid, Bourgerel) encloses a series of small fluvial drainage basins that drained towards the main Vilaine river stream; Most of them are now hardly reached by spring tides feeding local marshes.

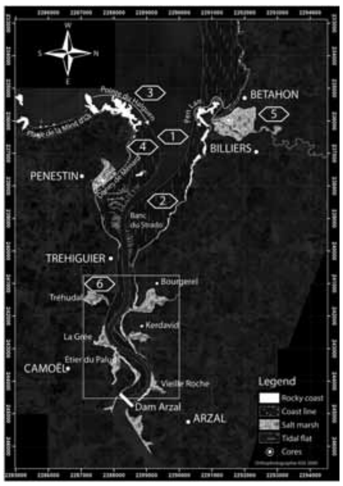

Figure2. Schematic map of the Vilaine estuary

Historic evolution

The channel of the Vilaine estuary (zone 1) remains stable through time, maintained by dredging. However bathymetric surveys show that channel depth and width decrease, progressively filled by tidal flats. The zone 2 mud flat is a very active depositional area. Its surface triples in less than 200 years, first in NE-SW and then in a SE-NW directions. Zone 3 barely changed these last two centuries. The coastline is rocky and subjected to slow erosion. The coast constitutes a reflective area for the swell and sediments coming from the south through longshore drift bypass this area to feed the estuary. Sediment provided in zone 4 by longshore drift are transported along the inner estuary, on the mixflats by tidal current and reworked by wave action which build up beach ridges protecting backbarrier salt marshes. Occasionally storm waves build up storm washover fans that can move up about l5m per year with pulses of a few meters at each step. The mix-flat located at the front of beach ridges and storm washovers is installed for more than 200 years. The zone 5 salt marshes are currently covered by spring waters and filled up progressively by the back barrier and small river channels deposits. The zone 6 inner estuary is a very stable depositional environment with mature salt marshes infilling largely inactive catchment areas (zone 6). Since the construction of the Dam Arzal, the edges of these marshes are cutoff by the Vilaine River incision. Rivers are poorly active and sediment is mainly transported by tidal currents during spring tides.

Discussion

A wide variety of sedimentary body is represented along the coastline bordering the Vilaine River estuary. The distribution of these bodies is highly constrained by hydrodynamic forcings. The influence of the swell is reflected by the presence of beach pebbles and shelly-sand into washover fans and barrier along the left edge of the estuary (Zone 4). The influence of tides is also important by creating large tidal flats and salt marshes (Zones 2, 4 and 5). Finally, wind action creates eolian dune deposits (Dunes of Ménard) in the shadow the rocky promontory “La Pointe du Halguen”.

The Vilaine estuary is filled by sediment provided by different sources. The main one is the littoral drift that provides shelly sand and pebbles to the outer part of the estuary. The second one is the mud fraction that feeds the tidal flats provided by ocean and fish farming activities. The continental part represents only 0.1 million ton per year.

The outer part of the estuary clearly shows an asymmetric functioning of the right and left banks that certainly relates to its asymmetrical, fault-bounded original structural shape. From 1820 to 1958, the right bank of the river (zone 2) experienced a lateral growth of 0.5% per year reaching 2% between 1958 and 2000. This growth was only 0.1% and 0.3% per years for the same periods on the left bank (zone 4). This evolution shows that the construction of the dam certainly played a role in this increase in the accretion rate of the mudflats but its influence on the differential growth of the two edges of the rivers is more debatable.

Before the construction of the dam of Arzal, the estuary was fed by both the load of the river and ocean sediment. Since 1970, river sediment load is stored behind the dam when oceanic particulate matters stay in front of it. Salt and fresh waters exchange are minimal.

Conclusions

The relict landform of the Vilaine estuary valley was certainly a condition for its morphosedimentary evolution. The building of the Dam Arzal surely influenced the hydrosedimentary evolution of Vilaine. The sheltered position at the back of a large embayment, makes also the estuary a relatively well-protected area suitable for sediment preservation.

Further studies are planned to complement the dataset and our understanding of this environment (drill cores, topographic current velocity and mud aggradation measurements…). These new data will complement our knowledge of the Holocene marine transgression along the Atlantic coasts (Proust et al. 2001; Menier et al.,2006).

References

Ashley, G.M. and Sheridan, R.E., 1994. Depositional model for valley fills on a passive continental margin. In: Dalrymple, R.W., Boyd, R.J. and Zaitlin, B.A., Editors, 1994. *Incised Valley Systems: Origin and Sedimentary SequencesSoc. Sediment. Geol. Spec. Publ.* **vol. 51**, SEPM, Tulsa, pp. 285–301.

Dalrymple, R. W., Zaitlin, B. A., and Boyd, R., 1992, Estuarine facies models--Conceptual basis and stratigraphic implications: Journal of Sedimentary Petrology, v. 62, p. 1,130-1,146.

Changes in intertidal benthic assemblages after the relocation of an industrial sludge discharges to a submarine outfall

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Introduction

The coastal area of Miengo (North Spain) has for many years received direct discharges of industrial wastewaters and this has lead to spatial and temporal changes in the intertidal rocky benthic assemblages in the nearby area. These discharges of the raw sludge contain mainly calcium carbonates, calcium and sodium clorures and calcium sulphures generated in the industrial processes. Previous work has shown that the direct discharges of this kind of sludge into the intertidal zone provoked in the past the lost of the main benthic assemblages and the partial defaunation of the boulder fields surrounding the point of discharge (ITSEMAP AMBIENTAL, 1994). After the new outfall was built, in 2002, the point of discharge of these raw sludges was relocated farther away from the shore (700 m). The relocation of the discharges in this high-energy coastal area ensures a higher dilution and dispersion rate of the plume that may lead to a recovery of these perturbed benthic assemblages. Thus, the present study examines the short-medium term changes observed in the middle shore and lower shore benthic turf assemblages after de cease of these direct discharges.

Methods

Study area

The study was carried out in the intertidal area surrounding the Solvay Quimica S.L. outfall (Miengo municipality, Cantabria) (Figure 1). In 2002, the new outfall started discharging effluents and a an Environmental Monitoring Program (EMP) was conducted between 2003 and 2006 in the intertidal area, within an area of about 1500 m in radius from the old point of discharge. Benthic assemblages in algal turfs were sampled every summer in 7 sites along the shore (Figure 1).

In each site, the assemblages living in middle shore (*Corallina* turf) and low shore (*Bifurcaria* level) habitats were analysed. Two replicates samples of a standardised surface area of 625 cm^2 (Hiscock, 1979, Borja, 1991) were collected in each of the two levels. Samples were frozen prior to sorting and taxonomic identification to species level. Abundance of macrofauna (number of individuals m^{-2}) and biomass of seaweeds (g dry weight m^{-2}) were recorded for each sample and analysed using univariate and multivariate procedures.

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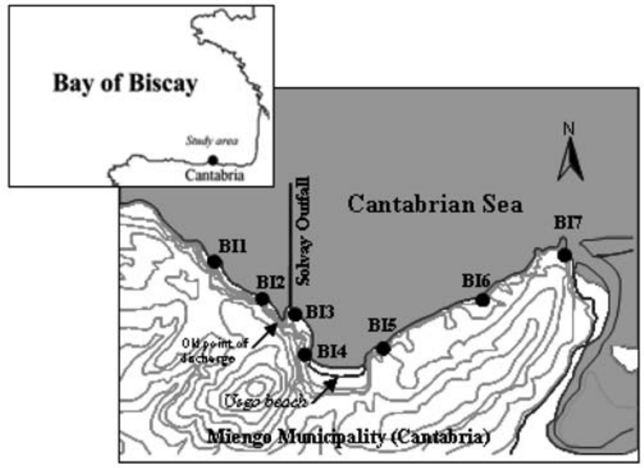

Figure 1 Map of the study area showing the sampling sites in North Spain.

Results

The analysis of the benthic assemblages in these habitats showed a great temporal and spatial variability and a slight increase in species richness in the whole area after the new outfall started discharging (Table 1). This pattern was stronger in the sites located westwards (BI1 and BI2) from the old point of discharges except for the site BI3.

The assemblages in this site were still less structured in 2006 and showed a great variability through time. Meanwhile, the abundance and biomass of organisms after 4 years in the most affected sites were still variable as in the less affected sites but a slight increase in the abundances and biomass could be detected.

Discussion

The present work has shown the medium-term changes of intertidal benthic turf assemblages after the relocation of an industrial discharges in the coastal area. The removal of these sludges from the shore has permitted the recolonisation of the perturbed area. The decrease of the turbidity in the waters due to a higher dilution and dispersion of the plume together with the decrease of the water temperature (wastewater and sludge temperature in the pipeline ±80º C) and the increase of the salinity in the nearby coastal area have permitted the larvae and juveniles of different species of fauna and seaweeds to establish. The increase of *Corallina* and *Bifurcaria* turf cover in the affected area had lead also an increase of its associated mobile and sessile epifauna.

Table 1. Species richness (mean) at the different sites through time.

	Site	S						
		BI1	**BI2**	**BI3**	**BI4**	**BI5**	**BI6**	**BI7**
Time	**2003**	50	35	68	56	74	74	61
	2004	77	37	109	91	85	82	59
	2005	79	78	62	77	100	83	49
	2006	85	87	58	94	92	91	67

Acknowledgements

This work was funded by Solvay Quimica S.L. company as part of its environmental monitoring program.

References

Borja, A., 1991. Capacidad de recuperación de las praderas del alga agarofita “Gelidium sesquipedale” sometida a explotación por arranque en el País Vasco. Agriculture and Fisheries Department, Government of the Basque Country, Technical Report: 42 pp.

Hiscock, K., 1979. Systematics surveys and monitoring in nearshore sublittoral areas using diving. In: Nichols, D., (Ed.). Monitoring the Marine Environment, Symposia of the Institute of Biology, London, 55-74.

ITSEMAP AMBIENTAL, 1994. Estudio “Dispersión y efectos de un vertido al mar”. Technical Report.

Recolonization process by macrobenthic fauna in the new intertidal areas created after restoration of farm lands in the Bidasoa estuary (SE Bay of Biscay)

Mikel A. Marquiegui [a], Florencio Aguirrezabalaga [a,b]

Introduction

The fertile plain of Jaitzubia is part of the salt marshes of the Bay of Txingudi (Bidasoa estuary), that is a wetland designed as Wetland of International Importance by the Ramsar Convention, "*Zona de Especial Protección para las Aves*" (ZEPA) and Place of Community Importance in the European Natura 2000 Network. This extensive flat area (70 hectares) was under tide influence until the 18th century, forming an arm of salt marshes with extensive reedbeds. Afterwards, most of this area was dried out, forming a mosaic of Atlantic prairies and cultures, together with reedbeds in its borders and some small marshy areas.

Since September 2001, when the Basque Government approved the *"Plan de Protección y Ordenación de los Recursos Naturales del Área de Txingudi"*, this area has been subject to great transformations, including the project "*Restauración Ambiental de Marismas de la Vega de Jaitzubia*". In this project, finished in October 2004, 25 hectares of farm lands were restored to their original nature under tide influence.

From 2004 to 2006, some studies have been carried out in this area to study the recolonization processes of the recovered lands by the benthic macrofauna.

Methods

With this aim, six stations (C1-C6) situated in the recuperated lands (Fig. 1) were designed to study benthic macrofauna and sediment. In 2004 and 2005 samples were collected in all the stations, meanwhile in 2006 only in three of them (C2-C4). Benthic macrofauna was sampled using a corer of 200 cm^2 of surface to a depth of 20 cm. Five replicates were taken in each station. Most superficial sediment (upper 5 cm) was washed through a 0,5 mm sieve; to sieve the remaining 15 cm, a 1 mm net was used. This method has been demonstrated as a good approximation of sieving all the sample through a 0,5 mm mesh (Bachelet, 1987) and has been used previously in the same area (Sola *et al.*, 1993, Insub and Grupo Ingeniería Química UPV/EHU, 2003; Garmendia *et al.*, 2003). Samples were collected between May and June.

Results and Discussion

A total number of 24.327 individuals belonging to 29 different taxa were collected in the fifteen samples analyzed: 11.387 individuals belonging to 24 taxa in 2004; 12.285 individuals and 19 taxa in 2005; and 655 individuals and 10 taxa in 2006. The faunal composition of all the stations is related with that characteristic of the *Scrobicularia plana* – *Cerastoderma edule* community (typical of European estuaries), excepting the station C6 in which faunal composition shows more fluvial influence.

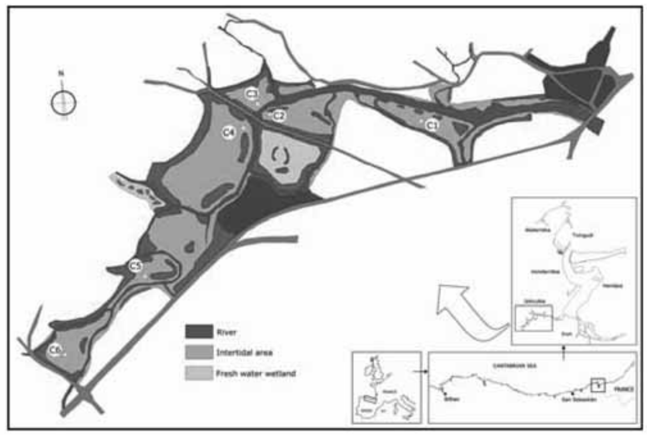

Figure 1. Map of the study area, showing the sampling stations.

The analysis of the classification dendrogram of the samples in function of the biomass, enables the recognition of three clusters of samples (Fig. 2): cluster A is formed by the stations that present the typical faunal composition of *S. plana* – *C. edule* community; cluster B is formed by the stations that present a transitional faunal composition to *S. plana* – *C. edule* community; and cluster C is formed by the stations that present faunal composition with fluvial influence.

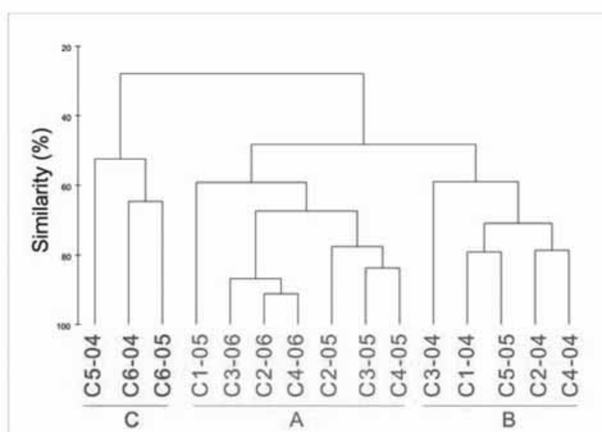

Figure 2. Dendogram of the stations (Bray-Curtis similarities).

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Recolonization

The results obtained provide evidence that the colonization of the recovered lands by the estuarine benthic macrofauna began shortly after the completion of the restoration program. And, also, show three different phases in the evolution of the macrofaunal community towards the typical characteristics of the *S. plana- C. edule* community. Comparing the results of the stations C2, C3 and C4 obtained in the three years it can be observed that 5-6 months after finished the recuperation works (2004) the new intertidal areas were mainly colonized by opportunistic species such as oligochaetes (this is the dominant group) and small polychaetes (*Streblospio shrubsolii, Manayunkia aestuarina, Desdemona ornata*…). Together with these species the polychaete *Hediste diversicolor* (larger and with longer life cycle) dominates the biomass of the community. Data for the length of this species shows that most of them were one year old or older. In consequence, it can be concluded that recolonization of these areas by *H. diversicolor* was due to both active or passive migration of adults from nearby areas and juvenile recruitment.

The results of 2005 show a new step in the direction of succession of the macrobenthic community towards the *S. plana-C. edule* community. The density and the number of species of the community decrease while the biomass increase; the abundance of some species typical of the community (as *Cyathura carinata*, *Hydrobia ulvae*) increase; *H. diversicolor* continues being the species that greater contributes to the biomass of the community, but now the individuals of *S. plana* collected (absent in 2004) made an important contribution to the community biomass. Moreover, from the analysis of size/age of the *S. plana* specimens collected, it can be concluded that part of recolonization of these areas by this species was made through the active and/or passive migration of adult individuals from nearby areas.

This process, rapid colonization by *H. diversicolor* and later by *S. plana*, is similar to that detected by Lewis *et al*. (2003).

The results of 2006 show a new step in the succession that is characterized by a reduction in the abundance of individuals and number of species, but an increase in biomass, and being now *S. plana* the species that greater contributes to the community biomass.

This general tendency in the processes of recolonization after an impact has been described by several authors (Pearson & Rosenberg, 1978; Beukema *et al*., 1999; Lewis *et al*., 2002; Cardoso *et al*., 2007).

Acknowledgements

This work was partially supported by the Direction of Biodiversity of the Department of Environment of the Basque Government and Txingudi Zerbitzuak S.A. Thanks are due to Igor Cruz, José Mª Ruiz, Lourdes Cantón and Maite Margeli for their helpful contribution to the development of this project. Also, we want to thank Félix Izco (Department of Hydraulic Works and Urbanism of the Gipuzkoako Foru Aldundia) by the loan of sampling equipment.

References

Bachelet, G., 1987. *Processus de Recrutement et Role des Stades Juvéniles d´Invertébrés dans le Fonctionnement des Systemes Benthiques de Substrat Meuble en Milieu Intertidal Estuarien*. Doctoral Thesis. University of Bordeaux. pp 478.

Cardoso, P.G., D. Raffaelli, A.I. Lillebø, T. Verdelhos, M.A. Pardal, 2007. The impact of extreme flooding events and anthropogenic stressors on the macrobenthic communities´dynamics. *Estaurine, Coastal and Shelf Science*. (In press).

Insub & Grupo Ingeniería Química UPV/EHU (2003). *Estudio de la zona de las islas del Bidasoa*. Unpublished report.

Garmendia, L., M. Marquiegui, F. Aguirrezabalaga, I. Cruz, L. Cantón, 2003. Efecto de la desaparición de los vertidos de aguas residuales urbanas sobre la comunidad reducida de *Macoma* en las islas del estuario del Bidasoa (Golfo de Vizcaya). *Boletin del Instituto Español de Oceanografía,* 19(1-4): 265-281.

Beukema, J.J., E.C. Flach, R. Dekker, M. Starink, 1999. A longterm study of the recovery of the macrozoobenthos on large defaunated plots on a tidal flat in the Wadden Sea. *Journal of Sea Research,* 42: 235–254.

Lewis, L.J., J. Davenport, T.C. Kelly, 2002. A Study of the Impact of a Pipeline Construction on Estuarine Benthic Invertebrate Communities. *Estuarine, Coastal and Shelf Science,* 55: 213–221.

Lewis, L.J., J. Davenport, T.C. Kelly, 2003. A Study of the Impact of a Pipeline Construction on Estuarine Benthic Invertebrate Communities. Part 2. Recolonization by benthic invertebrates after 1 year and response of estuarine birds. *Estuarine, Coastal and Shelf Science*, 57: 201–208.

Pearson, T.H., R. Rosenberg, 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology. An Annual Review.,* 16: 229-311.

Sola, J.C., J.M. Ruiz, J. Martínez, I. Adarraga, C. Pablo, A. Galfarsoro, C. Marfull, J.C. López, 1993. *Estudio de la zona de las islas del Bidasoa*. *Sedimento, Agua y Fauna Bentónica.* Unpublish report.

Changes in the marine sublittoral vegetation at the western Basque Coast between 1982 and 2007: a consequence of the climate change?

José María Gorostiaga[a], Nahiara Muguerza[a], Stefani Novoa[a], Alberto Santolaria[a], Antonio Secilla[a], Isabel Díez[a]

Introduction

Temporal changes in marine vegetation have been related to episodic natural or anthropic events, as well as long-term gradual changes in water quality (pollution increasing/decreasing). On the other hand, other natural factors that determine the climate and vegetation of a region, such as irradiance, swell, currents, pluviosity and temperature, have been considered until current days as rather stable environmental factors. Due to recent concern about the effects of global warming and climate change, more scientific attention is being devoted to the prediction of biological changes in marine communities (Bhaud *et al*., 1995; Alcock, 2003) as well as to the evaluation of effects already attributed to climate change (Hiscock *et al*., 2004; Bourcier, 1996; Helmuth *et al*., 2006). According to meteorological data, 1980 marks the beginning of changes in meteorological conditions of the Basque coast, characterized by a progressive seawater temperature increase (Borja *et al*., 2000), hot summers and a significant reduction in pluviosity.

A singular feature of the Basque coast, compared to other regions of the Bay of Biscay, is its warmer waters during the summer months (around 22ºC during the 70´s). This allows the presence of a higher proportion of southern floristic species in the area together with a reduction of northern ones. For this reason, the Basque coast could be especially vulnerable to the effects of climate change. The purpose of this work was to identify changes in the subtidal marine vegetation of a western stretch of the Basque coast occurring during 1984-2007.

Methods

In July 2007, a similar sampling survey to that carried out in 1982 was performed (Limia & Gorostiaga, 1987; Gorostiaga, 1995), but the sampling effort was increased in order to facilitate future comparisons. Seven transect lines (100 to 200 m long) were systematically distributed along 1.95 km of an exposed shoreline, from Pta. Kobaron to Pta. Muzkiz (western Basque coast). Four types of information was obtained: 1) Cover for main macrophytes was estimated (Braun-Blanquet scale) for each band of 10 m. 2) Biomass was obtained by means of a stratified destructive sampling at the depths of 2, 3, 6, 9, 10 and 11 meters. Inside of each depth stratum, a quadrat (50 x 40 cm) was placed at the central point. 3) An inventory (5 x 5 m) with the relative cover of species was obtained at each depth. 4) Frequency of dominant macrophytes was obtained at each meter of transect. Temporal and spatial differences in phytobenthic assemblages were explored by applying ordination and classification techniques using PRIMER software package. Biomass values were square root transformed and Bray-Curtis dissimilarity was applied to the data set. Classification of samples by hierarchical agglomerative clustering (group-average linking CLUSTER) was followed by non-parametric multidimensional scaling (MDS) as an ordination method. The indicator species which contribute most to the multivariate patterns detected were determined by means of the SIMPER.

Results

In the destructive sampling net used in 1982 (n=36), five types of communities were identified employing multivariate techniques (classification analysis): 1) *Gelidium sesquipedale* (47% of unit samplings) formed pure stands between 3-9 m depth; 2) *Pterosiphonia complanata* (33%) formed stands between 9-11 m depth. Patches of *Dictyopteris polypodioides*, *Calliblepharis ciliata* and *Heterosiphonia plumosa* were common; 3) *Gelidium latifolium, Corallina elongata, Pterosiphonia complanata* and *Falkenbergia rufolanosa* (8%) formed a caespitose vegetation at shallow waters (2m); 4) Residual communities typical from sandy shallow bottoms (2-3 m) were: *Halopytis incurva* (6%), *Cystoseira baccata* (3%) and *Cladostephus spongiosus* (3%).

From the equivalent sampling survey performed in 2007 (n=35) several changes were detected in the communities previously mentioned: 1) A reduction of the *Gelidium sesquipedale* stand: only 14% of sampling units corresponded to pure *Gelidium* stands. Mixed *G. sesquipedale* stands achieved the 14% of sampling units being *Codium decorticatum*, *Falkenbergia rufolanosa* phase and *Cystoseira baccata* the co-dominant species. In cleared areas of *G. sesquipedale* stands, patches of *Cystoseira baccata* (9%), a mixed vegetation of *Corallina officinalis, Codium decorticatum* and *F. rufolanosa* phase (8%), *Halopithys incurva* (3%), *C. decorticatum* (3%) and *F. rufolanosa* (3%) were developed. 2) The disappearance of *Pterosiphonia complanata* stand. This type of vegetation has been mainly replaced by a stand of *C. baccata* (17%), with patches of *C. officinalis* (3%), *C. decorticatum - Peyssonelia* sp. (3%), *Halopytis incurva* (3%), and the residual *Pterosiphonia complanata - Falkenbergia phase* (3%). Common species in 1982 such as *Dictyopteris polypodioides, Calliblepharis ciliata* and *Heterosiphonia plumosa* have significantly decreased in abundance. 3) The caespitose vegetation increased in shallow waters (14%), with changes in the relative abundance of

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the species such as the increase of *C. decorticatum*. 4) Of the residual communities typical of sandy bottoms only the *Halopytis incurva* community (3%) was recorded.

Comparing macrophytes cover estimates for each band of transect between both periods *Gelidium sesquipedale* and *Pterosiphonia complanata*, dominant macrophytes in 1982 at the depth ranges of 3-9 m and 9-11 m respectively, experienced a significant cover reduction. *G. sesquipedale* experienced a cover decrease of 50 % in the first 4 transects whereas *Pterosiphonia complanata* decreased 97%. Conversely, *Cystoseira baccata* (doubled % cover), *Falkenbergia rufolanosa* (tripled % cover), *Codium decorticatum* and *Pesyssonelia* sp. experienced a significant increase. Although the specific taxonomical status of the last species has not yet been elucidated, due to its marked photophylous character, it could be an alien species, different to the indigenous sciaphylous *P. squamaria* and *P. coriacea*.

The overall algal standing stock in the area has suffered a significant reduction in the typical depth range of *G. sesquipedale* (3-9m) stands, whereas shallow (2) and deeper (10 and 11 m) vegetation showed an opposite trend by the higher development of *Codium decorticatum* and *Cystoseira baccata*, respectivelly.

Discussion

The results show significant changes in the subtidal marine vegetation in the studied area during the last 25 years. *Gelidium sesquipedale* experienced a significant decrease in terms of biomass and percent coverage. Likewise, its fronds showed evident signs of stress such as a yellow-green colour (not the typical dark red), a loss of toughness and an increase of epiphytism. Of the several hypothesis considered (e.g. increase grazing activity; a disease affecting the fronds; sporadical harvesting) the discussion will be focussed on the following 3 possible explanations:

1) Pollution increasing, as a consequence of the progressive demographic increase (12000 vs 30000 habitants in the studied period) in the near town of Castro (4 km western of the studied area). However, this hypothesis must be rejected because *Cystoseira baccata* is more sensitive than *G. sesquipedale* to the effects of pollution (Gorostiaga & Díez, 1996). 2) Seawater temperature increase. In spite of the temporal evolution of seawater temperature for the studied area not yet been analyzed, Hiscock *et al*., (2004) have reported a seawater temperature increase of 1ºC in the period 1984-2004 in the coastal waters of Britain. However, this factor could seem partially responsible for the recorded changes, because in two other localities of the Basque coast (Plentzia and Pasaia) with similar water temperature, the fronds of *G. sesquipedale* showed a healthy appearance. A difference was that in the last two localities, the waters were more turbid as result a of the river flow influence, which reduced the irradiance in these special environments.

3) Irradiance increase. The higher frequency of sunny days in the studied area would have negatively affected the fronds of *G. sesquipedale,* causing a photo-oxidative stress and perhaps a higher consumption of phycobiliproteins.

To know if these changes were only restrained to the studied area or if it could be extended to other places of the Basque coast, the locality of Ea, 36 km east of Kobaron, was visited. This locality showed pure subtidal stands of *G. sesquipedale* in 1982 and similar changes were observed in 2007. Further studies will be carried out to elucidate if the changes detected in the subtidal vegetation of Kobaron could be extended to the overall Basque coast. Special emphasis will be done to explore possible relationships between the biological changes and temporal series of temperature and irradiance data. Field studies will be complemented with ecophysiological experiments to know the response of some key species to several environmental conditions.

References

Alcock, R., 2003. *The effects of climate change on rocky shore communities in the Bay of Biscay, 1895-2050*. PhD thesis, University of Southhampton.

Bhaud, M., J.H. Cha, J.C. Duchene, C. Nozais, 1995. Influence of temperature on the marine fauna- what can be expected from a climatic-change. *Journal of Thermal Biology,* 20: 91-104.

Borja, A., J. Egaña, V. Valencia, J. Franco, R. Castro, 2000. 1947-1997, estudio y validación de una serie de datos diarios de temperatura del agua de mar en San Sebastián, procedente de su Aquarium. *Ozeanografika,* 3: 139-152.

Bourcier, M., 1996. Long-term changes (1954 to 1982) in the benthic macrofauna under the combined effects of anthropogenic and climatic action (example of one Mediterranean Bay). *Oceanologica Acta,* 19: 67-78.

Gorostiaga, J.M., 1995. Sublittoral seaweed vegetation of a very exposed shore on the Basque coast (N. Spain). *Botanica Marina*, 38: 9-16.

Gorostiaga, J.M., I. Díez, 1996. Changes in the sublittoral benthic marine macroalgae in the polluted area of Abra de Bilbao and proximal coast (Northern Spain). *Marine Ecology Progress Series,* 130:157-167.

Helmuth, B., N. Mieszkowska, P. Moore, S.J. Hawkins, 2006. Living on the edge of two changing worlds: Forecasting the responses of rocky intertidal ecosystems to climate change. *Annual Review of Ecology Evolution and Systematics,* 37: 373-404.

Hiscock K, Southward A, Tittley I, & S. Hawkins, 2004. Effects of changing temperature on benthic marine life in Britain and Ireland. *Aquatic Conservation Marine and Freshwater Ecosystems,* 14 (4): 333-362.

Limia, J.M., J.M. Gorostiaga, 1987. Flora marina bentónica sublitoral del tramo de costa comprendido entre Pta. Covaron y Pta. Muskes (Vizcaya, N.E. España). *Act. VI. Simp. Naci. Bot. Cript.*, 81-88.

Assessing LIDAR data for coastal habitat discrimination

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Introduction

The airborne laser scanning LIDAR (LIght Detection And Ranging) provides high-resolution Digital Terrain Models (DTM) that have been recently applied to the characterisation, quantification and monitoring of coastal environments (e.g. Bork and Su, 2007). This study assesses the contribution of LIDAR altimetry and intensity data, topographic-derived features (slope and aspect), and multispectral imagery (three visible and a near-infrared band), to map coastal habitats in the Bidasoa estuary and its adjacent coastal area (Basque Country, northern Spain). The performance of high-resolution data sources was separately and jointly tested, with the maximum likelihood algorithm classifier in a rocky shore and a wetland zone, thus, including some of the most extended Cantabrian Sea littoral habitats, within the Bay of Biscay.

Methods

Study area

The Bidasoa estuary and its adjacent coastal area, the Bay of Txingudi, are located in SE of the Bay of Biscay, in the border between Spain and France. Two different geomorphological zones of the study area were selected to encompass a high variety of environments and natural habitats: a coastal rocky area (in Jaizkibel) and a wetland area (in Plaiaundi).

LIDAR data and multi-spectral imagery

The LIDAR is a laser altimeter that measures the range from a platform with a position and altitude determined from GPS (Wehr and Lohr, 1999). LIDAR system can also provide reflectance intensity of the surface ("LIDAR intensity") for the corresponding spectral band at which laser emits, which may be useful information for classifying land covers (Song et al., 2002). The local government of Gipuzkoa (Diputación Foral de Gipuzkoa), Spain, carried out a topographic map of the entire Gipuzkoa province in 2005 (from January to May), which covers an area of 221 700 ha, using the LIDAR technology. A terrestrial Digital Terrain Model (DTM) and intensity data were generated from the LIDAR data at 1 m resolution by the Cartographic Institute of Catalonia (Institut Cartogràfic de Catalunya, ICC). The sensor used was a laser Optech ALTM 3025 (Airborne Laser Terrain Mapper), property from ICC. It operates at the infrared band, 1064 nm; hence, it does not penetrate the water surface. Two topographic features have been calculated from this DTM: slope and aspect. LIDAR intensity images of the Gipuzkoa coast appeared speckled. To smooth this noise, a Multiplicative enhanced Lee filter was applied with 5 x 5 sliding windows.

Multispectral orthorectified imagery at 0.5 m spatial resolution had four spectral bands (blue, B: 390–530 nm; green, G: 470–660 nm; red, R: 570–690 nm, and near-infrared, NIR: 670-940 nm). Image acquisition (in spring-summer 2005 at low tide conditions) and pre-processing were financed by the Department of Environment and Land Use of the Basque Government.

Classification and accuracy assessment

Fieldwork was carried out to perform a supervised classification of the two zones. Two independent training sites were created from ground truth; one to calculate the statistics needed for the classification, the other to evaluate the reliability of classifications. The performance of multi-source airborne data to enhance the accuracy of the habitats of the two test sites was tested using a maximum likelihood classifier. To test the performance of each source type (called neo-channel), first, a so-called classification reference was performed using the three visible bands (i.e., RGB), given that the RGB colour image represents the conventional data source to classify habitats. Then, each neo-channel was separately added to the RGB bands and the classification accuracy was compared with the results of the classification reference. Thus, six neo-channels have been added to the visible bands: the NIR band, three LIDAR-derived features (height, slope, and aspect), and two LIDAR intensities (raw and filtered). The best neo-channels were jointly added to the colour bands to perform a final classification. As a post-classification processing, a majority filter with a 3 x 3 sliding window was applied twice to remove isolated pixels.

As measures of classification accuracy, we have used the producer's accuracy (PA) and user's accuracy (UA) for each category. These measurements are derived from the confusion matrix (or error matrix) which is created from the comparison between the classification and the verification data. As overall accuracy measurements we have used the mean producer's accuracy MPA (mean of all PA), the mean user's accuracy MUA (mean of all UA), and the kappa coefficient of agreement (K).

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Results and discussion

The assessment of the habitat classification accuracy on the Jaizkibel rocky zone and Plaiaundi wetland area are shown in Table 1 and 2, respectively. The results showed that reliability of coastal habitat classification was more enhanced with LIDAR-based DTM compared with the other data sources: slope, aspect, intensity or near-infrared band. The addition of the DTM to the visible bands produced gains of 10-27% in the agreement measures between the mapped and validation data (i.e. MPA and MUA) in the two test sites. Raw LIDAR intensity images were shown useless here, since they appeared heterogeneous and speckled. However, the enhanced Lee smoothing filter applied to the LIDAR intensity improved the classification accuracy measurements, specially in the wetland zone (gains: 7.9% in MPA and 11.6% in MUA). This suggests that it can be useful for habitat mapping when few data sources are available.

Table 1. Accuracy assessment (PA and *K*) of classification of rocky zone with Colour Bands (CB) alone (classification reference), adding the near-infrared band (NIR), LIDAR DTM and Lee-filtered LIDAR intensity (Lee); Slo: slope; Asp: aspect; SNC: selected neo-channels; PC filter: postclassification filter; IRWA: intertidal rock with algae; Subt: subtidal; Supral: supralittoral.

HABITAT	CB	+ NIR	+ DTM	+ Slo	+ Asp	+ Lee	SNC	PC filter
Corallina	48.3	87.3	64.0	67.4	50.0	64.8	82.2	82.6
Barnacles	53.0	73.9	64.4	47.4	52.3	49.6	80.7	83.7
IRWA	63.6	79.4	81.7	84.7	72.6	77.5	94.7	97.3
Subt. sand	98.4	100	100	94.3	98.4	99.0	98.2	98.4
Supral. rock	23.4	40.4	84.7	75.7	75.7	85.3	84.4	87.0
Rock cliffs	56.3	69.5	94.8	81.6	65.1	71.3	98.1	99.7
Shrubs	93.1	93.5	97.8	92.4	91.9	82.5	96.9	98.6
Wood	95.3	94.3	96.2	93.7	95.4	98.5	98.2	98.5
Shingles	51.0	49.7	77.6	62.2	15.1	43.4	79.0	80.9
Subt. rock	94.3	89.6	97.7	82.6	94.8	97.4	87.8	87.5
Seawater	79.5	86.0	98.4	77.9	79.8	76.5	98.5	99.9
Shade	100	100	100	100	100	100	100	100
Artificial	79.7	79.9	80.4	84.0	79.8	83.8	86.0	86.6
Cont. water	94.9	99.7	89.0	80.3	95.2	98.3	97.5	98.2
Grassland	74.0	84.0	92.9	81.9	81.9	93.8	93.6	96.9
Arable land	66.3	67.8	96.8	66.3	84.7	86.4	94.3	94.5
Mean	73.2	80.9	88.5	79.5	77.0	81.8	91.9	93.2
K	0.72	0.77	0.93	0.74	0.78	0.78	0.94	0.95

The synergy between LIDAR data with multispectral bands produced high accurate classifications (MPA: 92% for the sixteen rocky habitats and 88% for the eleven wetland habitats). The data fusion was able to discriminate intertidal communities such as *Corallina elongata* (Figure 2), barnacles (*Pollicipes pollicipes*), and stands of *Spartina alterniflora* and of *Phragmites australis*, which presented high percentage of confusion when conventional visible bands are used alone. All these results were corroborated by the *K* coefficient of agreement. The high classification accuracy found here, selecting data sources, highlights the value of integrating LIDAR data with multispectral imagery for habitat mapping in the intertidal complex fringe.

Table 2. Accuracy assessment (PA) of classification of wetland zone. For abbreviations refer to Table 1.

HABITAT	CB	+ NIR	+ DTM	+ Slo	+ Asp	+ Lee	SNC	PC filter
Gracilaria	93.7	95.3	96.1	90.8	93.8	94.2	96.9	98.4
Mudflat	83.3	85.2	96.6	81.4	83.7	89.9	93.2	93.5
Spartina	45.9	66.4	59.0	55.2	41.7	48.6	66.7	70.9
Riparian w.	50.1	62.9	73.7	69.4	52.7	65.9	79.0	77.2
Phragmites	78.0	75.6	73.7	77.2	72.9	83.5	78.6	79.3
Grassland	95.4	97.3	96.2	94.6	95.9	97.6	98.5	98.9
Gravel beach	99.2	97.2	99.3	94.1	97.3	99.3	98.0	99.3
Artificial	86.6	86.2	95.4	83.4	86.4	88.5	95.2	97.4
Water surf.	57.1	74.9	77.5	58.8	57.7	84.3	89.3	92.2
Chara	75.2	79.8	80.7	75.9	75.1	78.3	79.7	79.3
Shade	61.3	71.7	91.3	50.7	62.5	82.4	96.3	96.7
Mean	**75.1**	**81.1**	**85.4**	**75.6**	**74.5**	**82.9**	**88.3**	**89.4**
K	**0.72**	**0.79**	**0.86**	**0.72**	**0.72**	**0.84**	**0.90**	**0.92**

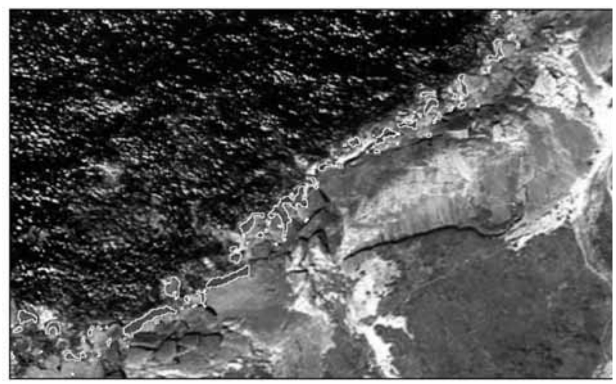

Figure 1. Maximum likelihood classification of *Corallina elongata* (white polygons), combining multispectral and LIDAR data, superimposed to a false colour composite (NIR, red, green).

Acknowledgements

This study is supported by the Dep. of Environment and Regional Planning of the Basque Country, which also provided the multispectral images, and the Euskadi-Aquitania interregional funding programme. Diputación Foral de Gipuzkoa provided LIDAR data. The authors wish to acknowledge the contribution of M. Elorza for their valuable technical support with LIDAR system.

References

Bork, E.W., Su, J.G., 2007. Integrating LIDAR data and multispectral imagery for enhanced classification of rangeland vegetation: A meta analysis. *Remote Sensing of Environment*, 111: 11-24.

Song, J.H., Han, S.H., Yu, K., Kim, Y.I., 2002. Assessing the possibility of land-cover classification using LIDAR intensity data. ISPRS Commission III, Symposium 2002, 9–13 September 2002, Graz, Austria, pp. B-259-263.

Wehr, A., Lohr, U., 1999. Airborne laser scanning - An introduction and overview. *ISPRS Journal of Photogrammetry and Remote Sensing*, 54: 68−82.

Seafloor cartography and habitat mapping of the Basque inner continental shelf

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Introduction

Habitat maps are an essential source of information for integrated coastal management and the implementation of several European Directives (i.e. Habitat Directive, Marine Strategy Directive, Water Framework Directive and the Common Fisheries Policy). In particular, the aim of the Habitats Directive (Council Directive 92/43/EEC) is to contribute towards ensuring biodiversity through the conservation of natural habitats, wild fauna, and flora within Europe. In order to facilitate this objective, a coherent European ecological network of Special Areas of Conservation (SAC), named Natura 2000, was set up. Each Member State must propose a list of sites in which natural habitat types and species, native to its territory, are hosted. Since 2003, the Basque Biodiversity Directorate agreed to establish a permanent observatory of the Natura 2000 network in the Basque Country (Figure 1), to guarantee fulfilment of their objectives and its formulation. A lack of cartographic information of the Basque continental shelf and the identification and characterisation of the most significant marine habitats within the Basque Country was thereupon made evident.

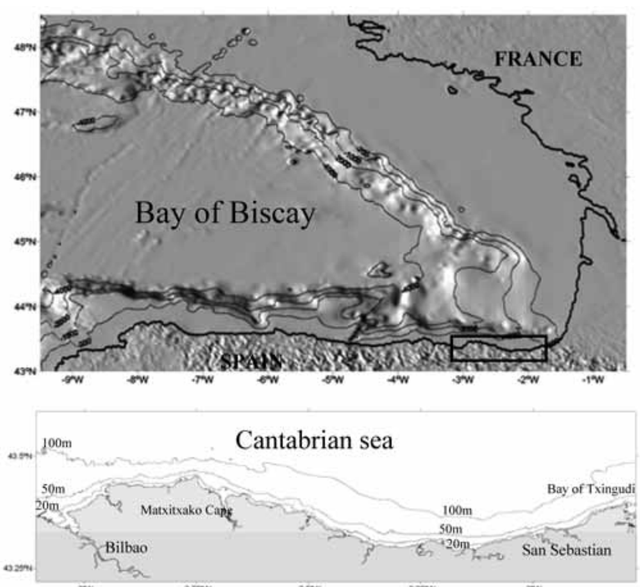

Figure 1. Upper: study area within the Bay of Biscay. Lower: part of the Basque continental shelf.

For the Basque continental shelf and coastal zone, a 3 year project started in 2005. The aims were to generate seafloor cartography and seabed characterisation, to define and mark out marine habitats, and to identify the main species of flora and fauna associated to each habitat type. In order to reach these goals, specific objectives were defined: (i) to obtain high resolution bathymetric data of the inner continental shelf; (ii) to characterise different seabed types, in relation to geological and geomorphological features and sediment composition; (iii) to gain knowledge of the habitat distribution pattern, in relation to environmental factors; (iv) to produce habitat maps of the intertidal and subtidal zones; (v) to classify habitats using the EUNIS classification of the European Environment Agency; and (vi) to identify and locate habitats of Community interest.

Methods

Bathymetric and seafloor backscatter information were acquired using high-resolution multibeam SeaBat 7125 and SeaBat 8125 systems; both equipments have very similar characteristics and most of the work was undertaken with the latest SeaBat 7125 model. It operates at 400 kHz frequency and produces 256 beams, at 128º angle swath and up to 50 swaths per second. Bathymetric data were acquired and processed using the PDS2000 software. Tidal correction was applied using the nearest gauge and, on this basis, a 1-m resolution seafloor Digital Terrain Model (DTM) was produced. Finally, the DTM was exported into an ESRI grid format. The DTM was then integrated into an ArcGis environment.

Spatial algorithms were applied to extract relevant topographical parameters: slope, orientation, shaded relief, and the topographical position index. Orientation or aspect of the DTM was calculated, to determine seafloor exposure to wave fetch. The shaded relief was calculated employing Lambert´s cosine law, with different altitude and azimuth values of light source; this was done in order to highlight geomorphologic features that could assist in the interpretation of seabed classes. The Topographic Position Index (TPI) was used as a measure of relative elevation; it provides an indication of whether any particular pixel forms part of a positive (e.g., crest) or negative (e.g., trough) feature of the surrounding terrain.

The distribution of wave energy along the continental shelf was calculated using hydrodynamic numerical modelling. The wave analysis was undertaking assuming deep water conditions (off the continental shelf). The most representative cases were simulated and waves were propagated up to the coast. Results were processed, subsequently to obtain the average wave flux per meter of width of the front along the coast. Thereafter, the average flux of wave energy within the first meter over the seafloor was calculated to obtain the wave influence on the

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seafloor. The grid of energy distribution was integrated into ArcGis 8.1, at 400 m resolution.

High resolution ortophotographs were used to identify and classify the supralittoral, intertidal and first 5-10 meters of underwater habitats. Habitat classifications were made using 0.25 m resolution airborne photographs taken in 2002 and 2004 by the Environment and Territory Management Department of the Basque Government.

Results

The whole Basque inner continental shelf (from 5-10 to 50-70 m water depth) was cartographied and a Digital Elevation Model was produced at 1-m spatial resolution. Other topographical information such as slope, shaded relieve, orientation and TPI was extracted from the aforementioned model.

A classification and description of identified marine habitats was done integrating all the abiotic information extracted from the multibeam and hydrodynamic modelling.

A reduced number of classes were defined for each parameter. Depth was classified into 3 classes: infralittoral (<25-30 m), circalittoral (between 25-30 and 70 m), and continental shelf (>70 m). The definition of seafloor classes was carried out taking into account the morphology, backscatter, texture and geology. Thus, eleven seafloor types were defined. For soft bottom classification, ancillary sediment samples information was used.

Wave energy classes were defined taking into account previous knowledge about good weather wave breaking limit.

With all this information, multisource habitat classification was performed and correlated to the EUNIS habitat classification. After that, Community Interest Habitats included in the Annex I of the Habitats Directive and priority habitats were identified. Finally, a map series of 1:10.000 scale was produced (Figure 2).

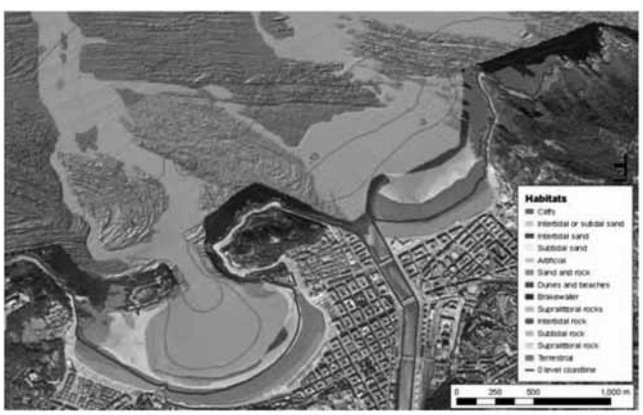

Figure 2. Map of the marine and intertidal habitats of La Concha beach (San Sebastián). Orthophotography corresponds to non-classified and terrestrial zones. Bathymetric levels (in m) and the coastline are shown using blue lines.

Discussion

The integration of data from different remote sensing techniques has made possible to obtain habitat maps of both intertidal and subtidal zones. Only shallow water areas remain unclassified due to the lack of valuable information for habitat mapping, firstly, because navigation was not possible, and, on the other hand, because turbidity or sunlight conditions on the sea surface restricted the use of aerial photography for seabed identification.

The use of a high-resolution multibeam system is making available essential information about seafloor characteristics. Moreover, new seabed features, unknown up to now in the Basque continental shelf, are being identified and described. Nevertheless, sampling data is still required for multibeam data validation.

The main parameters taken into account for habitat classification were: water depth, seafloor type, geomorphology and wave exposure. Water depth is the key parameter that determines the distribution of the different habitats specially for hard sustrata. It could be considered that depth is stable in time, except highly dynamic sedimentary areas where the seafloor can change dramatically from rocky substrata to sandy coverage. Light penetration is also dependent on turbidity, which may vary in time and space. In order to establish a coherent boundary between algal communities and animal communities ancient knowledge about red alga *Gelidium sesquipedale* distribution was taken into account (Borja *et al*., 2000, 2004). Nevertheless, underwater video recordings along tracks perpendicularly to the coast would be required to better stablish this limit along the Basque inner continental shelf.

For soft bottom, species distribution showed a certain degree of correlation with environmental variables. The main parameters that incluence the species distribution are the grain size and wave energy.

Future work will include a sampling survey along the whole coast to validate the habitat classification done in this project, and the generation of a habitat distribution model for the Basque continental shelf and the Cantabrian sea.

This project will generate base knowledge and the results obtained will be of special interest for integrated coastal management, decision makers, description of seabed processes, and studies of climate change and related impacts.

Acknowledgements

This project is supported by the Department of Environmental and Land Use of the Basque Country and the Euskadi-Aquitania interregional funding programme.

References

Borja, Á., V. Valencia, R. Castro, J. Franco, J. Bald, A. Uriarte, M. Mendizabal and F. Aguirrezabalaga, 2000. Establecimiento de las bases técnicas de conocimiento del área de San Juan de Gaztelugatxe con vistas a su posible declaración como reserva marina. Informes Técnicos (Departamento de Agricultura y Pesca, Gobierno Vasco), 87: 152 pp.

Borja, A., F. Aguirrezabalaga, J. Martínez, J.C. Sola, L. García-Arberas and J.M. Gorostiaga, 2004. Benthic communities, biogeography and resources management. In: Borja, A. and Collins, M. (Eds.). Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, 70: 455-492, Elsevier, Amsterdam

Facies, biocoenoses and fishery impacts on Le Danois Bank deep-sea benthic ecosystem (El Cachucho) using photogrammetry

Francisco Sánchez,*[a] and Alberto Serrano[b]

Introduction

Le Danois Bank is a marginal shelf located in the Cantabrian Sea at 5ºW longitude and 44ºN latitude (Le Danois, 1948). During the years 2003, 2004 and 2005 the Bank was studied by the ECOMARG project, focusing mainly on the study of the benthic-demersal ecosystem and applying a multidisciplinary approach (www.ecomarg.net). The aim of the project was to study the physical scenario, including both bathymetry and hydrographic features, and the different compartments of the benthic fauna (endobenthic, epibenthic, supra-benthic and demersal communities). In some areas, where the presence of rocky outcrops hampered the use of clasical sampling methods (box-corer, beam trawl, etc.) and where biogenic and vulnerable habitats existed, we use a new non-intrusive method based on deep-sea photogrammetry.

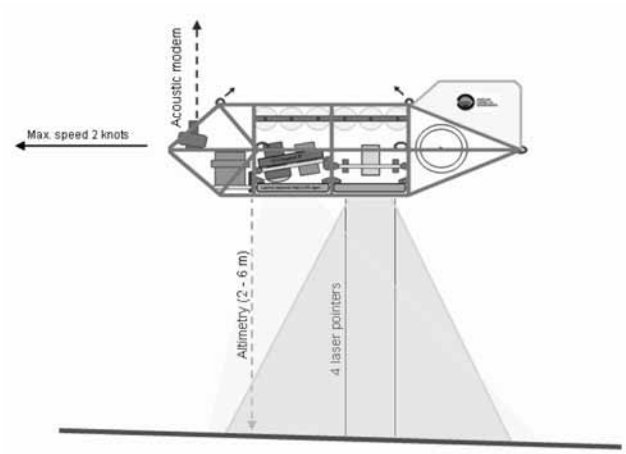

Figure 1. Diagrammatic side-view of photogrammetric sledge TFS-2 showing positions of acoustic modem, battery, altimeter, electronic flash, junction box, still camera and laser pointers.

A towed underwater photogrammetric sledge TFS-2 carrying a high resolution still camera was designed and details are discribed. This system has the capacity for operate in a wide-ranging surveys of the sea-bed and its fauna, from 25 to 1000 m depth. The analysis of information provide a detailed habitat mapping based on image analyses.

Methods

Photogrammetric sledge

This system was designed at the IEO (Spanish Institute of Oceanography) of Santander to sample deep macro-epibenthic communities (down to 1000 m) quantitatively. It is equipped with a high-resolution digital still camera that takes shots along constant prefixed time intervals and is sincronised to an powerfull electronic flash (Figure 1). It uses a series of 4 parallel laser beams in order to return each photograph´s perspective and later correctly estimate the dimension of the surface covered by each picture and of the organisms and structures lying on the sea bottom. It is therefore a direct, quantitative sampling system (Lundälv, 1971). It also is equipped with a CTD probe to characterize the oceanographic features (pressure, temperature and salinity) prevailing at each site. The system was designed to glide from 2 to 6 meters distance to the sea bottom and may be towed in a hanging vertical position at a 0.5–1.5 knots speed. Distance to the bottom is controlled by digital signals from a submetric precision altimeter, which are sent in real time to the ship using an acoustic modem.

During the TREBOL survey, carried out in april 2005, the summit of Le Danois Bank (from 460 to 570 m depths) has been surveyed using this system with a total of six transects (Figure 2). In each transect, between 2 and 6 km length over the sea floor, a range number of 280-600 pictures were taked.

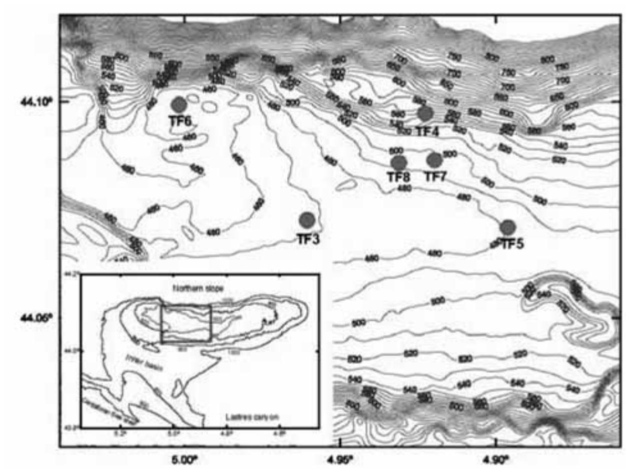

Figure 2. Photogrammetric sledge transects location on Le Danois Bank summit.

Data analysis

Each image is asociated to environmental variables (longitude, latitude, depth, pressure, temperature and salinity) using a time code. In a first step and using an image procesor, the scale of each picture is calculated from the four laser points geometry analysis (image calibration). In a second step the surface covered by each photo is estimated and the size of

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each element (facies, species, etc.) is also obtained. When overlap exist between picture areas, is possible to applied the mosaicing tools to create wide views of habitats. To know the characteristics of sedimentary grounds (particle size and organic matter content) we use the information of the samples collected using a box-corer.

Results and Discussion

Geological and biological characteristics appear in various combinations and it is important to first describe both items separately to produce a compilation of all characteristics occurring in the study area. For this purpose, the classification schem is built up of different main information layers. This configuration offers the oportunity to easy access all potential combinations of features in a further analysis. Three main layers are defined: facies (layer 1); biocoenoses (layer 2) and external features (layer 3). Facies is used in a strict geological point of view and only to describe the different geological and sedimentological appearance (hardground, rocky outcrops, soft sediment, soft sediment with current ripples, etc.). Layer 2 is composed of different biocoenosis classes which are associated with distinct facies and defined taking in consideration the results of a previous epibenthic communities study (Sánchez *et al*, 2007). Finally, layer 3 consist of a pool of external features that are secondarily added to the benthic ecosystem. This one is subdivided into two sub-classes: dropstones and antropogenic impacts (lost gillnets, longlines, trawl damages, rubbish, etc.). In addition, other environmental characteristics (water temperature and salinity, current, etc.) were included in the analysis to detect their effects on habitat and communities spatial distribution (Figure 3).

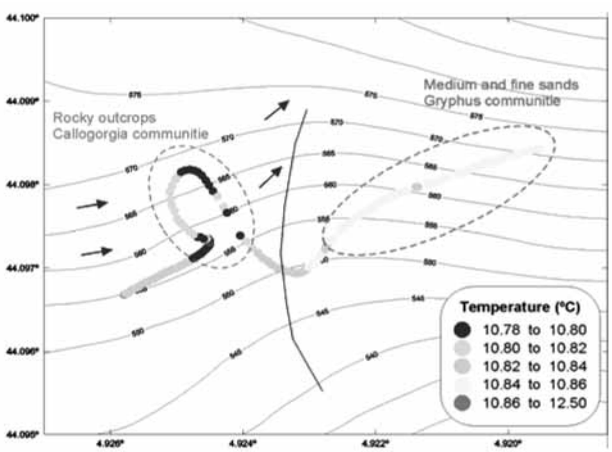

Figure 3. Photogrammetric transect TF4 showing the location of each image over the sea floor (depths contour interval 5 m) including water temperature, current, facies and communities.

The results from this methodology shows that the *Gryphus-Galeus* community (Sánchez *et al*, 2007) was the most extended in the soft sediment facies of the Le Danois summit (Figure 3). Their habitat is characterised by medium and fine sands with a low organic matter content. Typical species of this community are the braquiopod *Gryphus vitreus*, the bivalve *Limopsis aurita*, the gastropod *Colus gracilis*, the hermit crab *Pagurus alatus*, the forkbeard fish *Phycis blennoides* and the small shark *Galeus melastomus*. The increase of the water current speed in some areas of the Le Danois summit, limits the presence of sedimentary coverage and facilitates the necessary presence of rocky outcrops for the sessile organisms of great bearing like the community characterized by the gorgonians *Callogorgia verticillata*, which also includes large-sized Geodidae and Hexactinellidae sponges (*Asconema setubalense*, *Geodia megastrella*, i.e.) together with the cnidarians *Caryophyllia smithii* and *Acanella arbuscula* and the fish *Chimaera monstrosa* (Figure 3). A clear increase of megafaunal concentration and species richness is recognised for biocoenoses in which live gorgonians and sponges are rather abundant.

Anthropogenic pressure is also identified by means of this methodology. The existence of rests of lost gillnets and longlines is remarkably in the rocky outcrops of the bank which reveals a high fishery impact years ago. Some damage caused by fishery activities, in particular destructive trawling techniques, has been observed at a number of large-sized benthic organisms like *Callogorgia verticillata* and *Asconema setubalense*.

Conclusions

Detailed facies and biocoenoses spatial distribution based on image analyses was conducted on the hardgrounds of the Le Danois Bank summit. The results showed an obvious pattern which can be atributed to local current effects and sea-floor escarpement.

The new methodology used in this study is a valuable tool to locate, characterize and provide a high resolution maps of the vulnerable habitats of this ecosystem. The use of a sampling system that does not cause damage or alterations of benthic communities is particulary necessary in this ecosystem where the Environmental Ministry is about to create the first Spanish offshore Marine Protected Area.

Acknowledgements

This study was partially funded by the Spanish Science and Technology Ministry, and included in the ECOMARG Project (REN2002-00916/MAR). The invaluable work of the crew of the RV *Vizconde de Eza,* which belongs to SGPM (Agriculture and Fisheries Ministry), who made possible the use of the photogrammetric sledge during the TREBOL survey. This survey was support by the SGPM in order to study the impact caused by trawl gears using rock-hopper as groundrope.

References

Le Danois, E., 1948. *Les Profondeurs de la Mer*. Ed. Payot, Paris, 303 pp.

Lundälv, T., 1971. Quantitative studies on rocky bottom biocoenoses by underwater photogrammetry. A methodological study. *Thalassia Jugoslav.*, 7: 201-208.

Sánchez, F. A. Serrano, S. Parra, M. Ballesteros & J.E. Cartes, 2007. Habitat characteristics as determinant of the structure and spatial distribution of epibenthic and demersal communities of Le Danois Bank (Cantabrian Sea, N. Spain). *Journal on Marine Systems* (in press).

Seasonal export of foraminiferal and particulate mass fluxes in the Bay of Biscay

Neven Lončarić [*a,b], Hélène Howa [A,b], Sabine Schmidt [C] and Laurent Labeyrie [D]

Introduction

Biology and geographical distribution of planktic foraminifera are governed by the physical and chemical properties of the ambient water of the upper ocean in which they live. Such tight relationship between foraminiferal ecology and environmental characteristics allows a first order approximation of the past ecosystems from the fossil assemblages preserved in the deep-sea sediment cores. Regardless the fact that only complete understanding of the ecology of modern species provides a solid base for the firm paleoceanographic interpretations, previous studies of living planktic foraminifera from the Bay of Biscay were scarce (e.g. Bé & Hamlin, 1967) and the export and deposition fluxes of this major carbonate producing group remained in this area completely uninvestigated. This study provides the first seasonally resolved record of foraminiferal export fluxes settling from the productive zone of the pelagic Bay of Biscay. We aim to document changes in magnitude, composition and timing of foraminiferal and particle mass fluxes in relation to the seasonal alterations of the regional oceanography.

Methods

At the "Plateau des Landes" in the Bay of Biscay sediment export fluxes have been sampled since June 2006 as a part of the on-going ANR-FORCLIM program. Two Technicap PPS5 sediment traps with a collecting area of $1m^2$ and a 24-cup automated sampling carousel have been deployed at the WH station (44°32' N; 2°45' W), approximately 100 km off the Arcachon lagoon, at the water depth of 2000 m. The traps were moored at 800 m and 1700 m water depth, 1200 m and 300 m above the sea floor, respectively, programmed to sample consecutive 12-days intervals. The preliminary results of this study cover the time period from June 2006 until April 2007, and provide semi-annual record of pelagic particles settling towards the sea floor.

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Results

The most prominent maximum in foraminiferal export flux occurred in June and July, at the time of high SST and very low chlorophyll-a concentration in the surface water (Fig. 1). During the rest of the year the fluxes of all major species remained low. The magnitude of these fluxes appeared lower than what is typically found in the oligotrophic open ocean (Lončarić et al., 2007). The total foraminiferal flux was dominated by species *Globigerina bulloides*, *Globorotalia inflata*, *Orbulina universa* and *Neogloboquadrina pachyderma* (dex). Some secondary species like *Hastigerina pelagica* and *Globigerinoides trilobus* showed periodic maxima that differed from the general trend of the summer bloom. Next to the summer maximum, the total mass flux showed additional maxima during December and February/March that appeared correlated to the enhanced concentrations of the chlorophyll-a from the surface water, although delayed by a few weeks (Fig. 1). The gross of the mass flux was composed of the fine material of the <100 μm fraction, in particularly at the lower trap which revealed significantly higher fluxes comparing to the upper trap, with an order of magnitude higher contribution of the fine material.

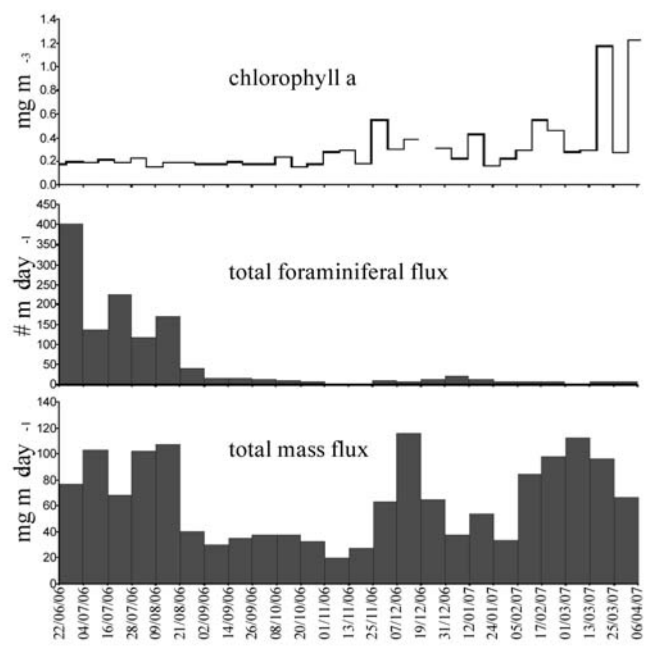

Figure 1. Total foraminiferal [# m^{-2} day^{-1}] and mass [mg m^{-2} day^{-1}] fluxes at the WH site (Plateau des Landes) from June 2006 till April 2007 recovered by the sediment trap at the water depth of 800m vs. satellite-derived chlorophyll-a concentration from the surface water [mg m^{-3}].

Conclusions

Between June 2006 and April 2007 enhanced foraminiferal export fluxes showed strong seasonal biasing, occurring only during the summer when 88% of the semi-annual foraminiferal flux of the fraction >250 μm has been exported from the productive zone. These maxima appeared poorly correlated to the satellite-derived chlorophyll-a concentration from the surface water. The foraminiferal fluxes were surprisingly low, comparable or even lower than the fluxes characteristic for the open oligotrophic ocean. In contrast to the previous observations from the water column (e.g. Bé & Hamlin, 1967) and the surface sediment (e.g. Caralp, 1967; Pujol, 1980), tropical species *Globigerinoides trilobus* appears present in the Bay of Biscay throughout the year. Large differences between the mass fluxes recorded at 800 m and 1700 m water depth and great contribution of fine material in the lower trap suggest other source of the sediment, rather than only vertical pelagic settling from the productive zone. Majority of these sediments that are discharged to the greater depths are likely associated with the nepheloid layers of suspended material originating at the continental slope (Durrieu de Madron et al., 1999).

Acknowledgements

We wish to thank the captains, crews and shipboard scientific parties of the R/V Côtes de la Manche (INSU/CNRS) for their assistance during the material recovery. This research was financially supported by the LEBIM grant from the province of Vendée (France) and it was carried out within the French national program ANR-FORCLIM.

References

Bé A.W.H. and Hamlin, W.H., 1967, Ecology of recent planktonic foraminifera: part 3 – distribution in the North Atlantic during the summer of 1962, Micropaleontology, 13(1), pp. 87-106.

Caralp, M., 1971, Les foraminifères planctoniques du Pléistocène terminal dans le Golfe de Gascogne: Interprétation biostratigraphique et paleoclimatique. PhD thesis, University of Bordeaux I, 187 pp.

Durrieu de Madron, X., Castaing, P., Nyffeler, F. and Courp, T., 1999, Slope transport of suspended particulate matter on the Aquitanian margin of the Bay of Biscay, Deep-Sea Research II, 46, pp. 2003-2027.

Lončarić, N., van Iperen, J., Kroon D. and Brummer, G.-J.A., 2007, Seasonal export and sediment preservation of diatomaceous, foraminiferal and organic matter mass fluxes in a trophic gradient across the SE Atlantic, Progress in Oceanography, 73, pp. 27–59.

Pujol, C., 1980, Les foraminifères planctoniques de l'Atlantique Nord au Quaternaire: écologie, stratigraphie, environnement. Mémoires de l'Institut de Géologie du Bassin d'Aquitaine, 10, 254 pp

Colonisation of hard bottom marine habitat in Hendaye Bay

Marie-Noëlle de Casamajor,[a] Sophie Bureau[b], Josiane Popovsky[b] and Laurent Soulier[b]

Abstract

This work was completed within the framework of a program Aquitaine / Euskadi whose general objective is to characterize the marine habitats of Hendaye bay. For this study, Cereca, Ifremer, Ima, Laphy and Azti worked together. This project is articulated around three investigations campaigns:

- a cartography of the habitats using multibeam echosounder : bathymetry and nature of the bottom ;
- a grab sampling for macrofaune identification of soft bottom ;
- two scuba-diving samplings for identification of hard substrata macrofauna.

Results concerning the settlements of hard substrata have been obtained within in this work. A close attention was paid to the sessile benthic species.

The hard zone of substrate were identified starting from the multibeam survey carried out by Azti. From these results six zones of prospection were given two on each both sides bay (two on cape Higuier and two on cape Sainte-Anne) and two on isolated reefs of Iruarri and Chicharvel (fig.1).

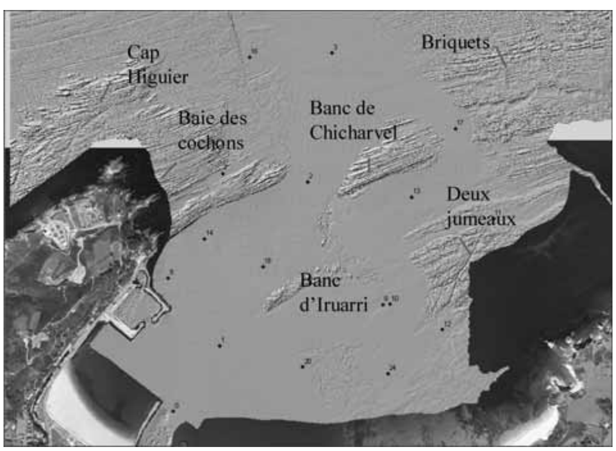

Figure 1. Localisation of sampling sites.

On each site, a transect of about thirty meters length was carried out. The species were indexed like their representativeness on the site.

These sites have been visited twice, in spring and autumn 2007 (June and October) in order to characterize the seasonnal species and those more annual.

These investigations made it possible to identify 178 species during two campaigns including 156 in spring and 148 in autumn. 36 species were defined like characteristics of the zone: they were observed on all sites and during the two campaigns (fig. 2).

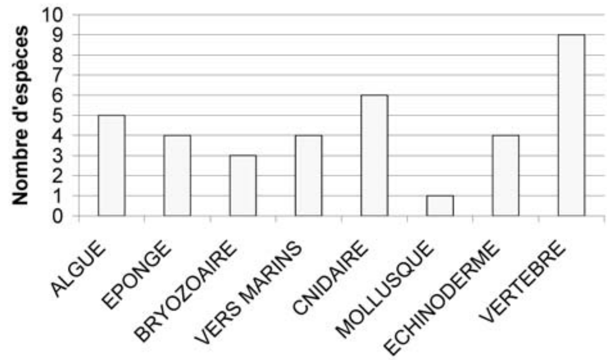

Figure 2. Distribution by biological group of the species most characteristic of the zone.

A work of analysis made it possible to characterize the sites using EUNIS marine habitat classification (A3 Infralittoral rock and other hard substrata).

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Induction to maduration of the sea urchin *Paracentrotus lividus* (Lamarck, 1816) in laboratory conditions

Joxe Mikel Garmendia*[a], María Jesús Belzunce[a], Javier Franco[a], Iratxe Menchaca[a], Marta Revilla[a]

Introduction

In the context of integrated evaluation of the marine ecosystem is being usual to use live organisms for toxicity evaluation of marine waters and sediments. The sea urchin *Paracentrotus lividus* is one of the key species used for such purpose. Mature gametes of sea urchins are needed to carry out toxicity tests but not always they are available in the field. Some studies have demonstrated that gonad development of sea urchins is influenced by multiple environmental factors, mainly food, temperature and photoperiod (Kelly, 2001; Gago *et a*l., 2003; Sánchez-España *et al*., 2004; Böttger *et a*l., 2006; Dumont *et a*l., 2006; James *et a*l., 2007).

In this study, a laboratory experiment has been carried with the objective of disposing of mature gametes when always necessary, overcoming the temporary limitation found in the field. The idea of the experiment is to accelerate the gonad development through the control and manipulation of the above mentioned parameters under laboratory conditions. The results are obtained by comparison of gonad characteristics of sea urchins directly sampled in the field and copies (also picked up from the field) kept under laboratory conditions for a period of time.

Methods

In November 2006, 60 sea urchins larger than 40 mm in diameter were sampled, on foot and at low tide, in a population settled down in the intertidal rocky area of Donostia-San Sebastián (Basque Country). Three pools (60 cm x 40 cm x 30 cm) were conditioned in the laboratory where 15 individuals were introduced in each one, at constant temperature of 20 ºC, natural photoperiod and not restrictive food (carrot and algae from the original area). Water conditions of water (temperature, salinity, oxygen, pH, ammonium) were daily controlled to assure an appropriate environment for the maintenance of the sea urchins. The remaining 15 sea urchins were used to establish the conditions at the starting point of the experiment.

With a monthly interval, the sea urchins were removed from each pool and measured. At the same time, 15 sea urchins of the same sampling area were picked up and also measured. In this way, 4 samplings coincident (except the first one) with the casting of a pool were carried out.

The measured parameters were: corporal height and diameter, individual weight (fresh and dry), gonad volume, gonad humidity and gonad weight (fresh and dry). Besides, a gonad index was infered and its evolution along 4 months was studied.

Moreover, the sea urchins were injected with KCl to verify their spawning capacity. With the obtained gametes, fecundations were carried out with the aim of evaluating the quality of gametes and to check their viability.

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Results and Discussion

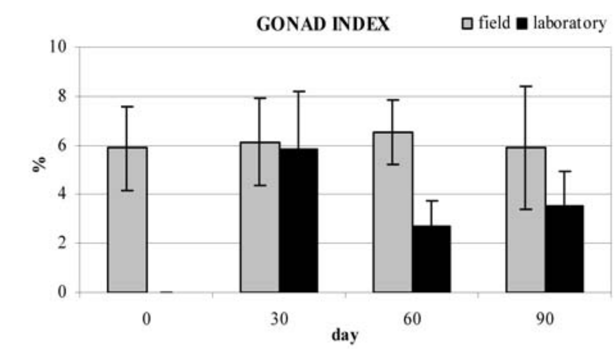

Figure 1. Median values and standard deviations of Gonad Index (gonad dry weight / body dry weight x 100) in sea urchins from field and laboratory during the experiment.

The gonad index shows the highest difference between field and laboratory in day 60 (Figure 1).

A different trend in gonad development could be observed: while gonads increase in size in the nature, they decrease in the laboratory (data not shown).

With respect to spawning success, in day 30, little difference is registered between both environments (20 % in the field and 13 % in the laboratory) and no differences in day 0 (20 % in both cases) (Figure 2).

In day 60, whereas the spawning success increases weakly (up to 33 %) in the field, a great increase is observed (up to 85 %) in the laboratory.

In day 90, the spawning capacity continues increasing up to 67 % (because the natural spawning period is getting closer) in the nature whereas the percentage maintains its level in high values (73 %) in the laboratory.

The highest differences between field and laboratory experiments are seen in day 60. Then, it seems that the gonad development stops in the laboratory, while it continues increasing in the nature becoming close to those from the laboratory in day 90.

These results show that 60 days is the most effective maintenance time in laboratory for achieving the objective of this work, the acceleration of gonad development.

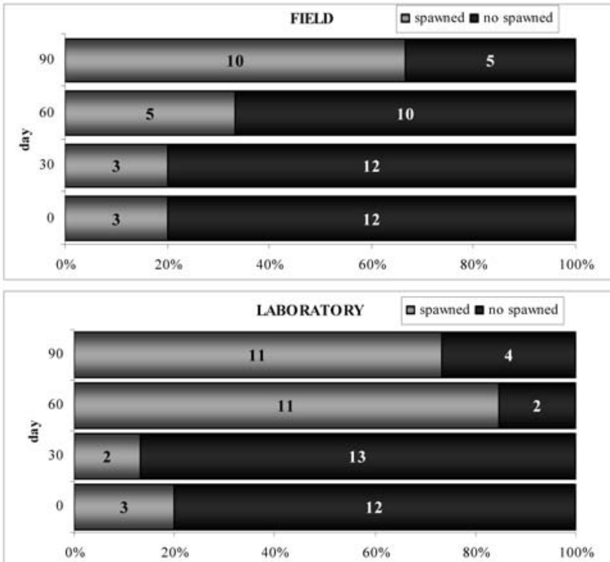

Figure 2. Spawned sea urchin % (bars) and number (into bars) from field and laboratory conditions.

A similar experiment was repeated with sea urchins sampled in September 2007. The results of this experiment will be compared with the first results and will be also presented at the Symposium.

Acknowledgements

This study was supported by the project FIT-310100-2006-7 funded by the Spanish Ministerio de Industria y Comercio, a contract of J.M. Garmendia (Ministerio de Educación y Ciencia programme Torres Quevedo) and a grant of I. Menchaca (Technological Center Foundation). We wish to thank also several people from AZTI for their help in sampling and laboratory tasks (Marivi, Irene, Goretti, Ekaitz).

References

Böttger, S.A., M.G. Devin, C.W. Walker, 2006. Suspension of annual gametogenesis in North American green sea urchins (*Strongylocentrotus droebachiensis*) experiencing invariant photoperiod - Applications for land-based aquaculture. *Aquaculture*, 261: 1422-1431.

Dumont, C., C.M. Pearce, C. Stazicker, Y.X. An, L. Keddy, 2006. Can photoperiod manipulation affect gonad development of a boreo-arctic echinoid (*Strongylocentrotus droebachiensis*) following exposure in the wild after the autumnal equinox?. *Marine Biology*, 149: 365-378.

Gago, J., P. Range, O. Luis, 2003. Growth, reproductive biology and habitat selection of the sea urchin *Paracentrotus lividus* in the coastal of Cascais, Portugal. In: Féral, J.P., David, B. (Eds.), *Echinoderm Research 2001*, Balkema, Lisse: 269-276.

James, P.J., P. Heath, M.J. Unwin, 2007. The effects of season, temperature and initial gonad condition on roe enhancement of the sea urchin *Evechinus chloroticus*. *Aquaculture*, 270: 115-131.

Kelly, M.S., 2001. Environmental parameters controlling gametogenesis in the echinoid *Psammechinus miliaris*. *Journal of Experimental Marine Biology and Ecology*, 266: 67-80.

Sánchez-España, A.I., I. Martínez-Pita, F.J. García, 2004. Gonadal growth and reproduction in the commercial sea urchin *Paracentrotus lividus* (Lamarck, 1819) (Echinodermata: Echinoidea) from southern Spain. *Hydrobiologia*, 519: 61-72.

Reproductive cycle of *Paracentrotus lividus* (Lamarck, 1816) in two contrasting areas of the Basque coast (southeastern Bay of Biscay)

Iratxe Menchaca*[a], María Jesús Belzunce[a], Javier Franco[a], Joxe Mikel Garmendia[a], Marta Revilla[a]

Introduction

Bioassays with the embryonic phase of the sea urchin *Paracentrotus lividus* are very common and recurrent as toxicological tools (Arizzi Novelli *et al*., 2006; Beiras and Saco-Álvarez, 2006; Casado-Martínez *et al*., 2006) due to its large geographic distribution, easy manipulation and simplicity for achieving gametes and performing *in vitro* fecundation.

Many studies have been focused on its reproduction in the Mediterranean Sea and Atlantic waters, which takes place only during spring and early summer (Sellem *et al*., 2007; Barnes *et al.*, 2001; Spirlet *et al.*, 1998), but more detailed information is necessary to carry out routine toxicity test and for the correct manipulation of water and sediments samples.

The aim of this study is to determine the annual cycle of gonad development of *Paracentrotus lividus* in order to know the availability of gametes in field and to compare the results of two different populations.

Methods

Samples were collected from November 2006 to October 2007, at two sites (Zumaia and Donostia-San Sebastian) located in the innermost part of the Bay of Biscay, the Basque Country coast (northern Spain). These sites differ in their marine vegetation and exposure to wave action. The corporal diameter, gonad index (*GI1: [gonad wet weight (g)/ body wet weight (g)]*100; GI2: [gonad dry weight (g)/ body dry weight (g)]*100*), spawning ratio (by injecting 0.5M KCl), gonad volume, gonad humidity, fertilization success and embryonic development (evaluating the quality and the viability of gametes) of 40-50 mm sea urchins were monthly monitored. Temperature and salinity of water were also registered *in situ*.

Results and Discussion

The lowest gonad indexes occurred at mid-spring in Donostia-San Sebastian, coinciding with the spawning event and water temperature increase. In contrast, the lowest values in Zumaia were registered at the end of winter (Fig. 1). The gonad recovery started in autumn-winter in both population.

The period of maturity in Zumaia was shorter than in Donostia-San Sebastian, where the percentage of fertile sea urchins was high (> 65%) from February to October, decreasing in mid-autumn and reaching low values (< 30%) from November to January (Fig. 2).

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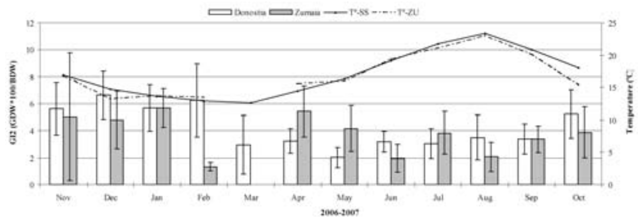

Figure 1. Median values and standard deviations of Gonad Index 2 (Gonad Dry Weight*100 / Body Dry Weight) in sea urchins from Zumaia (ZU) and Donostia-San Sebastian (SS) from November 2006 to October 2007.

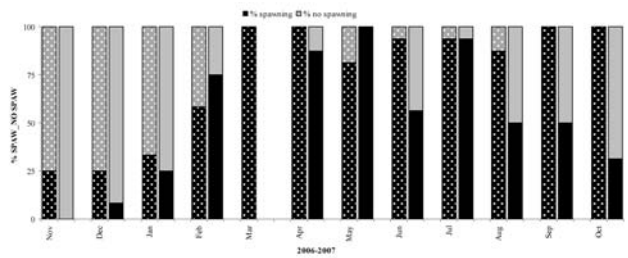

Figure 2. Median percentage values of spawned sea urchins (black bars) from Zumaia (smooth) and Donostia-San Sebastian (points) from November 2006 to October 2007..

Embryo-larval toxicity bioassays with Donostia-San Sebastian sea urchins could not be carried out at the end of summer and in autumn due to low quality of gametes (Table 1). This limitation was higher in Zumaia, mainly because of the lack of gametes. Temperature (Fig. 1) and photoperiod are very similar in both areas of study and cannot explain the differences observed in the reproductive cycles. The high degree of wave exposure in Zumaia and differences in food inputs could be explanatory factors.

Table 1. Embryogenesis success results from November 2006 to October 2007 (yes = more than 90% of the larvae developed the four arms; no= less than 90% of larvae developed the four arms; ** Lack or poor quality of gametes).

2006-2007	Donostia-San Sebastian	Zumaia
Nov	yes	no**
Dec	yes	no**
Jan	yes	no**
Feb	yes	no**
Mar	yes	no sample
Apr	yes	yes
May	yes	yes
Jun	no	no
Jul	yes	yes
Aug	yes	no**
Sep	no	no**
Oct	no	yes

Acknowledgements

This study was supported by the project FIT-310100-2006-7 funded by the Spanish Trade and Industry Ministry, a grant of I. Menchaca (Technological Center Foundation) and a contract of J.M. Garmendia (Education and Science Ministry programme Torres Quevedo). We wish to thank also several people from AZTI for their help in sampling and laboratory task.

References

Arizzi Novelli, A., C. Losso, G. Libralato, D. Tagliapietra, C. Pantani, A. Volpi Ghirardini, 2006. Is the 1:4 elutriation ratio reliable? Ecotoxicological comparison of four different sediment:water proportions. *Ecotoxicology and Environmental Safety*, 65: 306-313.

Barnes, D.K.A., A. Crook, M. O' Mahoney, S. Steel, D. Maguire, 2001. Sea temperature variability and Paracentrotus lividus (Echinoidea) population fluctuations. Journal of the Marine Biological Association of the United Kingdom 81, 359-360

Beiras, R., L. Saco-Álvarez, 2006. Toxicity of seawater and sand affected by the Prestige fuel-oil spill using bivalve and sea urchin embryogenesis bioassays. *Water, Air and Soil Pollution*, 177: 457-466.

Casado-Martínez, M.C., N. Fernández, J. Lloret, A. Marín, C. Martínez-Gómez, I. Riba, R. Beiras, L. Saco-Álvarez, T.A. Del Valls, 2006. Interlaboratory assessment of marine bioassays to evaluate the environmental quality of coastal sediments in Spain. III. Bioassay using embryos of the sea urchin *Paracentrotus lividus*. Ciencias Marinas 32, 139-147

Sellem, F., M. Guillou, 2007. Reproductive biology of *Paracentrotus lividus* (Echinodermata: Echinoidea) in two contrasting habitats of northern Tunisia (south-east Mediterranean). Journal of the Marine Biological Association of the United Kingdom 87, 763-767.

Spirlet, C., P. Grosjean, M. Jangoux, 1998. Reproductive cycle of the echinoid *Paracentrotus lividus*: analysis by means of the maturity index. Invertebrate Reproduction and Development 34, 69-81.

Population structure of native and introduced clam species in estuaries of Cantabria (Bay of Biscay)

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Introduction

The most important commercial moluscs in the estuaries of Cantabria are the native clam (Venerupis decussata) and the Manila clam (Ruditapes philippinarum), an exotic species. The later, original from Asia, was introduced in the European coasts across France (Parache, 1982), because of both the difficulty to obtain seed of native clams and the better commercial profits.

Manila clams have been easily adapted to the estuarine conditions, showing a fast growth rate (Perez Camacho and Cuña, 1985), higher than that of Venerupis species (Royo et al., 2001). In consequence, doubts about the possible inter-specific competence of both species have been suggested.

So, the objective of this paper is to make a first comparison between the current population structure of both species, in two different estuaries of Cantabria, in which both species are extensively harvested.

Methodology

The zones of study included the two most important estuaries of Cantabria (North Spain, Bay of Biscay), from both the fisheries and the ecological points of view: the Bay of Santander and the Nature Reserve of Santoña. Commercial grounds of these species are located mainly in the intertidal zones of these estuaries.

A total of 25 and 33 intertidal stations were sampled in each of those areas (Figures 1 and 2), within the “shellfish harvesting areas” established by the Fisheries Dept. Spatial distribution of sampling stations were carried out according to a preliminary designation of “priority harvesting zones”, based on information from several sources, including fishermen and Fisheries managers, legislation, scientific literature.

In each station, a 10 x 1 m transect surface was delimited and used for gathering all the clams. Harvesting was carried out by a professional fishermen using traditional methods. Collected clams were kept in labelled bags and transported to the laboratory in dark conditions. Once in the laboratory, the taxonomic identification of clams of both species was carried out prior to the biometric analyses. Shell maximum length, maximum width and height from the apex of each individual were measured with a precision calibre (±1 mm), before obtaining their fresh weight with a Sartorius balance (model BL150S), at a precision of ±0,01 g. Further estimates of dry weight were carried out after oven drying each single specimen (24 h - 105ºC).

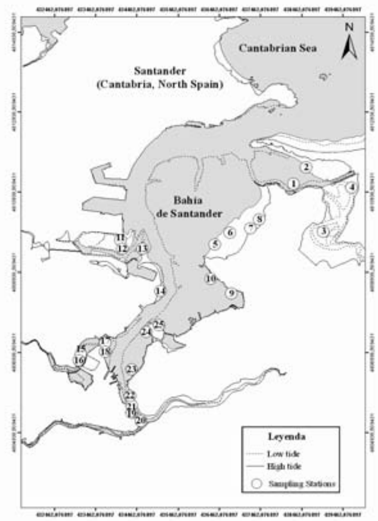

Figure 1. Map of Bay of Santander, showing the sampling stations.

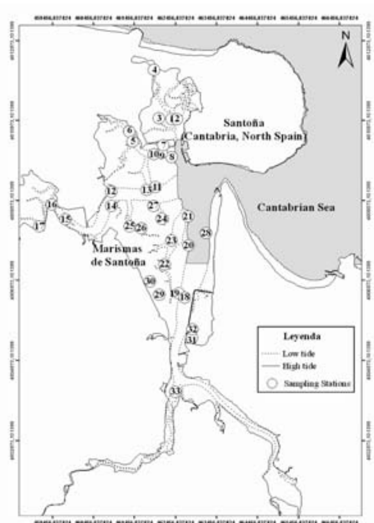

Figure 2. Map of N. R. Santoña, showing the sampling stations.

Abundance of native and introduced species in each station were expressed on a surface basis (ind m-2).. In addition, average densities were calculated within the priority zones and total in each estuary with their statistical corresponding ones (coefficient of variation, maximum data and minimum data) to make the comparisons between both estuaries.

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Results and Discussion

Population structure

In Figure 3, the maximum length frequency distributions registered for all the gathered specimens of native and exotic clams are shown, in both zones, Bay of Santander and Nature Reserve of Santoña, respectively. In the Bay of Santander, the greater percentage of clams of both species was located between 25 and 35 mm of size, with a maximum in the range of 30-35 mm. Further reductions in frequencies are from the range between 35-40 mm and, more significantly, between 40-45 mm, what agreed with the minimum legal size of capture.

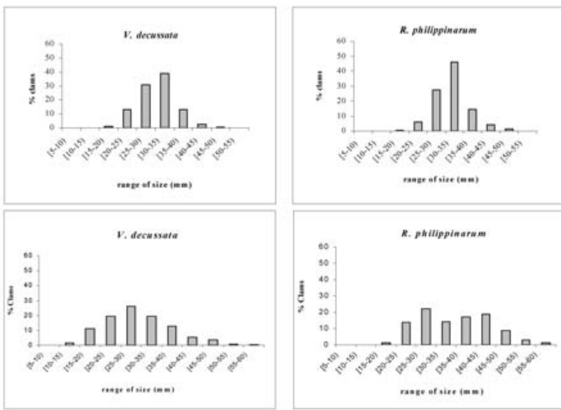

Figure 3. Caption Maximum length frequency distributions of native and Manila clams, in the Bay of Santander (top) and Santoña (bottom).

In the Nature Reserve of Santoña, the distribution of sizes was different for both species. In the case of the native clam, the interval with a greater frequency of individuals was that between 25-30 mm, somehow lower than that registered within the Bay of Santander. Nevertheless, for Manila clams the percentage of individuals is quite homogenous between the ranges [20-25) and [40-45) mm.. From those data, it is possible to suggest that there is a higher pressure on Manila clams within the Bay of Santander, zone where the population structure is similar for both species and the fishing pressure seems to be effective over the range of 35-40 mm.

In addition, relationships between size and dry weight for each species in each estuary showed a significant fitting to a potential equation of order 3, the same as previously observed for other bivalve molluscs. (Bald and Borja, 2000). According to these equations it is necessary to emphasize that, for a similar size ,Manila clams showed higher weights than native clams. This seems to be due to the structure of the shell, much more heavy and coarse in the case of Manila clam.

Estimation of densities

Average values of densities for each estuary as a whole indicated that in the Bay of Santander both species presented similar abundances (ca. 3,5 ind m-2), meanwhile within the Nature Reserve of Santoña the native clams were the predominant species (1,7 and 1 ind m-2, respectively).

When the comparisons were made between estuaries both species showed higher densities in the Bay of Santander. Those values may reflect the continuous management activities for the maintenance of stocks of the exotic species.

Relative proportions of species

Considering the collected individuals in each estuary as a whole, different relationships among the two species were observed. So, a 1:1 proportion was registered in the Bay of Santander, where a total of 860 individuals of native clams were gathered versus the 867 individuals of the exotic species. On the other hand, a 3:1 proportion was calculated for the Santoña area, where 499 individuals of native clams were collected versus the 189 individuals of the Manila species.

Regarding the proportions at the station level (Figure 4), it may be observed a clear predominance of exotic clams in many of the sampling stations of the Bay of Santander. This may ratify the effect of the frequent stock enhancement activities carried out in the Bay of Santander.

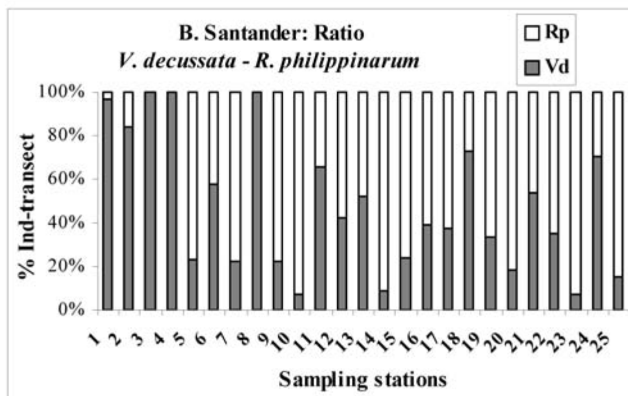

Figure 4..Proportions of clam species in the Bay of Santander

Acknowledgements

This study was supported by the Dirección General de Pesca y Alimentación from the Regional Government of Cantabria.

References

Borja, A. y J. Bald, 2000. Estado de los recursos marisqueros del País Vasco en 1998-1999 (Con especial atención a almeja y berberecho).Informes Técnicos Nº 86. 78 pp.

GESHA, 2005. Evaluación de recursos de interés marisquero en el litoral de Cantabria y desarrollo de protocolos aplicables a su gestión. 2004–2005. Consejería de Agricultura, Ganadería y Pesca. Gobierno de Cantabria.

Parache, A. 1982. La palourde. La Pêche Maritime 20: 496-507.

Pérez Camacho, A. y M. Cuña. 1985. First data on raft culture of Manila Clam (Ruditapes philippinarum) in the Ria de Arosa (NW Spain). ICES C.M. 1985/F:43:22pp.

Royo, A. D.Quintero, M. Hurtado Burgos y M. Hurtado Cancelo. 2001. Crecimiento y mortalidad en cultivos de almeja fina (Ruditapes decussatus L. 1758) y de japonesa (Ruditapes philippinarum Adams & Revé, 1850) a diferentes niveles de cobertura mareal. Monografías del Instituto Canario de Ciencias Marinas 4:156-161.

Recovery of the populations of *Chthamalus montagui* Southward and *Chthamalus stellatus* (Poli) (Crustacea: Cirripedia) after a small scale disturbance in an intertidal of the Basque coast

Amalia Martínez de Murguía[a] and José Ignacio Saíz Salinas[b]

Introduction

The barnacle belt, which dominates on exposed rocky shores of the Basque coast, is constituted by two species: *Chthamalus montagui* Southward, 1976 and *C. stellatus* (Poli, 1791). Although both species compete for space in the rocky intertidal, those species show a clear spatial segregation in the vertical axis: *C. montagui* is more abundant in the mid and high zone while *C. stellatus* dominates in the lower level of the barnacle belt. The objective of this project was to study the temporal changes in the populations of the sessile adults and juveniles of both species in controlled and experimental conditions in a representative shore of the Basque coast (San Sebastián). This data is important in order to estimate the time neccesary for the recovery of those populations after a small scale disturbance of the shore.

Methods

The study site was located at the Bay of San Sebastián. Non destructive sampling was carried out in three tidal heights where photographic monitoring of 30 permanent quadrats of 5 x 5 cm, control and experimental (cleared at the beginning of the study), was done quarterly during two years (1996 – 1998). In a complementary way, artificial plates for assessing recruitment were set up in the mid shore with different position in relation to the sea angle (parallel and perpendicular) and lasted for one recruitment season (from May to November of 1997).

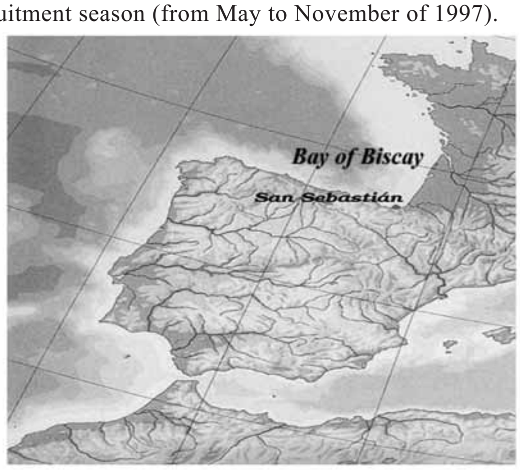

Figure 1. Geographic location of the study site.

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Results and Discussion

Results show that recruitment density is three times higher in the experimental quadrats than in the controls during the first year of study, while at the end of the second year there are no differences between the two types of quadrats (Figure 2). Recruitment of both species was higher in the vertical plates (parallel), although the species *C. montagui* dominates in the plates with more exposure to the sunlight in contrast with *C. stellatus*, which had higher recruitment in the plates that kept moister. The density of adults and juveniles doesn't show significant differences between both types of quadrats (control, experimental) at the end of the study, suggesting that the recovery of the populations takes two years in a rocky vertical substratum. Diferences in the relative proportion of those species in the intertidal community could be an indicator in the medium term of changes in sea water temperature (Southward, 1991; Pannacciulli, 1995) and as a consequence in climatic change.

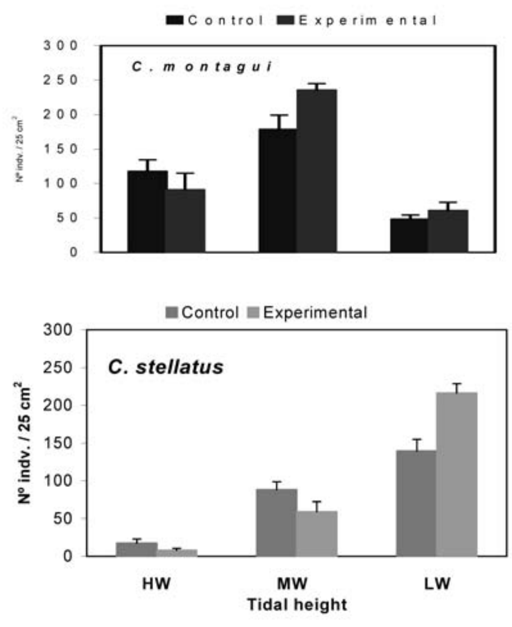

Figure 2. Mean density (± standard error) in 25 cm2 of adults and recruits of *C. montagui* and *C. stellatus* on the control and experimental quadrats in November 1998.

Conclusions

The vertical distribution of the adults of both species is determined by the vertical distribution of recruitment and mortality. The density of adults and juveniles doesn't show significant differences between both types of quadrats (control, experimental) at the end of the study, suggesting that the recovery of the populations takes two years in a rocky vertical substratum. Finally, abundance of recruitment of both species in the mean level of the study area is determined by the degree of wetness of the substratum.

References

AGUIRREZABALAGA, F., A. ALTUNA, A. MARTINEZ DE MURGUIA, A. ROMERO, K. ZABALLA & M. IBAÑEZ 1987. Contribución al conocimiento de la fauna marina de la costa vasca V. *Lurralde*, 10: 109-128.

BARNES, H. and M. BARNES 1966. The recovery of *Chthamalus stellatus* from the effect of a severe winter of 1962-63 on the shores of Pornic, France. *Cahiers de Biologie Marine*, 7: 247-249.

CONNELL, J.H. 1985. Consequences of variation in settlement vs. recruitment in rocky intertidal communities. *Journal of Experimental Marine Biology and Ecology*, 95: 11-45.

DANDO, P. R. and A. J. SOUTHWARD 1980. A new species of *Chthamalus* (Crustacea: Cirripedia) characterized by enzyme electrophoresis and shell morphology: with a revision of other species of *Chthamalus* from the western shores of the Atlantic Ocean. *Journal of the Marine Biological Association, U.K.*, 60: 787-831.

DAYTON, P.K. 1971. Competition, disturbance and community organization: The provision and subsequent utilization of space in a rocky intertidal community. *Ecological Monographs*, 41: 351-389.

FOSTER, B.A. 1971a. Desiccation as a factor in the intertidal zonation of barnacles. *Marine Biology*, 8: 12-29.

GARCÍA, C.B. and I. MORENO 1997. Recruitment, growth, mortality and orientation patterns of *Balanus trigonus* (Crustacea: Cirripedia) during succession on fouling plates. *Scientia Marina*, 62 (1-2): 59-64.

HYDER, K., JOHNSON, M.P., HAWKINS, S.J. and W.S.C. GURNEY 1998. Barnacle demography: evidence for an existing model and spatial scales of variation. *Marine Ecology Progress Series*, 147: 89-99.

JEFFERY, C.J. 2000. Settlement in different-sized patches by the gregarious intertidal barnacle *Chamaesipho tasmanica* Foster and Anderson in New South Wales. *Journal of Experimental Marine Biology and Ecology*, 252: 15-26

LEVIN, S.A. 1992. The problem of pattern and scale in ecology. *Ecology*, 73 (6): 1943-1967.

MARTINEZ DE MURGUIA, A. y J.I. SAIZ SALINAS 2000. Ciclo biológico de *Chthamalus montagui* Southward 1976 y *Chthamalus stellatus* (Poli) 1791 en la bahía de San Sebastián durante los años 1996-1997. *Ozeanografika*, 3: 101-110.

MENGE, B.A. 1991. Relative importance of recruitment and other causes of variation in rocky intertidal community structure. *Journal of Experimental Marine Biology and Ecology*, 146: 69-100.

MENGE, B.A. and J.P. SUTHERLAND 1987. Community regulation: Variation in disturbance, competition, and predation in relation to environmental stress. *American Naturalist*, 130: 730-757.

MINCHINTON, T.E. and R.E. SECHEIBLING 1993. Variations in sampling procedure and frequency affects estimates of recruitment of barnacles. *Marine Ecology Progress Series*, 99: 83-88.

OLIVIER, F., R. TREMBLAY, E. BOURGET and D. RITTSCHOF 2000. Barnacle settlement: field experiments of larval supply, tidal level, biofilm quality and age on *Balanus amphitrite* cyprids. *Marine Ecology Progress Series*, 199: 185-204.

O'RIORDAN, R.M., A.A. MYERS, D. MCGRATH, J. DELANY and A.M. POWER 1999. The sizes at settlement in natural populations of the cyprids of *Chthamalus montagui* and *C. stellatus*. *Journal of the Marine Biological Association, U.K.*, 79: 365-366.

PAGOLA, S. 2001. *Recuperación biológica del Abra de Bilbao: el seguimiento del macrozoobentos de sustrato rocoso y su optimización*. Tesis Doctoral, Universidad del País Vasco. 257 pp.

PANNACIULLI, F.G. 1995. *Population ecology and genetics of European species of intertidal barnacles*. Ph.D. Thesis, University of Liverpool. 143 pp.

SOUTHWARD, A.H. 1991. Forty years of changes in species composition and population density of barnacles on a rocky shore near Plymouth. *Journal of the Marine Biological Association, U.K.*, 71: 495-513.

Relative abundance and size structure of the deepwater red crab, *Chaceon affinis* (Milne-Edwards and Bouvier, 1894), in the Bay of Biscay

María Paz Sampedro,*[a] Celso Fariña[a], Ángel Fernández-Lamas[a], Juan Antonio Pereira and Ignacio Olaso[b]

Chaceon affinis is one of the largest species of the family Geryonidae inhabiting throughout eastern Atlantic Ocean. Recently a new gillnet fishery targeted genus *Chaceon* has been developed in ICES subareas VIII and IX. In 2002 a trap survey was carried out in the French continental slope (ICES divisions VIIIabd) in order to study fishing and biological aspects of deepwater red crab. From October to December, 125 operations were conducted at depths between 500 in 1000 m on rocky and muddy bottoms. Size, weight and sex data were recorded from a total of 3780 crabs. General Linear Models are used to determine factors affecting abundance estimates and population size structure. Catch rates did not differ significantly among depth strata or areas, but males were more abundant than females in all cases. The catch per effort unit (CPUE) varied from 19 to 2525 (crabs / trap line / 24 hours). Carapace width ranged from 68 to 206 mm in males and from 69 to 182 mm in females. The relationship between carapace width and water depth, area and sex was studied. Size was significantly influenced by sex, depth and area. Males were larger than females in the three depth strata established. Both sexes recorded the largest mean sizes in ICES statistical rectangle 23E3 at depths over 800 m.

Introduction

The deepwater red crab *Chaceon affinis* is geographical distributed throughout NE Atlantic from the Cape Verde to Iceland and is normally found on seamounts and escarpments at depths over 500 m (Manning and Holthuis, 1981). It attains its sexual maturity at 105-129 mm of carapace width and females are usually smaller than males (Fernández-Vergaz et al., 2000).

The Family Geryon comprises 25 species but only two of these species, *Chaceon maritae* and *Chaceon quinquedens,* have regular fisheries. As the case of other geryonids species, *C. affinis* has been the target of exploratory surveys and discontinuos fisheries.

Currently, *C. affinis* is caught as by-catch species in the gillnet fishery for anglerfish and as main species in a new gillnet UK fishery (ICES, 2007). Although there are no historical data, in 2006 the estimated landings for genus *Chaceon* were 22 tons and 283 tons in Subarea VIII and IX respectively.

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In 2002, in the framework of a cooperate research project within industry and scientist, a trap survey was carried out in the Bay of the Biscay. The survey was designed to catch deepwater red crab and operated within the species' depth distribution.

This work aims to determine whether intraspecific population caracteristics, size and sex distribution, and relative abundance by depth are similar in between studied areas.

Methods

A total of 125 trap line operations were conducted at three ICES statistical rectangles (22E4, 23E4 and 23E3) of Bay of Biscay, in depths from 500 to 1000 m, using the fishing boat "Balsaldúa" (Figure 1). Crabs were sorted by gender and their carapace width (CW, to the nearest mm) and total wet weight (in grames) were recorded. Relative abundance was estimated as numer of crabs per trap line per 24 hours. In order to have a minimum sample size, number of crabs were sorted in three depth strata (< 700 m, 700-800 m, ≥ 800m)

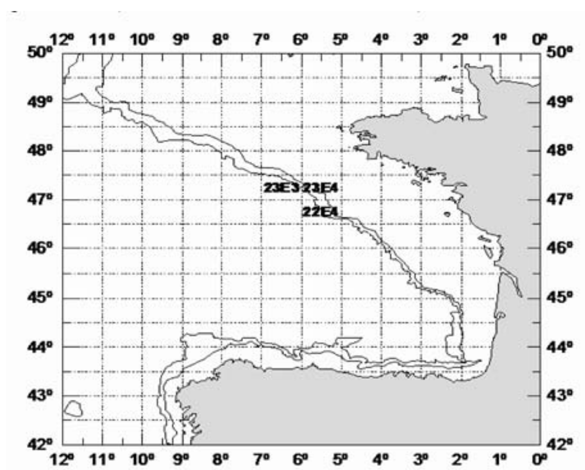

Figure 1. Location of ICES statistical rectangle studied in the exploratory survey.

An ANOVA was carried out to test the change in relative abundance by sex, depth strata and area studied as factors. To test differences in size an ANCOVA was undertaken. In this case depth was used as covariate and the effect of the sex and the area were analyzed.

Results and Discussion

Although the range of catch rates data was wide (19-2525 crabs), the 90 % of operations the CPUE was lower than 510 individuals per trap line per 24 hours. ANOVA results indicated that only sex had a slight significant effect (p=0.03) on catch rates. No differences on mean CPUE were found between depths or areas or interactions of variables used as factors (p>0.05). The median CPUE were greater for males than females (103 and 71 crabs/trap line/24hours respectively) (Figure 2). Dominance of males in depths < 800 m was also reported by López-Abellán et al., (2003) and Pinho et al. (1998).

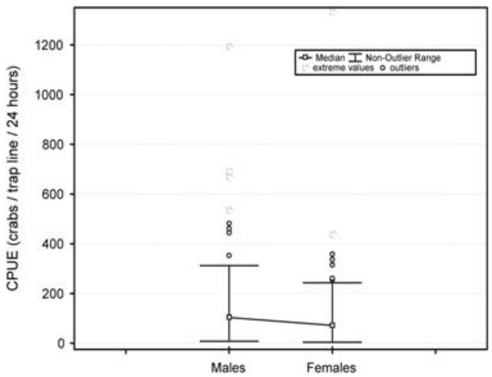

Figure 2. Comparison of CPUE by sex (median ± 95 % CI , outliers and extreme values are represented).

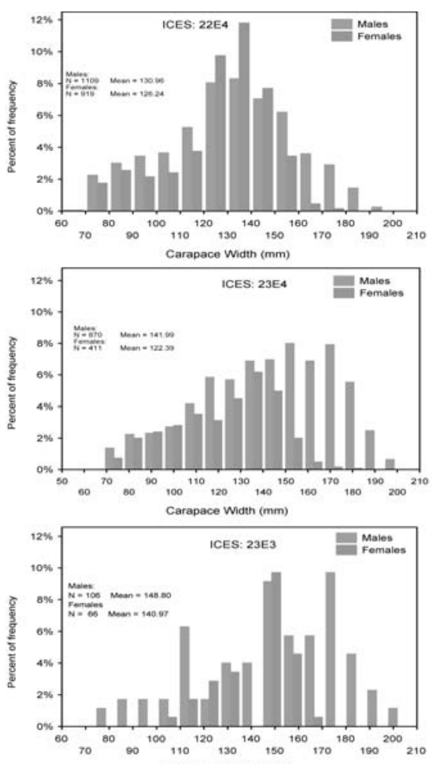

Figure 3. Size frequency and sex distribution for the three studied areas. Number of crabs (N) and mean carapace width are indicated by sex.

Males carapace width ranged from 68 to 206 mm and from 69 to 182 mm in the case of females (Figure 3). GLM results indicated significant differences in mean size of males and females, and between depth strata and areas studied (p<0.001). Males were largest than females in the three areas and three depth strata studied. The largests crabs were observed in the statistical rectangle 23E3 and at the deeper depth strata (Figure 4). For both sexes, size was positevely correlated with depth, and the smaller sizes were found at depths below 700 m.

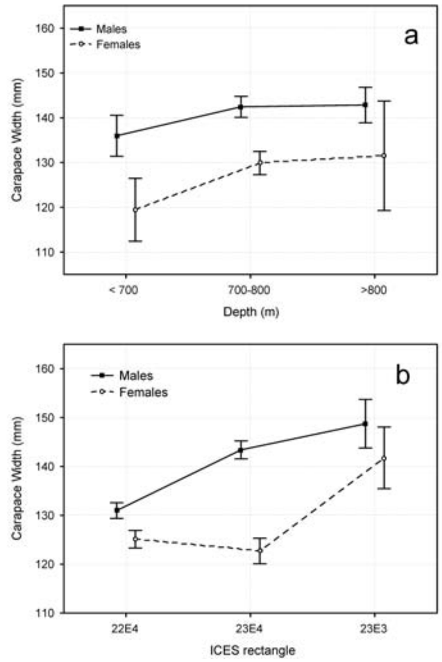

Figure 4. Mean carapace width ± 95 % CI for males and females caught in different depths (a) and areas (b) of Bay of Biscay. In figure 4b, the mean carapace width has been calculated after adjusting data to covariate values.

Conclusions

Males were more abundant and larger than females in all the depths and areas studied. Differences in size by sex were higher in the statiscal rectangle 23E4. For both sexes, the largest individuals were found in ICES statistical rectangle 23E3 at depths over 800 m.

Acknowledgements

The authors wish to thank the skippers and crew of the Basaldúa for their cooperation with this work.

References

ICES, 2007. Report of the working group on the biology and assessment of deep-sea fisheries resources (WGDEEP), 61 pp. ICES CM/ACE: 01.

Fernández-Vergaz, V., L.J. López-Abellán, E. Balguerías, 2000. Morphometric, functional and sexual maturity of the deep-sea red crab *Chaceon affinis* inhabiting Canary Island waters : chronology of maturation. Marine Ecology Progress Series 204, 169-178.

López-Abellán, L.J., E. Balguerías, V. Fernández- Vergaz, 2002. Life history characteristics of the deep-sea crab *Chaceon affinis* population off Tenerife (Canary Islands). Fisheries Research, 58 : 231-239.

Manning, R.B., L.B. Holthuis, 1981. West African brachyuran crabs (Crustacea: Decapoda). Smithsonian Crontibutions Zoology, 306 : 379 pp.

Pinho, M.R., J.M. Gonçálves, H.R. Martins , G.M. Meneses, 1998. Some aspects of the biology of the deep-water crab *Chaceon affinis* (Milne-Edwards and Boubier, 1894) off the Azores. ICES CM 1998/O:34, 13 pp.

Spatio-temporal Variability of Intertidal Phytobenthic Assemblages of the Basque Coast (N. Spain) Following the *Prestige* Oil Spill

Isabel Díez*[a], Antonio Secilla[a], Alberto Santolaria[a], José María Gorostiaga[a]

Introduction

On 19th November 2002, the single-hulled oil tanker *Prestige* sank in 3500 m of water, off the coast of northwestern Spain. The intermittent discharge of oil caused successive oil waves that arrived at the northern Spanish coasts. The Basque coast was the least affected as result of the application of operational oceanography and the use of the fishing fleet to remove oil at sea. Direct mortality of algal populations was not observed during the weeks that followed the main oil arrivals. In this context, trying to detect sublethal effects in naturally changing and heterogeneously distributed communities was a great challenge, hindered by the lack of previous baseline data. The aim of this study was to test the null hypothesis that no significant differences in the structure and composition of the assemblages occurred among localities with different oiling degrees and in different seasons and years. Likewise, the results obtained provide detailed quantitative data on the abundance of the most common species at different spatial and temporal scales, currently unavailable for the region considered.

Methods

Study area

The Basque coast extends for approximately 150 km in the southeastern corner of the Bay of Biscay. The continental shelf is less than 20 km wide and an strong and prevailing Northwesterly sea swell reaches directly the coast, which is mostly erosional with extensive cliffs. Tides are semidiurnal with a spring tidal range of 4.5 m. Mean water surface temperature off the Basque coast ranges between 12 ºC in February and 22 ºC in August.

Localities selection

Taking into account only on foot accessible places, the least and most affected locations were identified on the basis of the oil arrival inventory report (ORBANKOSTA, 2003). A subset of 6 locations were randomly selected among the least affected sites and another 6 among the most oiled sites.

Target habitat and community

The selected habitat corresponded to sections of open coast, very exposed-semiexposed to wave action, stable substrates (continuous bedrock and great blocks), with slight to moderate slope (0°-45°) at the highest level of the low intertidal zone. In this habitat the dominant macroalgal community throughout the Basque coast is that of *Corallina elongata*.

Sample collection

Each locality was represented by two random areas separated to each other 50 to 200 m. Areas were 15 meters long stretches parallel to coast. At each site 3 replicates of 40 x 40 cm quadrats were randomly sampled using visual estimates of faunal cover in % at specific level following the Braun-Blanquet scale. Samples were collected in each tidal level in two seasons, spring and autumn, over three years (from 2004 to 2006).

Data analysis

A five-factor analysis of variance (ANOVA) was used to test hypothesis on spatial and temporal patterns of distribution species richness *S*, Shannon diversity *H'* and mean abundance of the most common species. The factors considered were: year (three levels, fixed), season (two levels, fixed and orthogonal), oiling level (two levels, fixed and orthogonal to season), locality (six levels, random and nested in oiling level), area (two levels, random and nested in the interaction locality x oiling level). Three replicates represented each area. Prior to the analyses, the homogeneity of variances was checked by Cochran's C test. Data were transformed appropriately when necessary to stabilize variances. Student Newman-Keuls (SNK) tests were applied for *a posteriori* comparisons of means.

To identify spatial and temporal variation in the phytobenthic assemblages, permutational multivariate analysis of variance (PERMANOVA) was performed (Anderson 2001). Probability values were calculated using a random subset of 9999 permutations of the residuals under a reduced model. Factors and levels were identical to those in the univariate analyses. Data were square root transformed before calculation of Bray-Curtis coefficients to reduce influence of abundant species. Temporal and spatial variation was represented graphically by a non-metric multidimensional scaling (MDS) ordination done using PRIMER software package.

Results

A total of 167 taxa were recorded, comprising 110 Rhodophyta, 30 Phaeophyceae and 27 Chlorophyta. The assemblage was dominated by the calcareous alga *Corallina elongata*. The main accompanying species (cover > 2%) were the crustose species *Lithophyllum incrustans* and *Ralfsia verrucosa*, the epiphytes *Centroceras clavulatum*, *Caulacanthus ustulatus*, *Mesophyllum lichenoides*, *Herposiphonia tenella*

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and *Falkenbergia rufolanosa*, the caespitose forms Osmundea pinnatifida, *Chondracanthus acicularis* and *Laurencia obtusa*, and the macrophyte *Stypocaulon scoparium.*

Species richness and diversity

The number of species in the macroalgal assemblages was significantly lower in the first year of the study (2004). Likewise ANOVA detected significant seasonal differences, with higher species richness in spring. By contrast, there were not differences between the two oiling levels. Shannon diversity *H'* was also lower in 2004, whereas it did not show significant differences between seasons and oiling levels. Both community parameters showed a strong spatial variability at the scale of kilometres (locations) and tens of metres (areas). These differences between locations and areas were not consistent with time.

Algal cover

ANOVA detected significant annual differences, with lower algal cover in 2004. Also there were significant differences between seasons, showing assemblages higher cover in autumn. By contrast, analysis did not detect a significant oiling level effect. Differences between locations and areas were significant and varied with time.

Species abundance

ANOVA was performed for the dominant species *Corallina elongata* and the 11 most abundant accompanying species. The patterns of distribution varied between different taxa. The distribution of *Corallina elongata* was characterished by a considerable stability in time, likewise its cover did not show significant differences between the two levels of oil. However, this calcareous alga showed a strong spatial variability at the scale of kilometres (locations) and tens of metres (areas). Significant differences between the two oiling levels were only detected for *Caulacanthus ustulatus* and these differences were constant in time. Likewise, only *Lithophyllum incrustans* presented significant differences between years. As it is indicated by SNK comparisons, this crustose alga was less abundant in 2004. The species that showed significant seasonal differences were *Centroceras clavulatum* and *Laurencia obtusa* (more abundant in autumn) and *Osmundea pinnatifida* and *Falkenbergia rufolanosa* (more abundant in spring). Althought more abundant in autumn, *O. pinnatifida* presented a significant interaction year x season because in 2006 differences between autumn and spring were not significant. The distribution of most of the species was characterished mainly by a marked spatial variability at the scales of tens of metres. Likewise, most investigated algae showed significant differences at the scales of several kilometres (locations). The consistency of spatial differences in time varied between species.

Spatio-temporal variation in the algal assemblages

The results of the permutational analyses of variance performed on the whole species data set showed a significant effect of all factors considered in the analysis. The main source of variation was the seasonal effect. This result was confirmed by the MDS ordination in which a seasonal change in composition of the assemblages was observable. Samples of autumn were located in the lower part of the plot and samples of spring were located in the upper part. Differences between seasons, localities and areas were inconsistent with years as it was indicated by the significant interactions year x season, year x locality (oiling level) and year x area (oiling level x locality). By contrast, differences between the two oiling levels were constant in time. The MDS ordination plot showed a tenuous separation of assemblages according to the oiling level with less impacted localities mainly placed in the left part of the diagram.

Discussion

Species richness, diversity and algal cover were significantly lower in 2004, so It is not excluded that the arrival of oil to the Basque coast might have had a damaging effect on intertidal communities. Significant differences were not detected between localities slightly or moderately affected by oil in any of the considered structural parameters. If there was any impact of *Prestige* oil spill on the flora, it was equally in all studied locations, implying that the 'not visual' pollution might have a higher incidence than the 'visual' one, or that differences between the two established oiling levels were not enough to generate impacts of different intensity. Moreover, significant differences were detected among locations of each oiling level. These results indicate that other environmental factors such as wave exposure, nature of substrate or sedimentation level play a greater role in the differences between localities that the oiling level. Likewise, significant differences were detected between areas of each location, which were not consistent with time, indicating that the communities are highly heterogeneous in species richness, diversity and algal cover at the scale of tens of meters. The dominant species *Corallina elongata* and most of the accompanying species did not show significant interannual differences in terms of coverage. Also, there was no differences between the two oiling levels. However, analyses revealed that there was a high spatial variability at the scale of kilometres (locations) and tens of metres (areas) for most of the taxa. On the other hand, multivariate analyses showed a significant effect of the oiling factor in communities composition. As this effect was consistent in time whereas oil pollution decreased, other environmental factors were considered responsible for the differences detected.

Acknowledgements

This work is supported by the Spanish Ministry of Science and Technology (Project vem2003-20082-CO6-PRESTEPSE) and by the Basque Government (ETORTEK actions-IMPRES).

Abundance and bathymetric distribution of crab *Geryon trispinosus* (Herbst, 1803) on the Porcupine Bank.

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Introduction

The deep sea crab, *Geryon trispinosus* (Herbst, 1803) lives in the North-eastern Atlantic and the Mediterranean Sea, inhabiting deep muddy bottoms.

From 18 species of genus *Geryon* in the Atlantic Ocean, 6 species are harvested commercially and have attracted considerable scientific interest (Gonzalez *et al*., 1996). In the North-eastern Atlantic fisheries on *Geryon* species are opportunistic.

Since 2001, the Porcupine Bank is surveyed annually every autumn by one Spanish bottom trawl survey. Survey abundance indices of *G. trispinosus* obtained in this area during the period 2001-2007 fluctuated without trend.

The aim of this study is to present information about the bathymetric distribution and population structure of *G. trispinosus* on the Porcupine Bank.

Methods

Data were collected in the seven Porcupine bottom trawl surveys 2001-2007 organized by the Spanish Institute of Oceanographic and carried out every autumn on board the R/V "Vizconde de Eza". A random stratified sampling design was applied using the following stratification of the study area: Two sectors (Northern and Southern) and three depth strata were defined: A= <300 m, B=300-450 m and C=450-800 m. Velasco (2007) gives more details of survey methodology. A total of 85 valid hauls were carried out in 2007 (Figure 2).

Data by haul of numbers and weight of *G. trispinosus* catches were collected. Random samples by haul were obtained and arapace length, carapace width and other biometrics data were measured. Length classes of 5 mm were used.

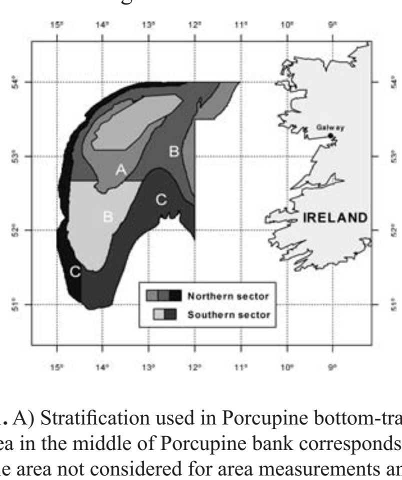

Figure 1. A) Stratification used in Porcupine bottom-trawl surveys. The grey area in the middle of Porcupine bank corresponds to a large non-trawlable area not considered for area measurements and stratification.

Results and Discussion

Deep sea crabs were caught in 27 hauls. From a total of 2509 individuals caught in the study area, 207 (170 males and 37 females) were biologically sampled.

Size composition was unimodal for males and females (Figure 3).

Presence of the deep sea crabs in shallowest strata was not detected.

In the Northern sector the abundance of this species was very small and only males were captured. Greater densities were obtained in Southern sector.

Males bathymetric distribution ranged from 360 m to 743 m, and females from 437 to 664 m.

Males resulted larger than females, as shown by the means presented in Table 1.

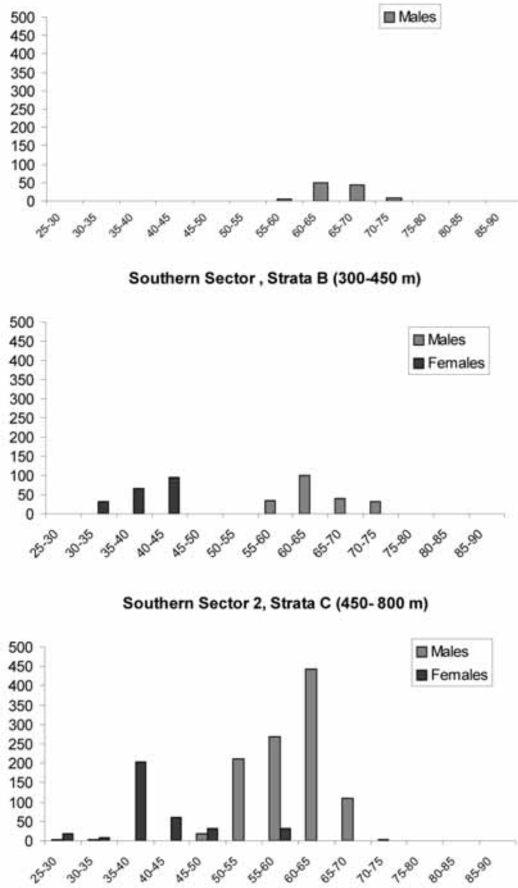

Figure 3. Size distributions classes (CL, 5 mm) for males and females related to sectors and depth strata.

	SECTOR 1	SECTOR 2	
	450-800 m	300-450 m	450-800 m
	CL mean	CL mean	CL mean
Males	64.9	64.1	59.4
Max	30.2	51.4	29.5
Min	86.8	70.3	71.9
Females	-	39.1	40.5
Max	-	31.2	27.2
Min	-	43.6	56.8

Table 1. Mean, maximum and minimum size (carapace length in mm) for males and females by sectors and depth strata.

Higher abundances of *G. trispinosus* for both sexes on the Porcupine Bank were obtained in the deepest strata in the southeastern part of the bank, an area characterized by muddy bottoms and tender slope. Distribution patterns and abundance might be related with suitable substrate (Hastie, 1995).

The distribution of deep sea crab *G. trispinosus* on Porcupine bank in autumn 2007 shows a patchy distribution with no sex segregation. In previous years this distribution of *G. trispinosus* do not showed fluctuations.

Conclusions

- Deep sea crab *Geryon trispinosus* in Porcupine bank is caught mainly in Southern sector, probably related with soft sedimentary grounds.
- The highest abundances for males and females are found in the deepest areas.
- Males mean size is larger than in females in all the area, and females were not found in the Northern sector.

Acknowledgements

We wish to thank to S. Parra, C. Rodriguez, T. Ibarrola, I. González Herraiz, B. Castro and U. Autón for their contribution with the biological sampling and identification. We would also like to thank the IEO for their financial support of M. A. T. with research training grant.

References:

González, J. A., J. I. Santana, V. Fernández-Vergaz. 1996. "The family Geryonidae (Decapoda, Brachyura) in the Canary Islands." *Crustaceana* 69: 627-635.

Hastie L.C. 1995. Deep-water Geryonid crabs: a continental slope resource. *Ocean Mar. Biol. Ann*. Rev. 33, 561-584.

Velasco. 2007. Informe de la campaña Porcupine 2007. Documento interno del Instituto Español de Oceanografía.

Changes in the intertidal zoobenthic communities of the Basque coast (N. Spain) after the *Prestige* Oil Spill

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Introduction

After the *Prestige* oil spill (19th November 2002), an ecological monitoring was carried out in order to study the oil spill impact on the intertidal rocky assemblages of the Basque coast. The usefulness of benthic invertebrates as indicators of marine pollution has been widely documented.

Methods

Study area

A total of 12 locations were studied throughout the Basque coast. According to the oil arrival report (ORBANKOSTA, 2003), 6 locations were randomly selected among the most oiled places and another 6 among the least oiled ones.

The selected habitat corresponded to sections of open coast, very exposed-semiexposed to wave action, stable substrates (continuous bedrock and great blocks), with slight to moderate slope (0°-45°). Two tidal levels were studied: the highest level of the low intertidal zone (dominated by the assemblage of the algae *Corallina elongata*) and the medium intertidal zone (dominated by the barnacle *Chthamalus* spp.)

In each location two sites were randomly selected, and each one was represented by 3 replicates. Species cover was estimated on 40x40 cm quadrats using Braun- Blanquet cover scale (Braun-Blanquet, 1951). The sampling sites were studied in spring and autumn over the years 2004, 2005 and 2006.

Data analysis

A five-factor analysis of variance (ANOVA) was carried out to test hypothesis on spatial and temporal patterns of distribution species richness *S*, Shannon diversity *H'* and mean abundance of the most common species using GMAV5 software. The factors considered were: year (three levels, fixed), season (two levels, fixed and orthogonal), oiling level (two levels, fixed and orthogonal to season), locality (six levels, random and nested in oiling level), area (two levels, random and nested in the interaction locality x oiling level). Three replicates represented each area. Prior to the analyses, the homogeneity of variances was checked by Cochran's C test. Data were transformed appropriately when necessary to stabilize variances. Student Newman-Keuls (SNK) tests were applied for *a posteriori* comparisons of means.

Temporal and spatial variation was represented graphically by a non-metric multidimensional scaling (MDS) ordination done using PRIMER software package (Clarke & Warwick, 2001).

Results

Low intertidal zone

A total of 83 taxa were recorded, comprising 27 Arthropoda, 22 Mollusca, 15 Annelida, 8 Cnidaria, 4 Bryozoa, 4 Porifera and 3 Echinodermata.

<u>Structural parameters of the faunal community and species abundance</u>

Species richness and Shannon diversity *H´* showed significant differences between the three years studied. An increasing trend was detected from 2004 to 2006. However, significant differences between seasons, oiling level and localities were not detected. Differences between areas were highly significant, but were not consistent with time.

ANOVA did not detect significant differences in the faunal cover between years, seasons and oiling level. However, the differences between localities and areas were significant and varied in the time as it was indicated by the significant interaction year x area.

The two more abundant species of invertebrates in the *Corallina elongata* assemblage were the limpet *Patella ulyssiponensis* and to a lesser extent the barnacles *Chthamalus* spp. In the case of the limpet *Patella ulyssiponensis*, ANOVA did not show differences between years and seasons. Nevertheless, differences between oiling levels were detected, being its cover significantly lower in the most affected locations. Likewise, distribution of *P. ulyssiponensis* was characterished mainly by a marked spatial variability at the scales of kilometers (locations) of tens of metres (areas), being these differences inconsistent with time. On the other hand, *Chthamalus* spp. cover did not show significant differences between years, season, oiling levels and areas, but showed differences within the localities of each oil level, which were not consistent with the time.

<u>Multivariate analysis</u>

In the MDS diagram a differenciation between locations according to the oiling level was observable. Samples of the locations less affected were located in the right part of the plot whereas samples of the most affected localities were located in the left side.

Medium intertidal zone

A total of 13 taxa were recorded, comprising 9 Mollusca, 3 Arthropoda and 1 Cnidaria.

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Structural parameters of the faunal community and species abundance

The number of faunal species did not show significant differences between parameters such as year, oiling level an localities, but showed significant seasonal differences. According to the subsequent SNK analysis, the richness was only higher in spring of the year 2005. In addition, this parameter also showed a strong spatial variability at the scale of tens of metres (areas) and were varied with the time as it was indicated by the significant interaction year x area, and season x area. The Shannon diversity H´ showed significative differences between years, being the year 2004 more diverse than 2005 and 2006. In addition, also showed a strong spatial variability at the scale of kilometers (localities) and tens of metres (areas). In this last case, the differences were not consistent with time.

ANOVA did not detect significant differences in the faunal cover between years, seasons, oiling level and localities. However, the differences between areas were significant and varied in the time as it was indicated by the significant interaction year x area.

ANOVA also was performed for the dominant species (*Chthamalus* spp.) and the most abundant accompanying species (*Patella* spp.). In the case of the Crustacea *Chthamalus* spp., there were not detected signifficant differences between its cover between years, seasons, oiling level and localities. However, the differences between areas were significant and varied in the time as it was indicated by the significant interaction year x area. The *Patella* spp. cover did not show significant differences between years, seasons and oiling levels, but showed a strong spatial variability at the scale of kilometers (locations) and tens of metres (areas).

Multivariate analysis

The MDS diagram shows a heterogeneous group of samples, so any evident differenciation between years, seasons and oiling level has not been observed.

Discussion

Low intertidal zone

The year 2004 showed lower values in the species richness and faunal diversity than 2005 and 2006. Likewise, the *Patella ulyssiponensis* cover was significantly lower in the localities visually more oiled. According to the literature, the presence of hydrocarbons can cause an acute reduction in limpets populations (Petpiroon et al., 1982; Newey and Seed, 1995; Raffaelli and Hawkins, 1999; Moore, 2006). Both facts could indicate that the high PAH´s concentration in the environment was the cause of these results. However, in the first case, another factors such as the atypical sea swell registered in the year 2004 and its relation with these results should be analized in further works, in order to reject this hypothesis. In the same way, the existence of significant differences in the substratum topography and sedimentation rates between the most and least oil affected localities, could influence in the differences detected in the *Patella* cover, so this hypothesis should be also tested.

Medium intertidal zone

The structural parameters of the community analized in this intertidal zone did not show significant differences between years, seasons and oiling level, except in the case of the Shannon diversity *H´* which was significantly higher in 2004. These results probably reflect favourable humidity conditions for the faunal assemblages during 2004. This suggestion is based on the atypical sea swell data recorded in 2004. This hypothesis will be tested in further works.

Acknowledgements

This work is supported by the Spanish Ministry of Science and Technology (Project vem2003-20082-CO6-PRESTEPSE) and by the Basque Government (ETORTEK actions-IMPRES).

References

Moore, J.J., 2006. State of marine environment in SW Wales, 10 years after the Sea Empress oil spill. A report to the Countryside Council for Wales from Coastal Assessment, Liaison & Monitoring, Cosheston, Pembrokeshire. CCW Marine Monitoring Report No: 21. 30pp.

Newey, S. and R. Seed., 1995. The effects of the Braer oil spill on rocky intertidal communities in South Shetland, Scotland. Mar. Pollut. Bull., 30, 274-280.

ORBANKOSTA. 2003. Inventario de datos sobre la afección de la costa vasca debido al vertido del Prestige. Technical report. IHOBE. Basque Government.

Petpiroon, S., Dicks, B., 1982. Environmental effects (1969 to 1981) of a refinery effluent discharged into Littlewick Bay, Milford Haven. Field Studies, 5, 623-641.

Raffaelli D. & Hawkins S., 1996. Intertidal Ecology Intertidal Ecology. Chapman & Hall, London, 356 pp.

Galician beaches affected by the Prestige oil spill: macroinfaunal comparison between years 2003-2004

Carolina Castellanos, Carolina García-Ruíz, José Manuel Viéitez and Juan Junoy[1]

Introduction

Eighteen sandy beaches were sampled along the 1659 km of the Galician coast (NW Spain). Here it is exposed the results of two sampling periods; six (may 2003) and eighteen (may 2004) months after the Prestige oil-spill. The objective of this study is to know the impact of the spill and cleanup activities on the macroinfauna community. The beaches including was América and La Lanzada (in Pontevedra province); Corrubedo, Xuño, Louro, Carnota, Rostro, Area Longa, Traba, Seiruga, Baldaio, Barrañán, Doniños and Frouxeira (in La Coruña province) and San Román, Esteiro, Llas and Altar (in Lugo province). Figure 1. All beaches studied were affected to some degree by the fuel.

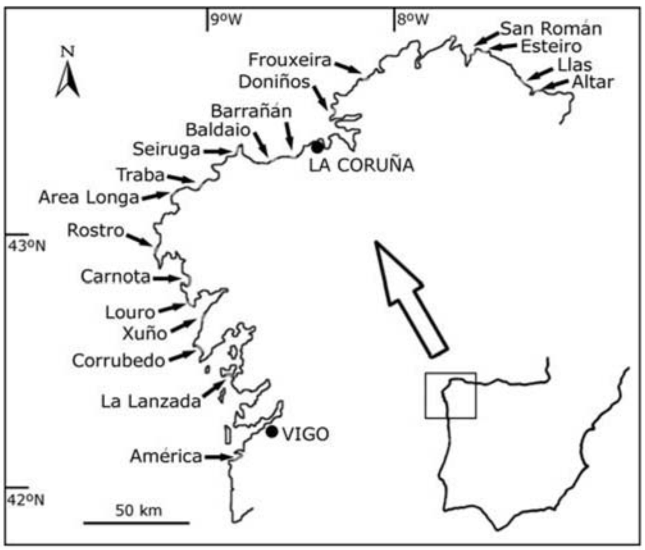

Figure 1. Map showing location of sampled beaches.

Material and Methods

These beaches were sampled once during the spring low tides. In the middle of the beach, a transect was extended from above the drift line to below the swash line. Beach division was based on Salvat's zonation scheme (Salvat, 1964), and five sampled stations marked to levels: 1) 2 m above the drift line; 2) drift line; 3) retention level; 4) resurgence level; and 5) saturation level. At each station six 0.05 m^2 replicates were taken with plastic cylinders to a depth of 30 cm and sieved through a 1 mm mesh. The residue was preserved in 7 % formalin; the macroinfauna was later sorted from the sediments, identified, and counted. A sample of sediment for grain size analysis and organic matter content was collected at each station.

Species number, diversity (H'), biotic coefficient and biotic index (Borja, A, Franco, J and Pérez, V, 2000) were calculated for every beach in both sampling periods. Table 1.

Table 1. Species number (S), diversity (H'), biotic coefficient (BC) and biotic index (BI)

	S		H'		BC		BI	
	2003	2004	2003	2004	2003	2004	2003	2004
América	13	19	1.6	1.7	3.5	3.7	3	3
La Lanzada	12	17	1.4	2.1	4.1	3.3	3	2
Corrubedo	21	26	2.5	2	1.8	2.3	2	2
Xuño	13	18	0.9	1.9	2.7	4.2	2	3
Louro	15	21	1.9	2.3	2.8	2.4	2	2
Carnota	19	22	1.8	2.1	3	2.4	2	2
Rostro	5	12	0.3	1.7	6	4.4	7	4
Area Longa	17	14	2	2.1	2.5	2.5	2	2
Traba	11	12	1.9	1.8	4.6	4.02	4	3
Seiruga	15	17	1.4	1.5	2.7	3.7	2	3
Baldaio	14	16	1.9	2.2	4	3	3	2
Barrañán	16	13	1.7	1.6	4.3	2.3	3	2
Doniños	8	17	1.2	0.3	2.1	3.6	2	3
Frouxeira	9	16	0.9	1.7	3.8	2.1	3	2
San Román	23	19	2.2	2.2	2.3	2.5	2	2
Esteiro	17	19	1.9	2	2.5	2.8	2	2
Llas	11	16	1.4	1.8	2.7	3	2	2
Altar	12	21	1.7	2.4	3.6	2.6	3	2

Results and Discussion

The most affected beaches were those situated in the arc between Corrubedo and Frouxeira beaches. Ten of these beaches were totally covered with crude oil (Data from Spanish Ministerio de Medio Ambiente). On Rostro beach, big tar balls (diameter > 15 cm) were present during the 2003 and 2004 Expedition.

Faunal composition of Galician beaches consists of typical psammophilous species dominated by crustaceans and polychaetes. The most frequent species were the amphipod *Pontocrates arenarius*, the isopod genus *Eurydice,* the polychaete genus *Scolelepis* and the amphipod *Talitrus saltator*. The number of species by beach was lower in 2003 in comparison with results obtained before the spill (Junoy

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et al., 2005). This number of species increased in 2004. This increase is due to Rare species (species present only in three or less occasions).

Macroinfaunal abundance was also lower in 2003, except for *Pontocrates arenarius* which reaches higher densities six months after the spill, maintaining this density in 2004. *P. arenarius* appeared in all beaches in both years. Other common species, i.e. *Talitrus saltator*, reached their higher densities eighteen months after the spill. This species lives in the upper level of the beach where the cleanup activities accumulated the fuel, producing a severe impact in this species, according to the 2003 results. In fact, in 7 out of the 18 beaches no macroinfauna was collected in the drift line and above.

The most contaminated beach by Prestige was Rostro with a value of 7 in the biotic index in 2003 and 4 in the year 2004. This biotic index is stable in eight beaches, with tendency to decrease in seven. In three beaches increased the value of the biotic index (Xuño, Seiruga and Doniños).

References

Borja, A.; Franco, J y Pérez, V. 2000. A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. *Marine Pollution Bulletin*, 40 (12): 1100-114.

Junoy J., C. Castellanos, J. M. Viéitez, M. R. de la Huz, M. Lastra. 2005. The macroinfauna of the Galician sandy beaches (NW Spain) affected by the *Prestige* oil-spill. *Marine Pollution Bulletin,* 50 (5): 526-536.

Salvat, B. 1964. Les conditions hydrodynamiques intersticielles des sediments meubles intertidaux et la repartition verticale de la faune endogée. *Cahiers de Recherche de la Academie de Science de Paris* 259, 1576-1579.

First data on suprabenthic communities from three Galician beaches (NW Spain)

Barriocanal, Irene; Frutos, Imnaculada; Viéitez, Jose Manuel and Junoy, Juan

The results from the analysis of the zoological groups captured with a hand-pushed suprabenthic sledge, in the swash zone parallel to the shore line, were obtained by sampling three galician beaches (Corrubedo, Frouxeira and Altar) during the winter of the year 2006.

This study is a part of the Project VEM 2004-08544. The present comunication deals with the first seven months (from september 2005 to March, 2006).

A total of 23453 individuals have been collected among the three beaches, 86.8% belonging to Corrubedo beach, 7.3% to Frouxeira beach and 5.9% to Altar beach.

The great majority were crustaceans. The highest mean speciffic richness belongs to Corrubedo beach (15 ± 5.14 spp), Altar with 14.85 ± 4.16 spp. has also a high mean value, and Frouxeira obtained the lowest mean speciffic richness (7.57 ± 2.98 spp.).

The highest mean abundance value belongs to Corrubedo (264,6 ± 243,31 ind./5m^2) and the lowest was obtained in Altar beach (17.87 ± 16.23 ind./5m^2), Frouxeira beach presents a mean abundance of 22.13 ± 20.05 ind./5m^2).

Introduction

The importance of suprabenthic fauna, also called hyperbenthos, has been recognized due to its high abundance and main role in the nutrient regeneration and food source in the surf zone inside the trophic mesh. The suprabenthic fauna is mainly composed of crustaceans. The dominant group collected in this study is mysids although the community also includes amphipods, cumaceans, isopods, decapods and fish.

This study is a part of Project VEM 2004-08544. The sampling program began in September 2005 and finished in September 2007. The present communication deals with the winter of the year 2005-06 (from September 2005 to March 2006).

The main object of the present study is to carry out a research about the temporal variation and quantitative structure of populations that represent this fauna from September 2005 to March 2006, and to make database of the populations and species which live in the three beaches sampled (Corrubedo, Frouxeira and Altar)
(Fig 1).

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Figure 1. Map showing the location of the sampled beaches.

Methods

Ten samples per beach were taken in daylight and low tide during the seven month period. The total sampling area was 50 m^2 by beach per month.

A hand-pushed suprabenthic sledge (Fig. 2) with an opening of 50 cm wide and 20 cm high equipped with a 0.5 mm mesh net was used.

Each sample was taken by pushing manually the sledge. A rope was used which had one end tied to a little anchor and the other end tied to the slege. This rope had a total length of 10 m.

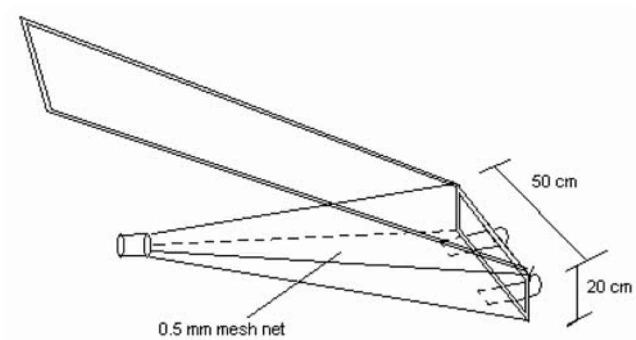

Figure 2. Hand-pushed suprabenthic sledge.

Then, the little anchor was drived in the sand, the slege was placed next to this anchor and at the moment that the wave came the person ran straight to the end as far as the rope allowed in the swash zone parallel to the shoreline.

The samples were preserved in 70% ethanol. Later the macrofauna was separated and identified.

Results and Conclussions

Among the three beaches, Corrubedo presented the highest number of individuals sampled which represented the 86.8%, Frouxeira obtained the 7.3% of representativity and the lowest number of individuals collected (5.9%) belonged to Altar beach. (Table 2).

Corrubedo beach with nearly three kilometres length (Table 1), showed the highest mean density values ranged between 839.8 ind/5m^2 in November and 28.5 ind/5m^2 in January (Table 3). This beach showed the highest diversity (21 species) in October; with the lowest value being 10 species in January. The dominant species were the isopods *Eurydice affinis* (23.5%; Mean abundance: 62.1 ind/5m^2) and *Idotea pelagica* with a mean abundance of 45.2 ind./5m^2 (17.1%) and the cumacean *Cumopsis fagei* (13.7%; Mean abundance: 36.3 ind./5m^2).

Corrubedo beach is the only one where the fish *Echiichthys vipera*, the cumacean *Eocuma dollfusi*, the decapod *Diogenes puligator* and the isopod *Lekanesphaera rugica* were found.

Frouxeira beach, whose length is three kilometres (Table 1), showed a mean density value ranged between 47.1 ind/5m^2 (October 2005) and 13.3 ind/5m^2 (February 2006) (Table 3). The dominant species were the mysid *Gastrosaccus roscoffensis*, which represented the 58.9% of individuals (Mean abundance: 10.5 ind/5m^2) and the isopods *Eurydice naylori* (18.1%) and *E. affinis* (7.7%) with 4 ind./5m^2 and 1.7 ind./5m^2 respectively.

The number of species was ranged between 12 (September and November 2005) and 4 from January to March 2006.

The number of fish larvae in this beach were the highest among the three beaches (56 individuals sampled in March).

Altar beach is the narrowest with 950 m length (Table 1), showed the lowest mean density value ranged between 37.5 ind/5m^2 (November 2006) and 5.1 ind/5m^2 (March 2006). The amphipod *Pontocrates arenarius*, with a mean density of 5 ind/5m^2 accounted for 27.8% of speciemens, the isopod

Idotea pelagica (14.6%) with a mean abundance of 2.6 ind./5m2 and the mysid *Schistomysis parkeri* (7.6%; Mean abundance: 1.4 ind./5m2) were the dominant species. The number of species is this beach is ranged between 24 in December 2005 and 9 in January 2006.

Altar samples were the only ones where fish of the Family Gobiidae , the decapod *Crangon crangon* , the mysid *Praunus neglectus* and the isopoda *Idotea baltica* and *Synisoma lancifer* were sampled.

To conclude, these are the results of the research:

- Isopods (abundance) and amphipods (number of species) are the dominant suprabenthos groups in this three galician beaches.

- The highest species richness and abundance belong to Corrubedo beach, Altar beach present the lowest abundance, and Frouxiera beach obtained the lowest values in species richness.

- A difference in the dominant groups among the three beaches is presented. Isopods (*Eurydice affinis*) is the dominant group in Corrubedo beach, mysids (*Gastrossaccus roscoffensis*) in Frouxeira beach and amphipods (*Pontocrates arenarius*) in Altar beach.

Table 1. Data from Junoy et al. 2005.

	Location		Wide (m)	Large (m)
Corrubedo beach	42º32'N	9º01'W	139	2900
Frouxeira beach	43º35'N	8º10'W	215	3000
Altar beach	43º34'N	7º14'W	220	950

Table 2. Summary of the three beaches.

Beaches	Number of Individuals	Abundance	% Represantivity
Corrubedo	20374	264, 6ind./5m^2	86.8%
Frouxeira	1704	22,1ind./5m^2	7.3%
Altar	1376	17,9ind./5m^2	5.9%

Table 3: Richness and abundance in the three beaches.

	Altar Beach		FrouxeiraBeach		CorrubedoBeach	
	Specific richness	Abund.	Specific richness	Abund.	Specific richness	Abund.
	S	D (ind./ 5m2)	S	D (ind./ 5m2)	S	D (ind./ 5m2)
Sept 05	21	26.5	12	25.1	19	253.8
Oct 05	17	32.8	7	47.1	21	616.2
Nov 05	19	37.5	12	16.7	26	839.8
Dec 05	24	9.5	9	27.4	11	14.6
Jan 06	9	5.5	4	17.1	10	28.5
Feb 06	13	11.36	4	13.3	17	62.6
Mar 06	5	5.1	4	40.5	11	45.2

References:

Junoy, J., C. Castellanos, J.M. Viéitez, M.R. de la Huz and M. Lastra. 2005. The macroinfauna of the Galician sandy beaches (NW Spain) affected by the Prestige oil-spill. Marine Pollution Bulletin 50, 526-536.

The benthic fauna of slope pockmarks from the Kostarrenkala area (Capbreton canyon, SE Bay of Biscay)

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Introduction

Pockmarks are depressions in the seabed, generally circular or ellipsoidal at the top (from 1 m to 1 km long) and cone-shaped in cross–section, with a maximum bottom depth ranging between 0.5 and 58 m. It is generally believed that they are formed by rapid expulsion of liquid (groundwater in coastal areas) or gas (methane seeping) through seafloor sediments (Dando, 2001). This methane-rich fluid could be the principal source of energy for high-productive benthic communities. Active pockmarks are known to shelter chemosynthetic animals (some bivalves Thyasiridae and Lucinidae, a mouthless and gutless nematode, all containing endosymbiotic bacteria). Furthermore, in active pockmarks, rock–like concretions (crusts, slabs…) are known to sometimes occur at the seabed, due to the cementation of sediment particles by methane-derived carbonates. These new hard substrates allow the settlement of allochtonous epifaunal species (mainly Anthozoa, but also hermit crabs, echinoderms…), subsequently favour the attraction of their potential consumers and thus contribute to enhance pockmark benthic biodiversity and biomass with respect to surrounding areas (Judd, 2001). So far, few studies have been specifically dedicated to pockmark benthic communities in relation to their methane seeping activity.

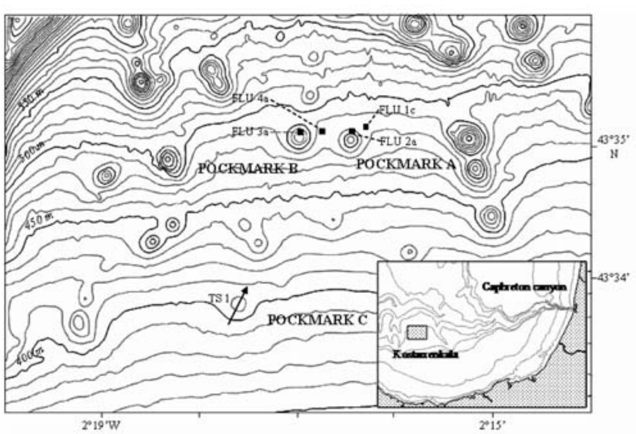

Figure 1. Flusha (FLU) and sledge (TS) sampling stations at pockmarks A, B and C from the Kostarrenkala area (Capbreton canyon).

A recent multibeam mapping of the Capbreton canyon (Bourillet et al., 2007) revealed the presence of many slope pockmarks (> 45 units) on its southern margin (Kostarrenkala area), located along NS alignments between 400 and 800 m water depth (fig.1). The main objectives of PROSECAN IV cruise (May 2007) were to investigate the geochemistry and biology of some of these pockmarks in order to distinguish between active and inactive structures. The present paper focuses on the structure of their benthic communities and on their faunal peculiarities by comparison with adjacent slope communities previously studied in the same area (Marquiegui & Sorbe, 1999; Corbari & Sorbe, 2001; Frutos & Sorbe, unpublished data).

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Methods

Only 3 slope pockmarks of the Kostarrenkala area were investigated during PROSECAN IV cruise (A: 512 m depth, B: 525 m depth and C: >410 m depth). Benthic communities were sampled during daytime by means of two gears: a) with a Flusha box-corer (box dimensions: 31 x 29 cm; bottom area sampled: 0.0899 m^2). The top sediment layer (ca upper 10 cm) of each core was carefully cut off and the macro-infauna was collected by washing the sediment through a 0.5 mm mesh sieve; b) with a small sledge equipped with one net (mesh-size: 440 µm; rectangular opening area, height: 34 cm, width: 50.5 cm) without opening-closing system (non quantitative sampling). This sledge mainly sampled the motile fauna in the 17-51 cm water layer above the seafloor. However, due to the absence of a closing system, the suprabenthic sample was probably contaminated by pelagic organisms from the water column during sledge deployment and recovery. So, no attempt was made to estimate the density of the organisms collected by the sledge.

Results

Although without statistical significance, macro-infaunal species richness and density values recorded at the base and at the side of pockmarks A and B are in the same order of magnitude, with a trend of higher values at the central part of both depressions. A total of 33 species were recorded in the 4 samples examined mainly represented by Polychaeta (22 sp.). Species richness ranged between 10 (base of pockmark A) and 18 species (base of pockmark B). Densities ranged between 177.8 ind. m^{-2} (side of pockmark B) and 289.0 ind. m^{-2} (base of pockmarks A and B). Four Polychaeta species belonging to genera *Aricidea*, *Levinsenia* and *Paradoneis* are considered as putatively new to science. Apart from live benthic species, samples also contained fish otoliths (maximum density: 77.9 otoliths m^{-2} at the side of pockmark A).

At pockmark C a total of 1352 individuals were recorded by suprabenthic sledge, distributed in 56 species mainly represented by Amphipoda (26 sp.) and Mysidacea (11 sp.). According to their relative contribution to total abundance, Euphausiacea (37.5 %), Amphipoda (36.0 %) and Isopoda (14.4 %) were the most abundant major groups. The five numerically dominant species represented 70.6 % of total abundance: unidentified furcilia larvae of euphausiids (34.1 %), *Orchomenella nana* (14.5 %), *Munnopsurus atlanticus* (11.6 %), *Rhachotropis caeca* (7.0 %) and *Halice abyssi* (3.5 %). Not identified at species level, the furcilia larvae (mix of different species) were probably sampled in the water column during sledge deployment/recovery (non closing system), thus explaining their dominance in the sample.

Discussion

First of all, it must be emphasized that the two sampling procedures (box corer, sledge) carried out during this study were complementary, each giving a peculiar insight on benthic macrofaunal assemblages. As usually observed elsewhere, polychaetes were largely dominant in the macro-infaunal community whereas amphipods ranked first in the near-bottom water community.

No hard substratum (carbonate consolidated sediments) was observed in the Flusha cores from the base as well as the side of pockmarks A and B and, consequently, no associated epifaunal organisms were detected in these samples. Fish otoliths were present in some cores, but under low densities not comparable to the high values mentioned by Dando *et al*. (1991) for the Scanner pockmark (range: 540- 3690 otoliths m^{-2}). Observed values of species richness for macro-infauna are comparable to values given by Dando *et al.* (1991) for the Scanner pockmark (range: 15-24 species $core^{-1}$), with a dominance of polychaete species in both cases. On the contrary, observed total densities for macro-infauna are demonstratively lower than values recorded by Dando *et al*. (1991) for the Scanner pockmark (range: 708- 1530 ind. m^{-2}). All the benthic species sampled by the box corer have been recorded elsewhere in the Capbreton canyon, including non-pockmark areas. Furthermore, no symbiont-containing species were detected in the core samples examined, such as the highly specialized bivalves *Thyasira sarsi* (Thyasiridae) and *Lucinoma borealis* (Lucinidae) mentioned by Dando *et al*. (1991) and Dando (2001) for the Scanner pockmark (see also Sibuet & Olu, 1998 for deep cold-seep communities). In the same way, the deep bivalve *Modiolaria fisheri* (Mytilidae) was not recorded in the core samples examined, although it was recently re-discovered at ca 860 m on the Capbreton thalweg (Sorbe *et al*., 2001; Le Pennec *et al.*, 2005).

The unique suprabenthic sample from pockmark C was compared with another one carried out at similar depth (397 m), in the same area but in a site without pockmark (CAPBRETON 90 cruise, Arcachon sledge, July 1990, 0-100 cm near-bottom water layer). Excluding the furcilia larvae (see above), the Schoener index of similarity between the two samples was 46.6 %, thus demonstrating that pockmark and surrounding bathyal assemblages are not so different in their structural composition. Furthermore, as for the macro-infaunal components, all the suprabenthic species sampled by the sledge have been recorded elsewhere in the Capbreton canyon. Surprisingly, a few species registered in this sample are known to normally live in shallower habitats: *Anchialina agilis*, *Leptomysis gracilis* (shelf mysids), *Rhachotropis integricauda* (shelf break amphipod). They are probably isolated specimens swept away from the shelf and collected in surficial water layers by the non-closing net of the sledge.

Conclusions

Due to the absence of rock-like carbonate concretions at the seabed, of specialized symbiont-containing species and to the similarity of community structure with surrounding slope areas, the 3 pockmarks A, B and C investigated in the Kostarrenkala area must be considered as inactive fossil depressions. However, we don't know if they are representative of the other pockmarks identified in the same area. Near-bottom turbid waters detected by video recordings around deeper structures during PROSECAN IV cruise (H. Gillet, personal communication) demonstrate that further investigations need to be carried out on these deep depressions for a better understanding of their actual seeping activity.

Acknowledgements

Thanks are due to the crew of the RV *Thalia* and all participants to PROSECAN IV cruise for their assistance at sea, to P. Cirac, M. Cremer and H. Gillet (DGO, Talence) for the communication of useful data on the Capbreton pockmarks.

References

Bourillet, J-F, C. Augris, P. Cirac, J-P.Mazé, A. Normand, B. Loubrieu, A. Crusson, M. Gaudin, D. Poirier, C.S. Le Bris, L. Simplet, 2007. *Le canyon de Capbreton - Carte morpho-bathymétrique* – Feuille ouest. Quae éditions.

Dando, P.R., 2001. A review of pockmarks in the UK part of the North Sea, with particular respect to their biology. *Strategic Environmental Assessment, Technical Report* TR 002, 21 pp.

Dando, P.R., M.C. Austen, R.A. Burke Jr, M.A. Kendall, M.C. Kennicutt II, A.G. Judd, D.C. Moore, S.C.M. O'Hara, R. Schmaljohann. A.J. Southward, 1991. Ecology of a North Sea pockmark with an active methane seep. *Marine Ecology Progress Series*, 70: 49-63.

Corbari, L., J.C. Sorbe, 2001. Structure of the suprabenthic assemblages in the Capbreton area (SE of the bay of Biscay). Elbée, J. (d') and Prouzet, P. (coord.) *Océanographie du golfe de Gascogne. VIIe Colloq. Int. Biarritz,* 4-6 April 2000. Ed. Ifremer, Actes Colloq., 31: 87-95.

Judd, A.G., 2001. Pockmarks in the UK sector of the North Sea. *Strategic Environmental Assessment, Technical Report* TR 002, 70 pp.

Le Pennec G., M. Le Pennec & J.C. Sorbe, 2005. Eléments de biologie d'un bivalve peu connu, le mytilidé *Modiolaria fischeri*. Pp 103-106 In : Les Mollusques dans la recherche actuelle. *Actes du IIIe Congrès International des Sociétés Européennes de Malacologie*, 250 p.

Marquiegui, M.A., J.C. Sorbe, 1999. Influence of near-bottom environmental conditions on the structure of bathyal macrobenthic crustacean assemblages from the Capbreton canyon (bay of Biscay, NE Atlantic*). Acta Oecologica*, 20: 353-362.

Sibuet, M., K. Olu, 1998. Biogeography, biodiversity and fluid dependence of deep-sea cold-seep communities at active and passive margins. *Deep-Sea research II*, 45: 517-567.

Sorbe, J.C., B. Métivier, M. Le Pennec, 2001. Recent discovery of an abundant population of the deep Mytilidae '*Modioloria fisheri'* Smith, 1885 in the Capbreton canyon (SE of the bay of Biscay). Elbée, J. (d') and Prouzet, P. (coord.) *Océanographie du golfe de Gascogne. VIIe Colloq. Int. Biarritz, 4-6 April 2000.* Ed. Ifremer, Actes Colloq., 31: 96-101.

Preliminary results on the sponge fauna of Le Danois Bank (El Cachucho, Cantabrian Sea, N Spain)

Javier Cristobo,*[a b] Pilar Ríos,[c] Francisco Sánchez,[d] Alberto Serrano,[d] Izaskun Preciado,[d] Cesar Gonzalez-Pola,[a] Daniel González[a] and Santiago Parra[e]

Introduction

Sponges are an important part of the benthic fauna. They live in all areas of the marine world, from the shallow coastal seas to the deepest oceanic trenches. About 6000 species have so far been described by scientist, but perhaps there are three times as many as more species awaiting to be discovered. They play a essential roles in the biology and geology of coral reefs, they contribute to their construction, which is a role they played more prominently in geological times. Also sponges have importance in benthos ecology because their activity as filter feeders: they filter enormous volumes of water while removing almost all of the fine food particles. On the other hand, sponges and the chemical they produce are now attracting substantial interest globally, both for scientist and the general public as their application as pharmaceuticals and other exciting products (Lévi et al 1998).

Sponge grounds (e.g., sponge dominated communities), are examples of areas (mega-habitats) which are topographical, hydrophysical or geological features (including fragile geologic structures) known to support vulnerable species, communities, or habitats. Vulnerability includes considerations of both the likelihood that a population, community, or habitat will experience substantial alteration from short-term or chronic disturbance, and the length of time required to recover to its prior state, after a disturbance. The most vulnerable marine ecosystems are ones that are both easily disturbed and are very slow to recover, or may never recover. Vulnerable ecosystem features may be physically fragile, but some may be functionally fragile even if physically robust (FAO, 2007).

In this way, the main objective of the ECOMARG project is the integrated study of the benthic-demersal ecosystem of the singular Asturian marginal shelf (Le Danois Bank), a barely well-known area in spite of belonging to the Spanish EEZ and being subject to fishing activities. The study has a multidisciplinary strategy that includes the abiotic scenario and the benthic and demersal communities. Concerning the abiotic scenario, the morphosedimentary and bathymetric characteristics and also the characteristics of the water column were analysed. Regarding communities, the main compartments of the benthic domain were studied using a multigear system. i) Demersal fish and larger epibenthic communities were sampled using an otter trawl, ii) smaller epibenthos was sampled with a 3.5 m beam trawl, iii) suprabenthos was captured with a sled, iv) a box corer was used to sample endobenthos, and v) a WP2-type plankton net was used to collect near-bottom zooplankton. This methodological approach offers a vision of the biodiversity of the ecosystem and its communities' structure and distribution.

The trophic ecology of the dominant species of fish and crustaceans will be used to estimate of the energy flows, the consumption and niche overlap among high level trophic groups. All this information, together with the study of the impact of the fisheries working in the area, will be integrated in a trophodynamic mass-balance model (Ecopath) that will allow us to explain and to synthesize the characteristics of the ecosystem, to compare it with similar ones and to try to predict the consequences of the possible management measures that can be adopted in this remarkable area (Serrano et al, 2005).

Methods

Several samplers were used on each biological station in order to study the different compartments of the benthic fauna. Epibenthos and demersal species were studied using two different gears, a Porcupine baca trawl (ICES, 2003) and a beam trawl. Most of the differences in the catches between the baca and the beam trawl are related with the higher catchability of swimming and large-sized epibenthic species in the baca trawl, compared to the better sampling performance of the beam trawl for flat and slow fish and for sessile and small sized invertebrates. Porcupine baca trawl mesh size was of 90 mm along the net but with a 20 mm liner inside the cod end. Horizontal opening was of 18.5 ± 1.3 m and vertical opening of 3.14 ± 0.20 m. The sampling unit was a 30- minute haul, all carried out at daytime at a speed of 3.5 knots. Beam trawl horizontal opening was of 3.5 m and vertical opening of 0.6 m (mesh size of 10 mm). Beam trawls lasted 15 minutes at a mean speed of 2.5 knots. Both trawl gears were monitored using a Scanmar net sensors. The mean area swept was 57 273 m^2 in otter trawls and 3 258 m^2 in beam trawls. The number of individuals and the weight of each species were obtained from each sample. Area was divided following a bathymetric criterion: the upper part of Le Danois Bank (400-700 m) was identified as Stratum 1, and the marginal basin (700-1000 m)

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corresponded with Stratum 2. In hard bottoms, two different visual techniques were used: a photogrammetric sled and a ROV. The photogram-metric sled has a high resolution digital camera that shoots at set time intervals. It uses four laser pointers to determine the surface covered by each photo and the dimensions of species. It also uses a CTD probe to characterize each photo according to the oceanographic variables (pressure, temperature and salinity). A ROV Swordfish model manufactured by Deep Ocean Engineering was also used up to 600 m deep (Serrano et al, 2005).

All specimens were initially fixed in 6% formaldehyde and later preserved in 70% ethanol. Spicules were prepared for SEM as follows: the organic matter was digested with nitric acid taken to boiling point, following the methods of Rützler (1978) and Cristobo et al., (1993), and spicules were examined using a Scanning Electron Microscope. Skeletal architecture was studied by light microscopy. The classification system adopted in this work is that proposed by Hooper & Soest (2002).

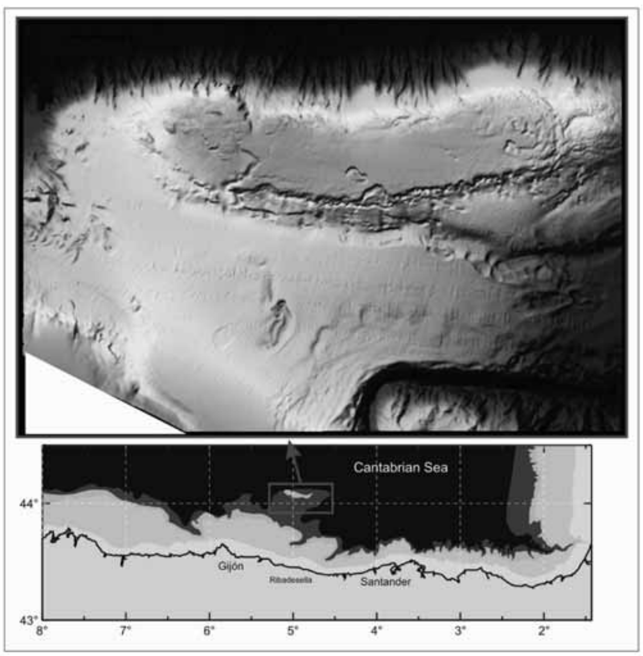

Figure 1. Location of Le Danois Bank in the Bay of Biscay..

Results

The Ecomarg benthic project has been conducting an intensive study of the benthic fauna of the Le Danois Bank (El Cachucho, in the Spanish fishermen terminology)(Fig. 1).

In this work 178 specimens were identified and assigned to classes Hexactinellida and Demospongiae (any representative of class Calcarea was collected).

During the spring survey and from beam trawl samples, the sponge *Pheronema carpenteri* was the most important species in biomass. The high values of the sponge are a consequence of the better sampling coverage in the spring survey in the inner basin area, where there are aggregations of this species just 750 individuals/Ha.

In 1948 and based on a very low number of sampling stations, Le Danois described in the first biological study of the area the presence of brachiopods at the top of the Bank and sponge aggregations (*Asconema setubalense*) in the inner basin (Le Danois, 1948). In the top of the bank, big specimens of *Geodia megastrella* (15 Kg. in weight) were found with higher abiotic habitat complexity (rocky outcrops) and medium biogenic habitat complexity.

In the preliminary results, we expect over 40 species. The Orders Astrophorida, Poecilosclerida, Hadromerida, Halichondrida and Haplosclerida were the best represented among Demospongiae and Lyssacinosida and Amphidiscosida among Hexactinellida.

Among the identified species (some of them reported for the first time in this area), most abundant are *Pheronema carpenteri*, *Geodia* spp., *Geodia megastrella*, *Stylocordyla cf borealis*, *Pachastrella monilifera, Phakellia robusta, Askonema setubalense, Bubaris vermiculata, Sphinctrella gracilis, Haliclona* spp. and *Desmacella inornata*.

Acknowledgements

This study was made possible thanks to the invaluable work of all the participants in the two ECOMARG surveys and the crew of the RV Vizconde de Eza (SGPM). This study was partially funded by the Spanish Science and Technology Ministry, and included in the ECOMARG Project (REN2002-00916/MAR).

References

Cristobo F.J., Urgorri V., Solórzano M.R., Ríos P (1993) Métodos de recogida, estudio y conservación de las colecciones de poríferos. In : *International Symposium & First World Congress on Preservation and Conservation of Natural History Collections*, Madrid 10-15 May 1992. (ed. F. Palacios et al.) 2, pp. 277–287. Dirección General de Bellas Artes y Archivos. Ministerio de Cultura. Madrid.

FAO, 2007. Draft International Guidelines on the Management of Deep-sea Fisheries in the High Seas. As adopted by the Expert Consultation on International Guidelines on the Management of Deep-sea Fisheries in the High Seas (Bangkok, Thailand, 11-14 September 2007)

Hooper J.N.A., van Soest R.W.M. (eds.) 2002. Systema Porifera: A Guide to the Classification of Sponges. *Kluwer Academic/Plenum Publishers*, New York 1101 pp.

ICES, 2003. Report of the study group on survey trawl gear for the IBTS Western and Southern Areas. *ICES CM* 2003/B:01, 22 pp.

Le Danois, E., 1948. Les Profondeurs de la Mer. Ed. Payot, Paris, 303 p.

Levi, C., Laboute, P., Bargibant, G. & Menou, J.L. 1998. Sponges of New Caledonian Lagoon. *Orstom Editions*. Paris. 214 pp.

Rützler K., 1978. Sponges on coral reefs. In Coral reefs: research methods (ed. Stoddart D.R. and Johanness, R.E.), pp. 81–120. *Unesco*, Paris.

Serrano, A., F. Sánchez, J. E. Cartes, J.C. Sorbe, S. Parra, I. Frutos, I. Olaso, F. Velasco, A. Punzón, A. Muñoz, M. Gómez, C. Pola & I. Preciado, 2005. ECOMARG Project: A multidisciplinary study of Le Danois Bank (Cantabrian Sea, N Spain). *ICES CM* 2005/P:11, 17 pp.

Presence of a rare genus of deep sea Porifera (Podospongiidae) from the Cantabrian Sea

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Introduction

Shallow-water coral reef systems are rich in sponge species and individuals (Diaz & Rützler, 2001) and these are estimated to have a huge impact on the system by filtering off the water column above the reef (Reiswig 1974) and within reef cavities (Scheffers et al. 2004). These functions presumably also apply to sponges in North East Atlantic bathyal coral reefs, built predominantly by *Lophelia pertusa* (L., 1758) and *Madrepora oculata* L., 1758 (Alvarez-Claudio, 1994).

Deep-water corals occur worldwide and have been known by fishermen and benthic scientist for centuries (Zibrowius 1980). However, these structures remain poorly studied and it is not until the last years that video material from manned and unmanned submersibles has brought home to a wider audience just how large and spectacular these reefs can be (Freiwald et al. 1999).

Recently, reports appeared on the mass occurrence of megabenthic sponge species (*Pheronema carpenteri* (Thomson 1869) and *Geodia* spp.) associated with bathyal reefs (Rice et al. 1990; Klitgaard & Tendal 2001, 2004; Reitner & Hoffmann 2003) underlining the possible great impact of filterfeeders on bathyal communities. Still, it is as yet unclear how extensive the distributions, diversity and biomass of bathyal sponges in general and these megabenthic species in particular are and how massive their occurrence is. The biodiversity of bathyal (-200 m) sponges is underexplored (Soest & Lavaleye. 2005)

In the COCACE projet, forty three bentic stations located along several transects perpendicular to the Central Cantabric coast off Asturias (southern Biscay Bay) were sampled. In this way, the main objective of the ECOMARG project is the integrated study of the benthic-demersal ecosystem of the singular Asturian marginal shelf (Le Danois Bank), a barely well-known area in spite of belonging to the Spanish EEZ and being subject to fishing activities. (Serrano et al, 2005).

In the preliminar analysis of Porifera fauna of these two expeditons, we found a rare deep sea sponge *Podospongia loveni* (Bocage, 1869) discovered in 1868 but only registered twice from Gibraltar to Portugal coast. Spicules of this species are illustrated for first the time by Scanning Electron Microscopy (SEM).

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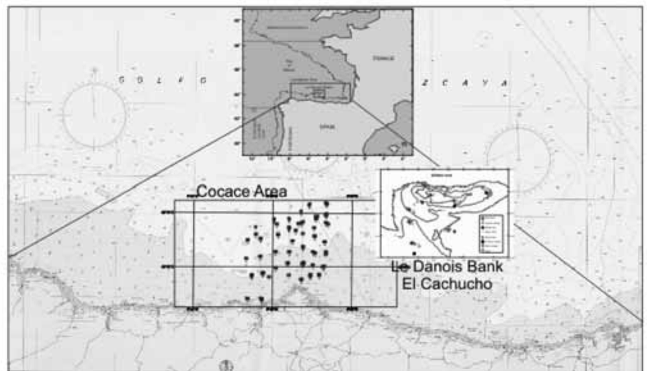

Figure 1. Map of the study area, showing the sampling stations.

Methods

In the COCACE projet, fauna samples were taken with an anchor dredge and an epibenthic sledge. The sampling stations were located on the self and the continental slope, depht ranging from 50 to 1347 m (Fig. 1) in forty three stations between Vidio Cap and the town of Gijón.

In the ECOMARG projet several samplers were used on each biological station in order to study the different compartments of the benthic fauna. Epibenthos and demersal species were studied using two different gears, a Porcupine baca trawl (ICES, 2003) and a beam trawl. Porcupine baca trawl mesh size was of 90 mm along the net but with a 20 mm liner inside the cod end. Horizontal opening was of 18.5 ± 1.3 m and vertical opening of 3.14 ± 0.20 m. The sampling unit was a 30- minute haul, all carried out at daytime at a speed of 3.5 knots. Beam trawl horizontal opening was of 3.5 m and vertical opening of 0.6 m (mesh size of 10 mm). Both trawl gears were monitored using a Scanmar net sensors. Area was divided following a bathymetric criterion: the upper part of Le Danois Bank (400-700 m) was identified as Stratum 1, and the marginal basin (700-1000 m) corresponded with Stratum 2. In hard bottoms, two different visual techniques were used: a photogrammetric sled and a ROV. The photogram-metric sled has a high resolution digital camera that shoots at set time intervals. It uses four laser pointers to determine the surface covered by each photo and the dimensions of species. It also uses a CTD probe to characterize each photo according to the oceanographic variables (pressure, temperature and salinity). A ROV Swordfish model manufactured by Deep Ocean Engineering was also used up to 600 m deep (Serrano et al, 2005). All specimens were initially fixed in 5% formaldehyde and later preserved in 70% ethanol. Spicules were prepared for SEM as follows: the organic matter was digested with nitric acid taken to boiling point, following the methods of Rützler (1978) and Cristobo et al., (1993), and spicules were examined using a Scanning Electron Microscope. Skeletal architecture was studied by light microscopy.

The classification system adopted in this work is that proposed by Kelly & Samaai, 2002.

Results

Podospongia du Bocage, 1869, is a genus generally found in deeper waters down to 600 m from Natal coast of South Africa, New Caledonia and the central and north Atlantic. There are only four valid species: *Podospongia loveni* (Bocage, 1869) (Type species), *Podospongia natalensis* (Kirkpatrick, 1903), *Podospongia india* (de Laubenfels, 1934) and *Podospongia similis* Lévi, 1993.

Species from this genus are charactericed by a choanosomal skeleton composed of tracts of megascleres radiating from a centrum and stipitate body

Specimens collected in the Cantabrian Sea (1 from El Cachucho and 15 from COCACE Projet area) (Fig. 1) were identified as *P. loveni*.

After holotype was destroyed (Kelly & Samaai, 2002) and with the existence of many specimens from a close region, we consider the possibilite to redescribe the species in order to characterize it and to have fresh material to comparation.

Habitus of all specimens is stipitate, globular with the body supported by a long stalk, ectosomal skeleton is distinctive with a layer of microscleres (spinorabdes), choanosomal skeleton consist of radiating tracts of megascleres which extend into the axis of the sponge (Fig. 2). Also spinorhabdes are scattrered in the choanosome. In addition we contribute with data about habitat that characterize the species.

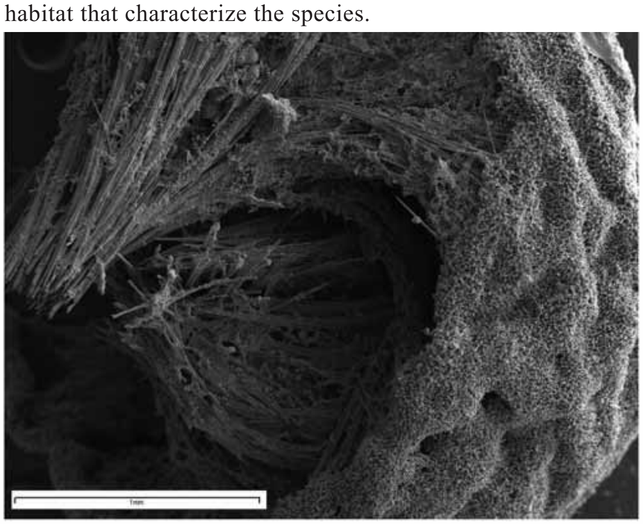

Figure 2. *Podospongia loveni*, Vertical section showing radiating tracts of megascleres and the layer of spinorhabdes in the ectosome.

Acknowledgements

This study was made possible thanks to the invaluable work of all the participants in the two ECOMARG surveys and the crew of the RV Vizconde de Eza (SGPM). This study was partially funded by the Spanish Science and Technology Ministry, and included in the ECOMARG Project (REN2002-00916/MAR) and a contribution to the COCACE projet (Central Cantabric Oceanographic Cruise, Oviedo University).

References

Alvarez-Claudio, C. 1994. Deep-water Scleractinia (Cnidaria: Anthozoa) from southern Biscay Bay. *Cahiers Biologie Marine*, 35: 461-469.

Bocage, B.du 1868. On *Hyalonema boreale*. Annals and Magazine of Natural History (4) 2(7): 36-36.

Bocage, B.du 1869. Eponges siliceuses nouvelles du Portugal et de l'Île Saint-Iago (Archipel de Cap-Vert). *Jornal de Sciencias mathematicas, physicas e naturais* 2 : 159-162.

Boury-Esnault N, Pansini M, Uriz M.J. 1994. Spongiaires bathyaux de la mer dAlboran et du golfe ibe´ro-maroccain. *Memoires du Muséum National d'Histoire Naturelle* 160 (Zoologie):1-174.

Cristobo F.J., Urgorri V., Solórzano M.R., Ríos P (1993) Métodos de recogida, estudio y conservación de las colecciones de poríferos. In : *International Symposium & First World Congress on Preservation and Conservation of Natural History Collections*, Madrid 10-15 May 1992. (ed. F. Palacios et al.) 2, pp. 277–287. Dirección General de Bellas Artes y Archivos. Ministerio de Cultura. Madrid.

Diaz M.C., Rützler K. 2001. Sponges: an essential component of Caribbean coral reefs. *Bulletin of Marine Science* 69: 535_/46.

Freiwald, A., Wilson, J.B. & Henrich, R. 1999. Grounding Pleistocene icebergs shape recent deep-water coral reefs.*Sediment. Geol*.125,1–8.

ICES, 2003. Report of the study group on survey trawl gear for the IBTS Western and Southern Areas. ICES CM 2003/B:01, 22 pp.

Kelly, M. & Samaai, T. 2002. Family Podospongiidae de Laubenfels, 1936. In: Systema Porifera: A Guide to the Classification of Sponges, (Hooper, J.N.A. & van Soest, RW.M. eds.), pp 602-620. New York.

Klitgaard A.B., Tendal O.S. 2004. Distribution and species composition of mass occurences of large-sized sponges in the northeast Atlantic. *Progress in Oceanography* 61(1): 57_/98.

Reiswig H.M. 1974. Water transport, respiration and energetics of three tropical marine sponges. *Journal of experimental marine Biology and Ecology* 14:231_/49.

Reitner J, Hoffmann F. 2003. Porifera-Zonierungen in Kaltwasser-Korallenriffen (Sula-Rücken, Norwegen). In: Gradstein SR, Willmann R, Zizka G, editors. Biodiversitätsforschung: Die Entschlu¨sselung der Artenvielfalt in Raum und Zeit. Kleine Senckenberg-Reihe 45. Stuttgart: Schweizerbartsche Verlagsbuchhandlung. p 75_/87.

Rice A.L., Thurston M.H., New AL. 1990. Dense aggregations of a hexactinellid sponge, Pheronema carpenteri in the Porcupine Seabight (northeast Atlantic Ocean), and possible causes. *Progress in Oceanography* 24:179_/96.

Rützler K., 1978. Sponges on coral reefs. In Coral reefs: research methods (ed. Stoddart D.R. and Johanness, R.E.), pp. 81–120. Unesco, Paris.

Scheffers S.R., Nieuwland G., Bak R.P.M., Duyl F.C. van. 2004. Removal of bacteria and nutrient dynamics within the coral reef framework of Curacao (Netherlands Antilles). *Coral Reefs* 23:413_/22.

Serrano, A., F. Sánchez, J. E. Cartes, J.C. Sorbe, S. Parra, I. Frutos, I. Olaso, F. Velasco, A. Punzón, A. Muñoz, M. Gómez, C. Pola & I. Preciado, 2005. ECOMARG Project: A multidisciplinary study of Le Danois Bank (Cantabrian Sea, N Spain). ICES CM 2005/P:11, 17 pp.

Soest, R.W.M. & Lavaleye, M. 2005. Diversity and abundance of sponges in bathyal coral reefs of Rockall Bank, NE Atlantic, from boxcore samples. *Marine Biology Research*, 1:5, 338 - 349

Topsent E. 1928. Spongiaires de l'Atlantique et de la Méditerranée provenant des croisieres du Prince Albert 1er de Monaco. *Resultats des Campagnes Scientifiques accomplies par le Prince Albert I de Monaco* 74: 1-376.

Topsent, E. 1922. Les megascleres polytylotes des Monaxonides et la parenté des Latrunculiines. *Bulletin Institute Oceanographique de Monaco*, 415: 1-8.

Vacelet, J. 1969. Éponges de la roche de large et de l'étage bathyal de Méditerranée. Memoires du Museum National d'histoire Naturelle. Paris Ser. A 59 : 145-219.

Zibrowius, H. 1980 Les scle´ractiniaires de la Méditerranée et de l'Atlantique nord-oriental. *Mem. Inst. Oceanogr*. 11: 1–22.

Non native marine species in the N-NW Spanish coast

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Abstract

More than 70 marine non native species have been reported from marine environments of the North and North-western of the spanish coastlines. The majority of these species has established self-sustaining populations. The most important vectors of introduction are shipping, species imports for aquaculture purposes and species imports as part of the ornamental trade. Many species show a locally limited distribution, but almost half of all non native marine species have spread successfully across larger areas. Several introduced species are abundant and can be considered as invasive. Prime source regions are the Indo-Pacific region and the north-western Atlantic. For all source regions considered, the invasion rate has been increasing since the end of the last century.

The majority of these species are macroalgae, crustacean and molluscs. Very often there was a delay between a species being introduced and its being confirmed as present and established. Difficulties in identifying some species, or a lack of realisation that they have been introduced, have led to inaccurate records being kept. This number will be increase in the future, when the studies that working on this topic publish these results.

Introduction

All over the world, marine systems are being increasingly subjected to human mediated invasion of non-indigenous species. This begins the third most important perturbation in the marine ecosystems after over-fishing and marine pollution (OSPAR, 2000). Alien species are introduced non-native species that have become established outside their normal habitat or native bio-geographic region. Alien species are introduced to areas outside their natural habitats deliberated or by accident. In the marine environment, alien species are most commonly found in coastal and estuarine habitats, in areas associated with human activity such harbours, marinas and aquaculture sites. Once established in their new habitat, no native species could be a potential threat to the environment and to the native species as they may out-compete and sometimes take over their new environment (e.g. Eno *et al*. 1997, Nehring and Leuchs 1999, Wolff 2005).

One of the first summaries of aquatic invaders was prepared by Gollasch (1996) in German coastal waters. In 1997, Eno et al. published a summary of coastal aquatic alien species in the United Kingdom. In 1999, Reise *et al*. published a summary of invasive species in the North Sea and several regional updates were published thereafter: e.g. Weidema (2000) for Nordic countries, Gollasch and Naering (2006) for Germany, Jensen and Knudsen (2005) for Denmark and Wolff (2005) for The Netherlands. In 2006 Gollasch published an overview on introduced aquatic species known from European coasts.

In the N-NW Iberian Peninsula area, studies on non native species are very scarce and located in the space and time. At the moment the major groups information is very scarce (Martínez and Adarraga 2005, 2006, Cabal *et al.*, 2006b,). Only in the macroalgae groups have been realised dilated studies about distribution, density and competence of habitat with non-native studies (Rico and Fernández, 1997).

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Methods

In order to obtain a reviewed list of non native marine species a questionnaire has been distributed to Spanish marine biologist including targeted marine specialists with knowledge of particular taxonomic groups. Besides, information was also drawn from an extensive literature searched about alien species in the Spanish coast. These data are annually sending to ICES working groups that are focussed on introductions and transfers of marine organisms.

Results

The data collected at the moment, recorded seventy species of marine organisms that have been identified as non-native on marine fauna and flora from N-NW spanish coast. The first non native marine species in this area were recorded in the last years of the XIX century (e.g. *Bonnemaisonia hamifera Carpobrotus aciniformis, Crepidula fornicata*).Since 1980s, the number of species recorded have been increased, and more of the species are cited in the last twenty years (Figure 1). This increment is parallell to the the number of biological studies in this area from 1980, and in addition several studies have beeen focussed in non native species in coastal areas in the last years (ALIENS, OVAL, Martínez and Adarraga 2005, 2006).

Introduced species are distributed among most taxonomic groups, although so far no new vertebrates have been able to establish a permanent population. The main group consists of macro algae with 25 species (Figure 2). Between non-native species of macro-algae, stand out *Sargassum muticum*, especially sheltered to semi-exposed areas not densely covered by other seaweeds, harbours or aquaculture sites. The first record in the north of Spain was in 1985 (Fernández *et al,*. 1990) and it was recorded in northern Portugal in 1991 (ICES,

2005) showed their high rate of spread on the N-NW Iberian

Followed by macroinvertebrates with 31 species (Figure 2). More of them are crustaceans with 14 species, (e.g. Blue crab, *Callinectes sapidus,*Cabal *et al.* 2006a) and , mollusc with 9 species. The last new record was *Rapana venosa* (Rolán and Bañón, 2007) in Cambados (Pontevedra).

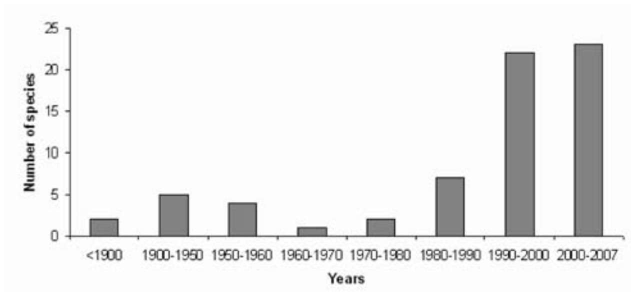

Figure 1. New records of non native species in Spanish coast from 1900.

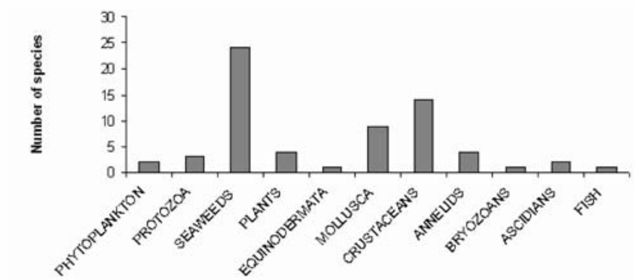

Figure 2. Number of non native species from different taxonomical groups in the N-NW Atlantic coast (Spain) New

Discussion

More of the species described here are considered to have been introduced in association with shipping (fouling, ballast water) or accidental introductions of shellfish for mariculture. The first origin for many of these species are Indo-Pacific region and the north-western Atlantic, but many of them arrive to this area from second spread from other waters of Europe (ICES, 2005).

The number of non native species found is low in comparison with data form adjacent areas as North Sea region, where were found between 126 to 140 established species and occasional records (Eno *et al.*, 1997, Reise *et al.*, 1999, Gollasch and Nearing, 2006). According to Gollash and Nehring (2006), brackish waters are characterized by the lowest number of indigenous species and seem provide opportunities for alien species invasions. The low indigenous species richness facilitates invasions of "new species". In this way, the observed trend in the abundance of invaders might be explained by a model related to the global pattern of increased species richness towards lower latitudes. However, this trend is not so clearly recognized in the Mediterranean and low latitude Atlantic where more alien species are present. In these "impacted" localities are greatly differ in their nature (small recreational harbours, large industrial harbours, urban areas, marinas,…).and potential vectors pressure should be expected to be more variable than in "natural" undisturbed localities. In conclusion, the number of alien species in the N-NW spanish coast will probably to rise due to the effects of disturbed "natural" coast.

Acknowledgements

The authors are grateful to a large number of colleagues who contributed to this inventory, but we cannot mention them individually here as the list would be too long. This work was supported by OVAL project from Instituto Español de Oceanografía (Ministerio de Educación y Ciencia).

References

Cabal, J., J. A. Pis-Millán and J. C. Arronte. 2006a. A new record of Callinectes sapidus Rathbun, 1896 (Crustacea: Decapoda: Brachyura) from the Cantabrian Sea, Bay of Biscay, Spain. Aquatic Invasions (2006) Volume 1, Iss ue 3: 186-187

Cabal, J., J.M. Rico, N. Anadón and L. Valdés, 2006b. Looking for Alien species in the N-NW Iberian Peninsula coast. In: I. Alvarez, M. de Castro, M. Gómez-Gesteira, M.N. Lorenzo and R. Prego (Editor), Oceanography of the Bay of Biscay. Aica ediciones, pp. 181-184.Oceanography of the Bay of Biscay 181-184.

Eno, N.C., R.A. Clark and W.G. Sanderson, 1997. Non-native marine species in British waters: a review and directory. Joint Nature Conservation Committee, Peterborough 135 pp.

Fernández, C.; L. M. Gutiérrdez and J. M. Rico, 1990. Ecology of Saragassum muticum on the north coast of Spain. Preliminary observations. Botanica Marina, 33: 423-428.

Gollasch, S., 1996 Untersuchungen des Arteintrages durch den internationalen Schiffsverkehr unter besonderer Berücksichtigung nichtheimischer Arten. Diss., Univ. Hamburg; Verlag Dr. Kovac, Hamburg, 314 pp

Gollasch, S. and S. Nearing, 2006. National checklist for aquatic alian species in Germany. Aquatic Invasions 1(4):245-249.

ICES, 2005. Report of the Working Group on Introductions and Transfer of Marine Organisms (WGITMO), By Correspondence. ICES CM 2005/ ACME: 05. 173 pp.

Jensen K and J. Knudsen, 2005 A summary of alien marine invertebrates in Danish waters. Oceanological and Hydrobiological Studies 34(Suppl 1): 137-162

Martinez, J. and I. Adarraga, 2005. Programa de vigilancia y control de la introducción de especies invasoras en los ecosistemas litorales de la costa vasca. 1. Costa de Guipúzcoa. Departamento de medio Ambiente y Ordenación del Territorio del Gobierno Vasco.267 pp.

Martinez, J. and I. Adarraga, 2006. Programa de vigilancia y control de la introducción de especies invasoras en los ecosistemas litorales de la costa vasca. 2. Costa de Bizcaia. Departamento de medio Ambiente y Ordenación del Territorio del Gobierno Vasco.267 pp.

Nehring S and H. Leuchs, 1999 Neozoa (Makrozoobenthos) an der deutschen Nordseeküste - Eine Übersicht.Bundesanstalt für Gewässerkunde Koblenz, Bericht BfG-1200, 131 pp

OSPAR Commission, 2000. Quality status report 2000. OSPAR Commissión, London. 108 pp.

Reise, K., S. Gollasch, and W.J. Wolff, 1999. Introduced marine species of the North Sea coast. Helgoländer Meeresuntersuchugen, 52: 219-234.

Rico, J. M. and C. Fernández, 1997. Ecology of Sargassum muticum on the north coast of Spain. II. Physiological differences between Sargassum muticum and Cystoseira nodicaulis. Botanica Marina, 40: 405-410.

Rolán E. and R. Bañón, 2007. Primer halazgo de la especie invasora Rapana venosa y nueva información sobre Haexaplex trunculus (Gastropoda, Muricidae) en Galicia. Noticiario SEM 47: 57-59.

Weidema IR (2000) Introduced species in the Nordic countries. Nordic Council of Ministers, Copenhagen. Nord Environment, 2000:13, 242 pp.

Wolff, W. J., 2005 Non-indigenous marine and estuarine species in The Netherlands. Zoologische Mededelingen. 79-1: 1-116

“El Cachucho”: a hotspot of biodiversity in the Bay of Biscay

Inmaculada Frutos [A, B]* And Jean Claude Sorbe[a]

Introduction

In October 2003 and April 2004 a multidisciplinary study of the “Le Danois” bank (called by local fishermen “El Cachucho” fishing grounds) was carried out. In complement to previous observations (Le Danois, 1948; Laubier et Monniot, 1985) and recent studies on benthic communities of this bank (Cartes *et al.*, 2007; Sánchez *et al.*, in press), the present paper deals with observations on its suprabenthic communities, i.e. the faunal assemblages (mainly small crustaceans) living in the inmediate vicinity of the bottom (Brunel *et al.*, 1978), in order to describe their quantitative structure.

Methods

During ECOMARG cruises the suprabenthic fauna was sampled during daytime with a slightly modified version of the suprabenthic sled described by Sorbe (1983). This gear is equipped with two sets of superimposed nets (0.5 mm mesh size) and towed at 1-2 knots over the bottom. This gear allows quantitative sampling of the motile fauna in the 0-50 and 50-100 cm water layers above the sea floor. Sled samplings were carried out at 9 stations from 484 to 1049 m depth.

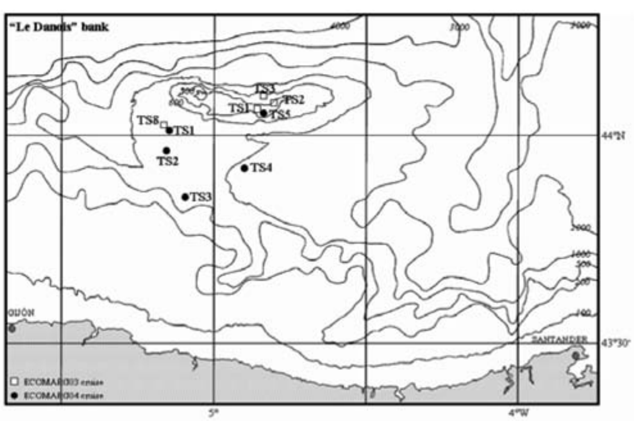

Figure 1. Map of the study area, showing the sampling stations.

Results

20,707 individuals belonging to 10 major zoological groups were identified in the material up to now examined (6 samples). The “Le Danois” bank suprabenthic fauna shows a very high diversity (273 species) mainly represented by amphipods (107 species). 34 bank species are putatively new to science: 15 amphipods (*Gitana* sp., *Autonoe* sp., *Apherusa* sp., *Eusirus* sp., *Leucothoe* sp., *Tmetonyx* sp., *Melphidippa* sp., *Melphidippella* sp., *Oediceroides* sp., Oedicerotidae sp., *Pseudo* sp., *Stenothoe* sp. and *Syrrhoites* sp.), 9 cumaceans (*Diastylis* sp., *“Leptostylis”* sp., *Paralamprops* sp., *Leucon (Crymoleucon)* sp., *Leucon (Epileucon)* sp., *Cumella (Cumella)* sp. and *Procampylaspis* sp.) and 10 isopods (*Ischnomesus* sp., *Macrostylis* sp., *Echinozone* sp., *Lipomera (Paralipomera)* sp., *Lipomera (Tetracope)* sp., Lipomerinae sp., *Munnopsurus* sp., *Pleurogonium* sp., *Politolana* sp. and *Arcturopsis* sp.). Amphipod *Liropus cachuchoensis* and isopod *Haplomesus longiramus* have just been described (Guerra-García *et al.*, 2007 and Kavanagh & Sorbe, 2006; respectively).

The “Le Danois” bank provides new boundaries for the geographical distribution of species not previously cited from the Bay of Biscay: boreal amphipods like *Amphilochoides manudens, Metambasia faeroensis, Melphidippa borealis*, *Dulichiopsis nordlandicus* and “endemic” Mediterranean amphipods like *Bathymedon monoculodiformis, Oediceroides pilosus, Pseudotiron bouvieri*.

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Conclusions

The comparison with previously described bathyal suprabenthic communities from the Bay of Biscay (Elizalde, 1994; Vanquinkelberge, 2005) demonstrates that the “Le Danois” bank supports a highly diverse and abundant suprabenthic fauna probably due to different edaphoclimatic conditions in the near-bottom environment (lower pelitic content on the sediment).

Acknowledgements

The autors are indebted to the crew of *RV Vizconde de Eza* (SGPM) and to all the participants in the ECOMARG cruises for their helpful assistance at sea. This study was included within the framework of the Spanish ECOMARG Project (REN2002-00916/MAR) conducted by Dr. F. Sánchez (IEO Santander). I. Frutos is the recipient of a postdoctoral fellowship from Mutua Madrileña.

References

Brunel, P., Besner, M., Messier, D., Porier, L., Granger, D. et Weinstein, M. 1978. Le traîneau suprabenthique Macer-GIROQ: appareil amélioré pour l’échantillonnage quantitatif étagé de la petite faune nageuse au voisinage du fond. *Internationale Revue der gesamten Hydrobiologie*, 63, 6: 815-829.

Cartes. J.E., Serrano. A., Velasco. F., Parra. S., Sánchez. F. 2007. Community structure and dynamics of deep-water decapod assemblages from Le Danois bank (Cantabrian Sea, NE Atlantic): influence of environmental variables and food availability. *Progress in Oceanography,* 75:797-816.

Elizalde, M. 1994. *Les communautés suprabenthiques bathyales de la marge sud du canyon du Cap-Ferret (Golfe de Gascogne).* Thèse Doctorat. Université de Bordeaux1. 216 pp.

Guerra-García, J.M., Sorbe J.C. & Frutos I. 2007. A new species of *Liropus* (Crustacea, Amphipoda, Caprellidae) from the "Le Danois" bank (southern Bay of Biscay). *Organisms, Diversity and Evolution*, (in press).

Kavanagh, F.A & Sorbe, J.C. 2006. *Haplomesus longiramus* sp. nov. (Crustacea: Isopoda: Asellota), a new ischnomesid spcies from the Bay of Biscay, North East Atlantic Ocean. *Zootaxa*, 1300: 51-68.

Laubier, L. et Monniot, Cl. 1985. *Peuplements profonds du golfe de Gascogne.* Éd. IFREMER. 630 pp.

Le Danois, E. 1948. *Les profondeurs de la mer*. *Trente ans de recherches sur la faune sous-marine au large des côtes de France*. Ed. Payot, Paris, 303 pp.

Sánchez, F., Serrano, A., Parra, S., Ballesteros, M., Cartes, J.E. (in press). Habitat characteristics as determinant of the structure and spatial distribution of epibenthic and demersal communities of Le Danois Bank (Cantabrian Sea, N Spain). *J Mar Sys*

Sorbe, J.C. 1983. Description d'un traîneau destiné à l'échantillonnage quantitatif étegé de la faune suprabenthique néritique. *Annales de l'Institut Océanographique*, 59: 117-126.

Vanquickelberghe, V. 2005. *Spatial distribution and biodiversity patterns of the hyperbenthos along NE Atlantic continental margins*. PhD dissertation. Gent University, 240 pp.

Presentation of the Bay of Biscay and English Channel operational model. Validation of hydrology on the shelf

Lazure P.[a], Herry C.[b], Langlois G.[c], Chifflet M.[d], Craneguy P. [b], Dumas, F. [a]

Introduction

The rise of Coastal operational oceanography led to the development of regional models. These hydrodynamical models have two main objectives. The first is to describe the circulation and hydrology at the regional scale with numerous applications like crises events (oil spill,…) or ecological issues (forecast of fish recruitment, harmful algal bloom,…). The second application is the downscaling to local scale which addresses other applications such as water quality. These models are used to describe the day to day evolution of hydrology and their forecast for the few coming days. Moreover, simulation of the past years (hindcast) is a rising need. These hindcasts are needed to validate the model and to build up data basis on which ecological applications can be developed.

We present a model of the Bay of Biscay and English Channel which has been developed in the framework of Previmer project. A first assessment of the ability of the model to reproduce the main hydrological features of the Bay of Biscay as discussed by Koutsikopoulos and le Cann (1996) has been performed. This qualitative assessment is not sufficient and most of the applications needs quantitative evaluation of model. Its first validation has been done by comparison of simulated temperature and salinity with satellite SST images and in situ temperature and salinity measurements. In this work, we focus on the hydrological validation over the continental shelf.

Method

Model

The MARS3D hydrodynamical model (Lazure and Dumas, 2007) is applied to the domain 8W-4E, 43N-52N. This domain encompasses both the Bay of Biscay and the English channel to deal correctly with the exchanges between these two areas as it has been shown recently (Kelly Gerreyn *et al*., 2006). This model is a Blumberg and Mellor (1987) like model. The horizontal grid size is 4km and 30 sigma levels are considered with higher vertical resolution near the surface.

Meteorological data are provided by the Arpège model of Météo France and bulk formulae are used for heat budget calculation. Run off of 59 rivers are prescribed in their estuaries on a daily basis when data are available (Loire, Gironde, Adour and Seine), otherwise climatological data are used. Initial conditions for temperature and salinity comes from a new climatology (presented during this colloquium). Ocean is considered at rest at the beginning of the simulation (01/01/2000). Open boundary conditions are provided by a large barotropic 2D model which extends from Portugal to

Iceland. This model is forced by tides, winds and pressure field. New boundary conditions from Mercator model are currently being tested but not used for this hindcast. No assimilation capability is used in this application. The model ran freely from 2000 to 2006.

Satellites SST

NAR (Near Atlantic Region, zone GASC) is an OSI SAF (Ocean and Sea Ice Satellite Application Facility) product that provide sea surface temperature (SST) data. NAR SST comes from NOA-18 polar-orbiting satellite (previously NOAA-17 and NOAA-16), the archive is available since 2001; the pictures have a spatial resolution of 2km and are produced four times per day.

In situ data

An almost comprehensive data set of in situ data of temperature and salinity observations has been build for this validation. The Rephy monitoring network which aims at catching HAB events provides on a weekly basis temperature and salinity coastal observations at several locations along the Bay of Biscay and English Channel. Other data comes from CTD casts of different surveys, from some time series of temperatures and salinities measurement on several island (Lazure *et al*., 2006) and from thermosalinometer data from the R/V "Côtes de la Manche".

Results

We show here some examples of validation of the model : comparison of model results with satellite images and *in situ* data. The work is still in progress and the validation and comparison results will be synthetized.

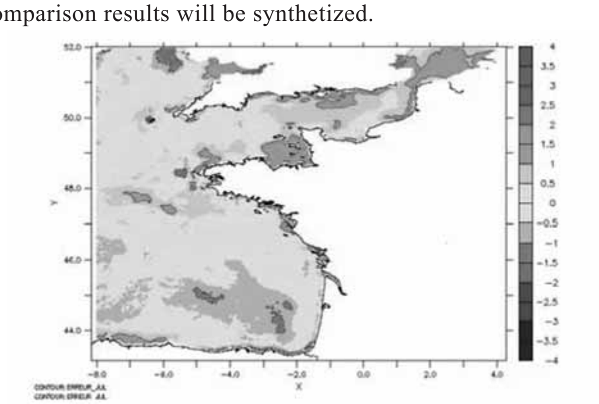

Figure 1. Temperature mean error in July.

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Temperature :comparison to satellite images

The comparison between model and satellite data has been performed on the basis of monthly average to cope with numerous cloudy situations.

Results for temperature show a good agreement in Summer as shown on figure 1. Mean error for July averaged from year 2002-2005 is generally less than 1°C in homogeneous water (estearn English channel) as well as in stratified water (most of the Bay of Biscay and western english channel.

In Winter, the agreement appear less satisfatory as shown on figure 2, the mean error in December is higher over the Armorican shelf and in the english Channel. However, the differences barely reach 1,5°C.

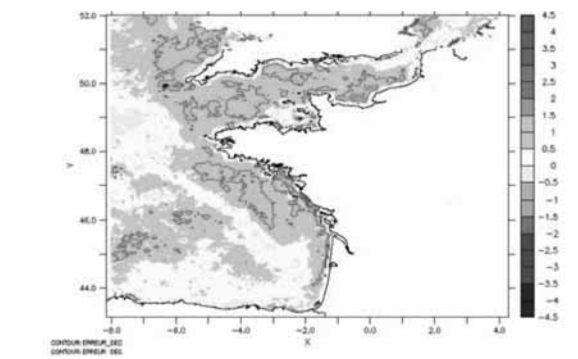

Figure 2. Temperature mean error in December

Comparison to *in situ* data (temperature and salinity)

In situ data are compared with model result at the same date and location. Near surface temperature and salinity measurements from the R/V "Côte de la Manche" have been used to validate model results. Fig 3 shows the path of this Vessel in 2003. She has focused her field trips over the shelf on shallow depths.

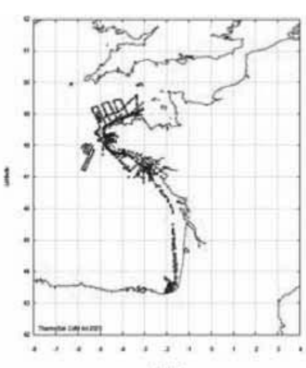

Figure 3. Location of thermosalinometer data in 2003

Comparison of temperature over the year 2003 highlights a good agreement between simulation and measurements. No shift appears and the slope between model and measurement is close to one (blue line of figure 4). During summer, the simulated temperature is lower than the observed one.

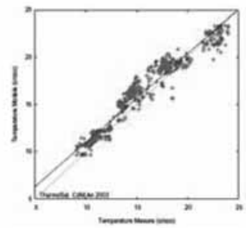

Figure 4. Temperature in 2003.

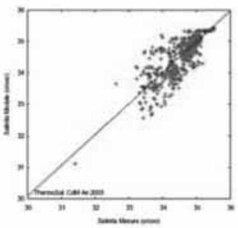

Figure 5. Salinity in 2003

The comparison of salinities is less satisfactory than for temperature. However, no bias is observed. Indeed, at low salinities, simulations are generally too fresh denoting probably a lack of mixing in the vinicity of river plumes. This is currently assessed in detail in an ongoing work.

Conclusion

This work of validation is in progress. Model performance has been assessed and quantitative comparison has been made. Results are encouraging and both salinity and temperature appear to be correctly simulated over the year. However, an analysis of discrepancies between model and simulation needs to be performed in view of the physical processes which are likely to be involved.

References

Kelly-Gerreyn B., Hydes D., Jegou AM, Lazure P., Fernand L., Puillat I., Garcia Soto C., 2006. Low salinity intrusions in the western English Channel. Cont. Shelf Res., 26 (11) 1241-1257. Koutsikopoulos C, Le Cann B., 1996. Physical processes and hydrological structures related to the Bay of Biscay anchovy. Scienca Marina ; 60 : 9-19.

Lazure P., Dumas F., 2007. An external-internal mode coupling for 3D hydrodynamical model for applications at regional scale (MARS). Adv. Wat. Res. (in press)

Lazure P., Jegou AM, Kerdreux M., 2006. Analysis of salinity measurements near islands on the French continental shelf of the Bay of Biscay. Scienca Mar., 70 Suppl. 1 7-14.

Variability of circulation off N and NW Iberia: insights from a forecast model

Manuel Ruiz Villarreal,* Pablo Otero, Marcos Cobas, Paula Conde and Martinho M. Almeida

Introduction

In narrow shelves, the usual shelf processes like density gradients associated to river plumes, winds, tides, topographical effects… interact with slope processes, which introduce additional variability and generate a highly dynamical system. The narrow shelf off north and northwest Iberia is a relevant example of a shelf system strongly influence by slope processes (e.g. Lavin et al, 2006; Ruiz-Villarreal et al. 2006).

In the last years, the Instituto Español de Oceanografía (IEO) has been applying in the area a high resolution ocean model with full physics and high resolution meteorological forcing. The model aims at providing insight on circulation for ecosystem studies in support to the intense IEO ecosystem research in the area. In this sense, the main interest is on high resolution shelf and slope processes (upwelling, river plumes, slope currents…). Since March 2007, the model is ran daily to provide forecasts with a 72 hour horizon. In this contribution, we will report on the insight on variability of circulation provided by this forecast model.

Methods

Model

The model used in the simulations is the Regional Ocean Modelling System (ROMS) in its ROMS-AGRIF version (Penven et al. 2006; Otero et al. 2007). Vertical discretization is 40 levels with resolution increased near the surface (θ_s=6.0) and the bottom (θ_b=0.2). Mean daily estimations of the run-off of 26 rivers are introduced in the model. Tide is introduced from results of the OSU tidal inverse model (TPX0.6; Egbert and Erofeeva, 2002). Surface forcing consists on hourly data from a high resolution (30 km) meteorological model (MM5 from Meteogalicia, http://www.meteogalicia.es). During some periods, an additional execution has been forced with HIRLAM015 model results from INM (http://www.inm.es)

Data

Sustained observations in the area comprise monthly hydrographical lines in Vigo, Coruña, Cudillero, Gijón and Santander (IEO Radiales project, http://www.seriestemporales-ieo.net), fisheries stock monitoring cruises in spring (IEO Pelacus project) and autumn (IEO Demersales project), Spanish Deep Standard sections (IEO Vaclan project, http://www.vaclan-ieo.es) and monitoring surface buoys over the slope: 4 of the Deep Water Network of Puertos del Estado and 1 recently moored by IEO at Santander slope.

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Results

The evolution of the daily upwelling index (UI) at 43º N 11º W, representative of synoptic meteorological conditions in the area, from 1 January 2006 is plotted in Fig. 1, where UI during cruises referred to in the text is highlighted. The two main seasons associated to prevailing winds are evident: upwelling in spring-summer and downwelling in autumn-winter. However, the strong event variability is remarkable.

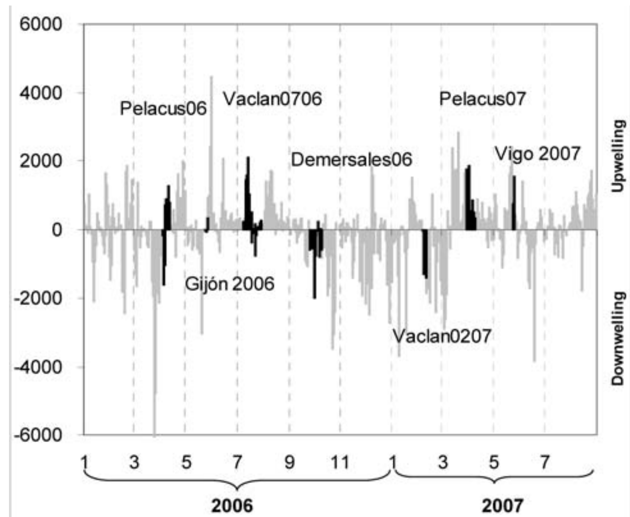

Figure 1 Upwelling index (x10^6 m^3 s^{-1} km^{-1}) with indication of cruises referred to in the text.

Different conditions were observed in the Pelacus cruises at the winter-spring transition. In 2006, the Pelacus cruise took place after a long downwelling event, which was associated to more freshwater on the western shelf and to the presence of warmer and saltier waters transported by the Iberian Poleward current on the W and NW shelf and slope. Contrastingly, Pelacus 2007 started after an upwelling event at the beginning of March and upwelling conditions dominated during the cruise. This was associated to the export of IPC offshore and to the southwards displacement of the freshwater plume on the western shelf. Details of the variability during this cruise and the frontal structures arising from the interaction of plumes and the slope IPC are obtained from the analysis of model output (see Figure 2).

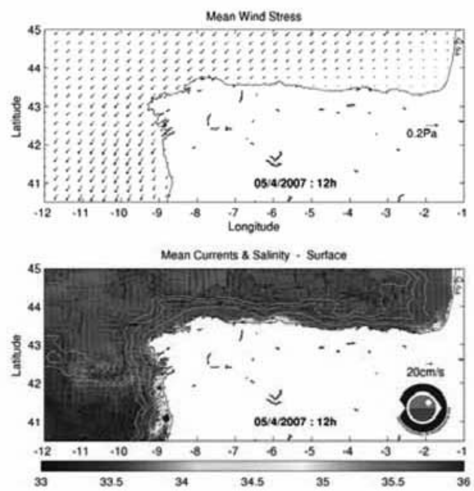

Figure 2 Near surface currents and salinity on 5-4-2007, a day of Pelacus 2007 cruise

Gijon 2006 and Vigo 2007 refer to the dates of the annual exercises of the National Marine Pollution Contingency Plan (Plan Nacional de contingencias por Contaminación Marina Accidental), when results of the forecast models were provided to managers of the simulated crisis. The exercise Gijon 2006 took place on the northern shelf during the relaxation of a southwesterly wind event in spring that enhanced the penetration of the slope poleward current on the shelf. Vigo 2007 took place in late spring conditions on the western shelf during an upwelling event, which induced sourtherly currents over the shelf and an offshore expansion of the plume (Figure 3)

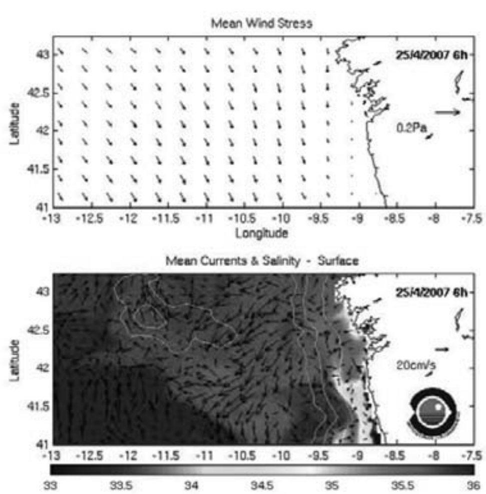

Figure 3 Near surface currents and salinity on 25-4-2007 during the Vigo 2007 exercise

Conclusions

A configuration for forecasting of shelf and slope in N and NW Iberia has been set-up. Continous improvement of the forecast model was made during exercises in 2006 and during the pre-operational phase from April 2007, when the model started to be executed daily. Apart from the operational use of the results, the model allowed us to get a picture of variability of shelf and slope circulation during 2006 and 2007. We are able to characterize river plumes, slope poleward current in autumn-winter, spatial variability of upwelling circulation, both on a seasonal and on an event scale. A characteristic feature of this EBC system is the change of NS to EW orientation of the coast. Our model results illustrate how this feature induces a different response in the western and northern shelf.

We have detected the main sources of uncertainty (atmospheric forcing, bathymetry, river run-off, initial conditions, no data assimilation…) in the simulations. These facts affect model performance in real and realistic simulations of shelf and slope areas and further research is needed. Finally, the results of the forecast model will be made available on a web server from 2008 on.

Acknowledgements

The sustained observing system and the setting up of the forecast model has been funded by IEO and projects ECOOP (European COastal-shelf sea Operacional observing and forecasting system, FP6-036355-2), PLATERIAS and REFORZA (Xunta de Galicia, PGIDIT03TAM60401PR and PGIDIT06RMA60401PR), ESEOO (VEM2003-20577-C14-02) and VACLAN (REN2003-08193-C03-01/MAR).

References

Egbert, G.D., Erofeeva, S.Y., 2002. Efficient inverse modeling of barotropic ocean tides. Journal of Atmospheric and Ocean Technology 19, 183-204.

Lavin, A., L. Valdes, F. Sanchez, P. Abaunza, J. Forest, P. Boucher, P. Lazure, and A. M. Jegou. The Bay of Biscay. The encountering of the ocean and the shelf. 2006. In The Seas, edited by Robinson and Brink, pp. 933-1001, Harvard Press.

Otero, P., Ruiz-Villarreal, M. and A. Peliz, 2007. Variability of river plumes off NorthWest Iberia in response to wind events. Journal of Marine Systems. *In Press*

Penven, P., L. Debreu, P. Marchesiello and J. C. McWilliams, 2006. Evaluation and application of the ROMS 1-way embedding procedure to the central California Upwelling System. Ocean Modelling, 12, 157-187.

Ruiz-Villarreal, M., C. González-Pola, G. Díaz del Río, A. Lavín, P. Otero, S. Piedracoba and J. M. Cabanas, 2006. Oceanographic conditions in North and NortWest Iberia and their influence on the Prestige oil spill. Marine Pollution Bulletin, 53(5-7), 220-238.

Analysis of Ekman transport patterns along the Bay of Biscay from 1967 to 2005

Ines Alvarez *[a], Maite de Castro [a], Moncho Gomez-Gesteira [a]

Introduction

Ekman transport has been widely treated in the literature since Ekman seminal paper (Ekman, 1905). Although the Ekman approach is simple, elegant, and clearly supported by laminar laboratory experiments (Pond and Pickard, 1993), the Ekman model is, however, rather dissimilar to the actual turbulent flow near the ocean or lake surface. The basic assumptions of Ekman's model of a steady-state wind and absence of any geostrophic currents are never completely realized in the open ocean. Particularly important is the effect of transient winds

Despite discrepancies between the classical Ekman description and further research, the term Ekman transport remains still valid to provide a macroscopical description of water transport near surface. The Ekman surface current or wind drift current depends upon the speed of the wind, its constancy, the length of time it has blown, and other factors.

In general, wind drift current is about 2 percent of the wind speed, or a little less, in deep water where the wind has been blowing steadily for at least 12 hours. So, although these conditions cannot be fulfilled in the close vicinity of coast, they are reasonable beyond the continental shelf. Ekman transport can result in: Driving surface waters apart (divergence) creating zones of upwelling; forcing them together (convergence) creating zones of downwelling; driving surface waters away from coasts (upwelling); and pilling them up onto coasts (downwelling).

The Bay of Biscay is located in the norteastern part of the Atlantic ocean between Spain and France. The area limited by 43-48ºN and 0-10ºW was considered for this study (Figure 1).

The aim of this study is to describe the different Ekman transport patterns in the Bay of Biscay.

Methods

Ekman transport data were obtained from the Pacific Fisheries and Environmental Laboratory at the National Oceans and Atmosphere Administration (PFEL-NOAA).

These data have been derived from one-degree surface atmospheric pressure field available as monthly averages from 1967 to the present (www.pfeg.noaa.gov). In addition to the global analysis of transport patterns corresponding to the whole area under scope (Figure 1 circles), the dynamics of three control points is considered in the present study. The first point (45.5º N, 2.5º W) is situated in front of the French coast and the other two points (44.5º N, 4.5º W; 44.5º N, 7.5º W) are located in front of the Spanish coast (Figure 1, crosses).

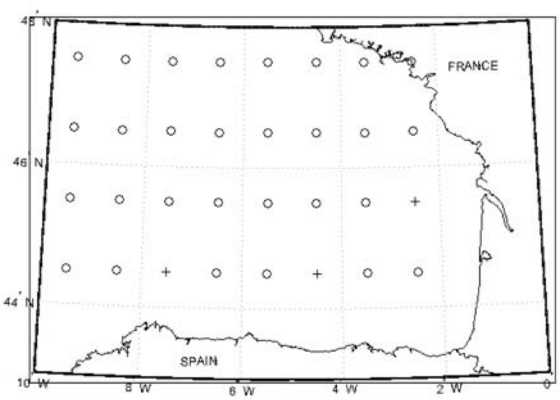

Figure 1. Area under scope.

Results and Discussion

The time evolution of both Ekman transport components has been analysed at the 3 control points. Figure 2 shows the time evolution of zonal (a) and meridional component (b) of the Ekman transport. Positive Qx values correspond to eastward transport and positive Qy values to northward transport. The zonal transport (Figure 2a) shows a similar behaviour at all points with maxima (eastward transport) during winter and minima (westward transport) during summer. The signal is clearly displaced towards positive values for the whole period. Remarkable differences can be observed among the different years. Depending on the year, it is possible to observe that the signal amplitude is highly variable. Differences can also be observed at the different control points. The amplitude of maxima, which measures the importance of southerly winds during winter, tends to be higher at 44.5ºN, 7.5ºW for nearly all the period of time showing that the amplitude of the signal increases westward. In addition, these amplitude maxima are much higher at the beginning of 1990, 2001 and 2007 than during the rest of the years.

The meridional transport (Figure 2b) shows a different behaviour. It is possible to observe a common pattern with minima (southward transport) during winter and maxima (northward transport) during summer. The signal is clearly displaced towards negative values for the whole period and the amplitude of peaks shows variability among years. The amplitude of minima is much higher at the end of 2000 and at the beginning of 2001. This episode corresponds to one of the observed situations with the highest amplitude of maxima for the zonal component.

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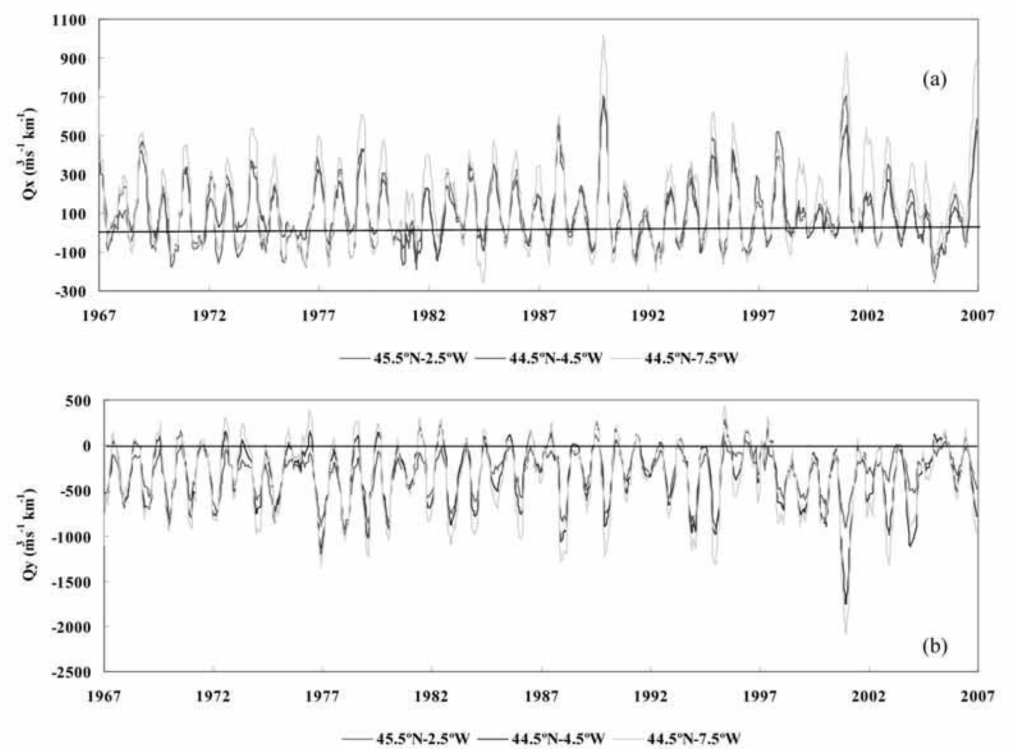

Figure 2. Zonal (a) and meridional (b) component of Ekman transport at the control points.

Figure 3 shows the seasonal variability of both components of the Ekman transport at 44.5ºN, 4.5ºW.

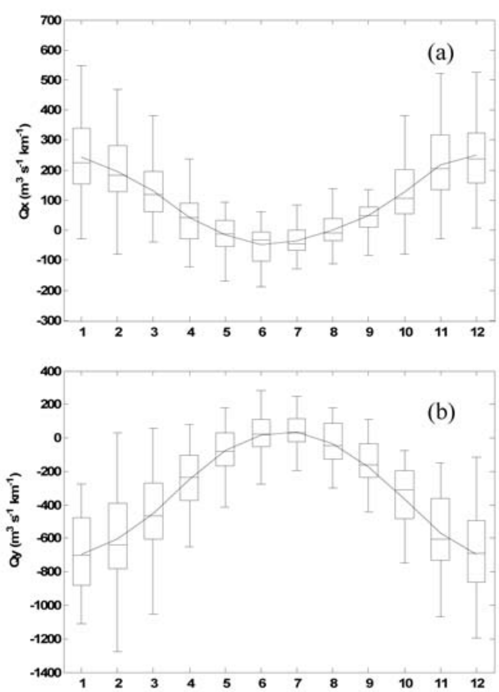

Figure 3. Monthly variability of Qx (a) and Qy (b) from 1967-2006 at 44.5ºN, 4.5ºW. Solid line represents the monthly average, line inside each box represents the median value, the lower (upper) bar represents the minimum (maximum) values and the lower (upper) box limits represents the first (third) quartile.

The mean monthly transport for the Qx component (Figure 3a) shows the highest values in December-January and the lowest ones in June-July. On the contrary, the Qy component (Figure 3b) follows the opposite pattern with minima in December-January and maxima in June-July. Thus, it is possible to observe the prevalence of winds with an important south component during winter and a north component during summer.

Conclusions

The zonal and meridional components of the Ekman transport show a marked annual cycle for the whole period of time under study, with maxima (minima) at the beginning and at the end of each year and minima (maxima) at the middle of each annual period for the Qx (Qy) component.

The evolution of transport is well represented by monthly averages. Thus, the Qx (Qy) component shows the highest (lowest) values in December-January and the lowest (highest) ones in June-July.

References

Ekman, W.K., 1905. On the influence of earth's rotation on ocean currents. *Arkiv för Matematik, Astonomi och Fysik*, 2 (11).

Pond, S., Pickard, G.L., 1993. Introductory Dynamical Oceanography, 2nd Edn. Bulterworth Heinemann.

Physical processes governing water circulation in the southeastern limit of the Bay of Biscay

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Introduction

Water circulation over the continental shelf of the southeastern limit of the Bay of Biscay is investigated and discussed here. The hydrodynamics of the Basque region appear to be complex. In addition, there is a lack of knowledge available on the marine currents. Hydrodynamic studies undertaken on the Basque coastal area are very limited and they have been confined, almost exclusively, to those in the surface waters (Ibáñez, 1979) and tides (Iribar and Ibáñez, 1979).

An exhaustive oceanographic and meteorological data recording and compilation is required in order to describe oceanic circulation over the Basque coastal area. In recent years, several studies have been undertaken over the Basque coastal area concerning wave climate and water level fluctuations and currents. Thus, along the coast between San Sebastián and Hondarribia (close the French border), an exhaustive monitoring project on marine dynamics was undertaken in order to improve the general knowledge of seasonal circulation in this coastal area (González *et al*., 2002; González *et al*., 2004; Fontán *et al*., 2006). Furthermore, a pilot oceanographic-meteorological station (Pasaia (AZTI)) was set up in August 2001 in front of the entrance to the harbour of Pasaia (Figure 1).

Consequently, a detailed analysis of the long-term data sets is required, in order to separate the observed currents into physical process components, each with specific time-scales of variability, such as high-frequency currents, tidal currents, wind-induced currents and seasonal flow.

Methods

The study area is located in the innermost part of the Bay of Biscay (Basque coast) between the west-east oriented coast of Spain and the north-south oriented coast of France (Figure 1). The Basque continental shelf, located within the eastern section of the northern Iberian Peninsula shelf, is the most complex of the three shelves bordering the Bay of Biscay (Armorican, Aquitaine and Northern Iberian Peninsula shelf). The Basque shelf is characterised by its narrowness. It ranges from 7 to 20 km; this can be compared to the neighbouring shelf of Aquitaine, which ranges from 60 to over 200 km (Pascual *et al*., 2004).

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The description of the oceanic circulation within the coastal section between San Sebastián and Hondarribia requires the analysis of available data; these data, to undertake this objective, can be summarised as follows. During 2000 and 2001 and at the beginning of the year 2002, several current meters were deployed at 25, 50 and 100 m water depth, along two transects, one offshore of San Sebastian and another one offshore of Cape Higuer (Figure 1). In addition, the oceanographic-meteorological station in Pasaia Harbour (Figure 1), features the following meteorological sensors: wind, atmospheric pressure and air temperature, since August 2001. The oceanographic information is provided by an ADCP, which carries out measurements of the speed and direction of currents at 6 layers within the water column. It incorporates also a tide gauge, together with a set of thermistors (from the surface, to a depth of 25 m) (www.azti.es; http//www.euskalmet.net). Ports of States (Spanish Ministry of Environment) have supplied meteorological data, corresponding to the meteorological station of Pasaia (Pasaia (Puertos) (www.puertos.es).

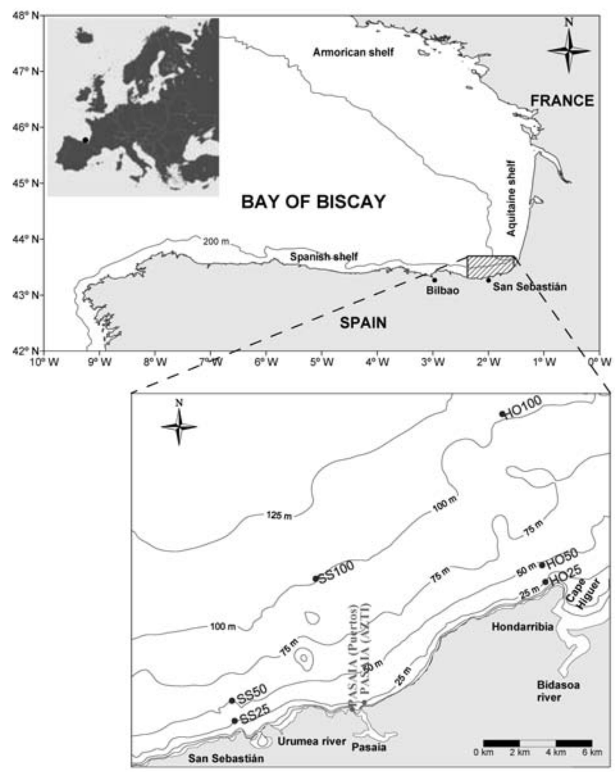

Figure 1 Map showing the location of the study area (shaded rectangle) and the location of the current meter moorings (blue circles) and meteorological stations (red circles).

All raw data were first de-spiked and when necessary, re-sampled to hourly values. The first step in the separation of the total current into specific process components was to remove tidal currents from the hourly data using harmonic analysis. The residual current was generated by subtracting the reconstructed tidal series, from the original signal. The next step was to perform coherence analysis in order to determine the wind-driven currents. The determined wind-induced currents were subtracted from the subtidal signal. Subsequently, the remaining high-frequency energy was removed; this was accomplished by applying a high-pass filter over the residual signal. Finally, the residual signal was reduced into low-frequency or seasonal band.

Results and Discussion

With regard to the meteorological conditions at the study area, significant differences in wind directions are observed between coastal locations. The southerlies are dominant to a great extent at the Pasaia (AZTI) station; whilst, the Pasaia (Puertos) station is dominated by southerlies and northerlies. The distribution of winds is very different from season to season. The seasonal wind regime is in agreement with Medina (1974) and Usabiaga *et al*. (2004), who noted that the dominant winds are from the south in winter and autumn, whereas northerly winds are the most frequent direction in spring and summer. However, at the Pasaia (AZTI) station, southerlies are dominant during all the year. This more homogeneous wind field at the Pasaia (AZTI) station is related to the enhancement of land breezes, due to their channelling along the Pasaia Bay.

In general, the contribution of the wind to the current fluctuations occurs over a wide range of frequencies beginning with semi-diurnal and diurnal land-sea breezes as well as inertial oscillations, to periods of several days representing the passage of cyclones/anticyclones, to lower frequencies near fortnightly periods representing changes in the prevailing weather together with seasonal oscillations. The eastward current component responds instantaneously to the wind action at all water depths; whilst, the northward current component responds instantaneously to the wind action, to a lesser extent.

Tidal currents at the study area have a small contribution to the overall current energy. This is in agreement with Le Cann (1990), Álvarez *et al*. (1998) and González *et al*. (2004). The strength of the tidal currents is proportional to the width of the continental shelf. Consequently, the tidal currents are very weak in the southern part of the Bay of Biscay (south of 45°N) (Koutsikopoulos and Le Cann, 1996) and stronger over the northwestern Armorican shelf (Le Cann, 1990). In general, the contributing of northward tidal currents is more important than the eastward tidal flows. This is because the northward wind fluctuations of the land-sea breeze interfere with the northward tidal currents at the diurnal and semi-diurnal frequency bands. However, it is difficult to separate out the semi-diurnal and diurnal tides from the land-sea breeze currents at the coastal areas.

In general, at the southeastern Bay of Biscay, a little percentage of the variance in total currents is contained in frequencies of tidal origin and the rest is spread over a broad energy band, which is mainly related to wind forcing.

Acknowledgements

This work was carried out with the financial support from the Department of Sustainable Development (Diputación Foral de Gipuzkoa, Spain), within the framework of the project entitled “Estudio de la dinámica marina y del medio físico de la costa comprendida entre Donostia-San Sebastián y Baiona”; this was an extensive monitoring project into marine dynamics (González et al., 2002). In addition, this study was partially funded by the Departmet of Transport and Public Works (DMC); the Department of Education, Universities and Research; and the Department of Industry of the Basque Government. The meteorological data have been obtained from the Pasaia Station (Ports of States, Spanish Ministry of Environment, www.puertos.es). We are very grateful to the sampling staff of the Marine Research Division (AZTI-Tecnalia), for the high quality of the work performed.

References

Álvarez, E., B. Pérez, J.C. Carretero and I. Rodríguez, 1998. Tide and surge dynamics along the Iberian Atlantic coast. *Oceanologica Acta*, 21(2): 131-143.

Fontán, A., J. Mader, M. González, Ad. Uriarte, P. Gyssels and M. B. Collins, 2006. Marine hydrodynamics between San Sebastián and Hondarribia (Guipúzcoa, Northern Spain): field measurements and numerical modelling. *Scientia Marin*a, 70 (Suppl. 1): 51-63.

González, M., P. Gyssels, J. Mader, A. Fontán, A. Del Campo and A. Uriarte, 2002. Estudio de la dinámica marina y del medio físico de la costa comprendida entre Donostia-San Sebastián y Baiona. Diputación Foral de Guipúzcoa. Unpublished Report.

González, M., Ad. Uriarte, A. Fontán, J. Mader and P. Gyssels (2004), Marine dynamics. In: Borja, A. and Collins, M. (Eds.). *Oceanography and Marine Environment of the Basque Country*, Elsevier Oceanography Series, 70: 133-157, Elsevier, Amsterdam.

Ibáñez, M., 1979. Hydrological studies and surface currents in the coastal area of the Bay of Biscay. *Lurralde*, 2: 37-75.

Iribar, X. and M. Ibáñez, 1979. Subdivisión de la zona intermareal de San Sebastián en función de los datos obtenidos con mareógrafo. In: Acta 1º Simposio Ibérico de Estudio del Bentos Marino, San Sebastián, 2: 521-524.

Koutsikopoulos, C and Le Cann, B., 1996. Physical processes and hydrological structures related to the Bay of Biscay anchovy. *Scientia Marina*, 60 (Suppl. 2): 9-19.

Le Cann, B., 1990. Barotropic tidal dynamics of the Bay of Biscay shelf: observations, numerical modelling and physical interpretation. Continental Shelf Research, 10 (8): 723-758.

Medina, M., 1974. La mar y el tiempo. Meteorología náutica para aficionados, navegación deportiva y pescadores. Editorial Juventud, 160 pp.

Pascual, A., A. Cearreta, J. Rodríguez-Lázaro and Ad. Uriarte (2004), Geology and Palaeoceanography. In: Borja, A. and Collins, M. (Eds.). *Oceanography and Marine Environment of the Basque Country*, Elsevier Oceanography Series, 70: 53-73, Elsevier, Amsterdam.

Usabiaga, J. I., J. Sáenz, V. Valencia and Á. Borja (2004), Climate and Meteorology: variability and its influence on the Ocean. In: Borja, A. and Collins, M. (Eds.). Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series 70: 75-95, Elsevier, Amsterdam.

Sedimentation patterns by river plumes in the southern margin of the Bay of Biscay: modelling and observations

Manuel González*[a], Ángel Borja[a], Luis Ferrer[a], Jean-Marie Jouanneau[b], and Olivier Weber[b]

Introduction

Rivers are important sources to the sea of terrestrial sediments. The river mouth and its immediate vicinity are the locations where the effluent first mixes, decelerates, and deposits the sediment load with a higher grain size. The injection of fluvial sediments by rivers into the coastal and offshore areas can be easily identified with satellite or aerial images by the plumes of suspended sediment near the river mouths. Sediment concentration distributions in the water column and at the bottom are highly variable off the river mouths. This depends on the behaviour of the plumes, whose dynamics are function of the mixing processes within the coastal sea, the strength of the discharge, the circulation, and wind and tide regimes (Arnoux-Chiavassa *et al.*, 1999). The expansion, contraction, and longshore orientation of surface plumes are often influenced by winds, waves and tides (Liu *et al.*, 1999; Stumpf *et al.*, 1993).

The river-mouth diffusion and sediment dispersion patterns are determined by three primary forces: (1) the inertia of outflowing river water and its associated turbulent diffusion; (2) the friction between the effluent and the seabed immediately seaward of the mouth; and (3) the buoyancy due to the density contrast between the outflow and the ambient coastal water (Wright, 1985). Farther out to the sea, the Coriolis force tends to deflect the river plume and associated effluent anticyclonically as viewed in the seaward direction.

Sediment loads affect the plume pathway and the final sedimentation patterns. Clear river plumes are always buoyant with respect to the receiving seawater, while in plumes loaded with suspended sediments the buoyancy are more complex. In these cases, the density of the freshwater-sediment mixture can be higher than the seawater, and the plume which enters the sea is initially hyperpycnal (negatively buoyant), becoming hypopycnal (buoyant) in the far field after the excess suspended sediment is released to the bottom (Chao, 1998). The extension of sediments in the Basque continental shelf has been studied in other contribution presented to this Symposium (Jouanneau *et al.,* this issue).

In this contribution, a Lagrangian Particle Tracking Model (LPTM), coupled to the Regional Ocean Modeling System (ROMS), is used to simulate the behaviour of river plumes in the southern margin of the Bay of Biscay (Basque Country area), in order to further understand their effects on material dispersion and sedimentation patterns over that area.

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Methods

The model used to obtain the hydrodynamics in the Basque Country area is ROMS (Regional Ocean Modeling System). ROMS is an evolution of the S-coordinate Rutgers University Model (SCRUM) described by Song and Haidvogel (1994). The numerical aspects of the ROMS model are described in detail by Shchepetkin and McWilliams (2005). ROMS model in the southern margin of the Bay of Biscay is used with a mean horizontal resolution of 2.2 km. Vertically, the water column is divided in 32 sigma coordinate levels, concentrated at the surface where most of the variability occurs, and in order to keep a good resolution of the sea surface processes. The model provides hydrodynamic information for the LPTM, using forcing and climatological data sets.

The surface atmospheric forcing has information about winds and air temperature at 10 and 2 m height above sea level, respectively, precipitation rate, relative humidity, and long and short wave radiation fluxes. These variables permit the air-sea heat and momentum fluxes calculation. For the tidal forcing, data from the OSU TOPEX/Poseidon Global Inverse Solution version 5.0 (TPXO.5) are used. Freshwater discharges of the main rivers, such as Adour (in France), Nervión, Oria, Deba, Urola, and Urumea (in the Basque Country), are incorporated into the model simulations. These data are provided by the French National Database for Hydrometry and Hydrology (HYDRO) and the Provincial Councils of Bizkaia and Gipuzkoa.

The conditions used on open boundaries are a combination of outward advection and radiation and flow-adaptive nudging towards prescribed external conditions, provided by the climatological data sets. This information is used for the initialization of variables within the model simulation. In order to simulate the freshwater movements and identify their origin, particles are released at the main river mouths and disperse, at a moderate computational cost, by a LPTM. Current fields computed on the ROMS grid are used by the LPTM to estimate the particle velocities. This model uses random turbulent velocity terms to parameterise unresolved subgrid-scale phenomena both along the horizontal and vertical axis. The method used for the particle movement is based on the 4th order Runge-Kutta scheme.

Results and discussion

Freshwater discharges from the rivers Adour, Nervión, and Oria, from 1st March to 6th April 2007 are shown in Figure 1. The analysis of these data shows that there were noticeable discharge peaks by the Spanish rivers on 8th March (maximum outflow at

Oria river, around 308 $m^3 \cdot s^{-1}$) and 24th March (maximum value of 372 $m^3 \cdot s^{-1}$ at Nervión river), with an increase of the mean freshwater runoff during the period between 20th March and 6th April. Rivers located at the Gipuzkoa region (Deba, Urola and Urumea) presented the same pattern than Oria river, but with a lower order of magnitude. For the case of the Adour river, the discharge behaviour was similar, but the highest peak occurred on 2nd April, with a value of 372 $m^3 \cdot s^{-1}$.

Figure 2 shows the fine silt and clay concentration on the sediment obtained from field measurements carried out for the Basque Country region. The maximum concentrations are located between the Urola river and the western area of the Urumea river. Concentrations on the sediment, for several grain sizes, are in good agreement with the results from the simulations performed with the LPTM, fed by the hydrodynamic information obtained with ROMS. The results show that the coastal jet and the grain-size composition of the river discharges play fundamental roles in the final sedimentation patterns, especially in extreme events such as the two observed during March 2007.

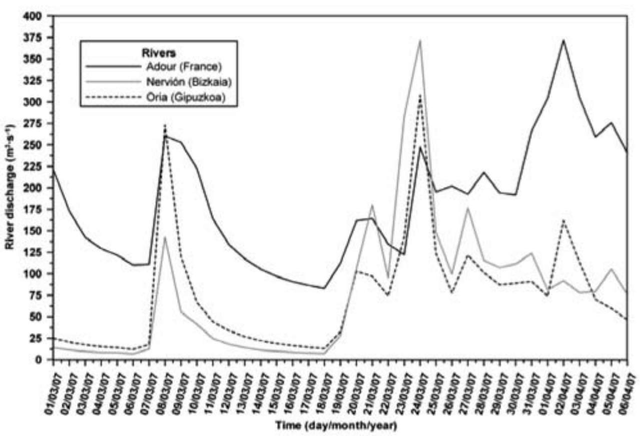

Figure 1. Daily freshwater discharges at the river mouths of Adour (France), Nervión (Bizkaia) and Oria (Gipuzkoa), from 1st March to 6th April 2007.

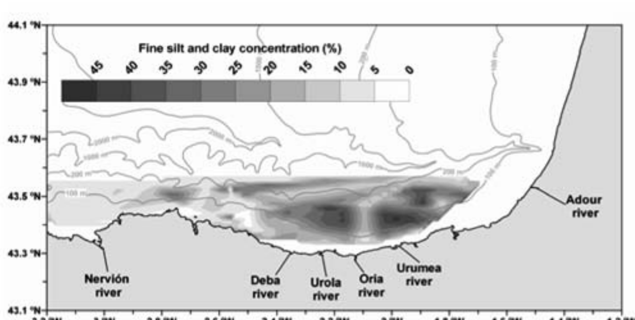

Figure 2. Fine silt and clay concentration (%) on the sediment for the Basque Country region, obtained from field measurements.

Conclusions

A Lagrangian Particle Tracking Model (LPTM) is used to examine the plume dynamics of river effluents and their associated sedimentation patterns in the southern margin of the Bay of Biscay. This model, driven by 3D current fields obtained by the Regional Ocean Modeling System (ROMS), demonstrates the suitability to explain the sedimentation patterns obtained with field measurements, especially in extreme events. The results show that dispersions of river plumes are determined by the buoyancy of the effluent, tides, and the wind field in the upper part of the water column. The coastal jet related to the plumes and the grain-size composition of the river effluents influence the dispersions of material offshore and the final sedimentation patterns.

Acknowledgements

This work has been carried out with financial support from different sources of the Basque Government (*Eusko-Jaurlaritza*): Dpto. Industria, Comercio y Turismo (Etortek); Dpto. Transportes y Obras Públicas; Dpto. Agricultura, Pesca y Alimentación; Dpto. Medio Ambiente y Ordenación del Territorio; and Dpto. Educación, Universidades e Investigación (PI-2003-17).

References

Arnoux-Chiavassa, S., V. Rey, F. Fraunie, 1999. Modeling of suspended sediments off the Rhone River mouth, *J. Coast. Res.*, 15: 61-73.

Chao, S.-Y., 1998. Hyperpycnal and buoyant plumes from a sediment-laden river, *J. Geophys. Res.*, 103: 3067-3081.

Liu, J.T., S.-Y. Chao, R.T. Hsu, 1999. The influence of suspended sediments on the plume of a small mountainous river, *J. Coast. Res.*, 15: 1002-1010.

Shchepetkin, A.F., J.C. McWilliams, 2005. The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model, *Ocean Model.*, 9: 347-404.

Song, Y.T., D.B. Haidvogel, 1994. A semi-implicit ocean circulation model using a generalized topography following coordinate system, *J. Comp. Phys.*, 115: 228-244.

Stumpf, R.P., G. Gelfenbaum, J.R. Pennock, 1993. Wind and tidal forcing of a buoyant plume, Mobile Bay, Alabama, *Cont. Shelf Res.*, 13: 1281-1301.

Wright, L.D., 1985. River deltas, in: R.A. Davis (Editor), Coastal Sedimentary Environments, New York, Springer, 1-76.

Comparison of lagoon hydrodynamics using synthetic descriptors

Martin Plus[a], Jean-Yves Stanisière[b], Danièle Maurer[a] and Franck Dumas[c]

Introduction

The comprehension of any marine system functioning goes through the study of the hydrodynamics responsible for the transport and the dilution of its different constituents (biota, suspended sediments, nutrients, contaminants, etc.). At the present time, hydrodynamical models are able to simulate the water masses movements in open ocean as well as in coastal areas with a relatively high precision and fine resolution. Nevertheless, the very high complexity of natural systems renders sometimes arduous the comprehension of the general functionning at the whole lagoon scale, sine qua non condition for any inter-systems comparison. This is particularly true for coastal tidal flat areas with meandering coastline, strong bathymetric gradients and large tidal areas. These are probably some of the reasons that brought the researchers to develop tools and concepts that allow a more synoptical description of the hydrodynamics of a system, such as for example the tidal prism, the transit time, the residence time, the flushing time or the age of water masses (Bolin & Rohde, 1973, Zimmerman, 1976, Dronkers & Zimmerman, 1982, Takeoka, 1984, Oliveira and Baptista, 1997, Brooks et al., 1999, Delhez et al., 1999, Deleersnijder et al., 2001, Delhez and Deleersnijder, 2002, Monsen et al., 2002, Shen & Haas, 2004).

In this study, we propose to use the same hydrodynamical model and some the above mentioned derived mixing and transport proxies in order to understand and compare the physics that prevail in two coastal lagoons from the southern Bay of Biscay: the Marennes-Oléron and Arcachon Bays (Figure 1). Particular attention was paid to the forces that drive the hydrodynamics (tides, wind, etc.) in order to understand their respective importances.

Methods

The model MARS-2D is a bidimensional free surface hydrodynamical model, solving the classical Navier-Stokes equations under the Boussinesq and hydrostaticity assumptions, as well as the advection/dispersion equations for a passive constituent in the horizontal plan. Detailed description of the model can be found in Lazure & Jegou (1998). As a first step, model results were confronted to current measurements (ADCP), to water elevation gauges data as well as salinity measurements performed on both sites. Then, the common following calculations were performed. The tidal prism was investigated through the calculation of inwards and outwards water flows, oscillating volumes (OV) and propagation of the tide inside the two Bays. Secondly, the residual fluxes (RF) as an eulerian descriptor, was calculated over a tide period and computed for each mesh as the product of the speed current by the water depth at each time step. It allows to assess, in shallow areas, when water flow is close to be one-dimensional (for the channels and the intertidal zones), the residual water flow direction and the quantity of displaced water (Salomon and Breton, 1996). The water renewal of the lagoons was studied thanks to a commonly used descriptor, the flushing time or turnover time. The flushing time is defined as the time necessary for a significant portion of a water parcel to be replaced by water coming from outside the lagoon boundaries, i. e. from the Ocean or the rivers. Following Koutitonsky et al. (2004), at time t=0, a dissolved passive tracer was set to one all over the lagoon domains and to zero elsewhere. Then, no further introduction of tracer was allowed during the simulation of the tracer advection-dispersion. The time necessary for the tracer concentration to fall definitively below 37% (i.e. e-1) of initial concentration was recorded for all the meshes inside the lagoon (local flushing time, LFT). The mean concentration of the constituent over the whole lagoon domain was computed, and the time for it to be dropped below 37% of the initial concentration was recorded as the integrated flushing time (IFT)

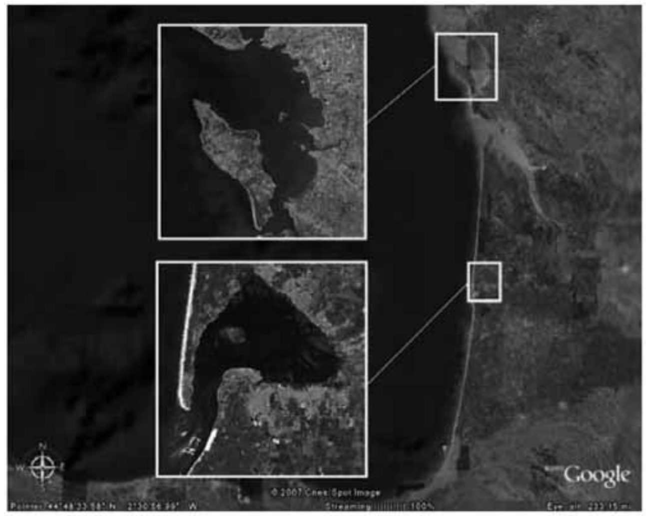

Figure 1 Map of the study area. Marennes Oléron (top) and Arcachon (bottom) lagoons.

Results and discussion

The use of an identical physical model on the two sites and the calculation of the same characteristic numbers allowed the description as well as the comparison of the two lagoon hydrodynamics.

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Despite some morphological related similitudes (surfaces, mean depths, intertidal surfaces, tidal regime and amplitude, OV:mean volume ratios, see Table 1), the two embayments exhibit different hydrodynamics.

Marennes-Oléron basin communicates with the ocean through two inlets located at its two extremities. The central narrowing implies a physical segmentation into two sub-basins with distinct functionnings. Towards the north, largely openned to the ocean, the tide appeared symmetrical while in the southern sub-basin, the tide is strongly asymmetrical. The residual circulation remains nevertheless always oriented towards the south, indicating a "channel-like" water circulation from north to south.

On the contrary Arcachon is a dead-end system with a sole communication with the open ocean. The tide plays like a "piston", pushing and sucking out periodically the waters in and outside the lagoon. The tide progresses on all the tide wave front without privileging any particular pathway, despite the complex channels network.

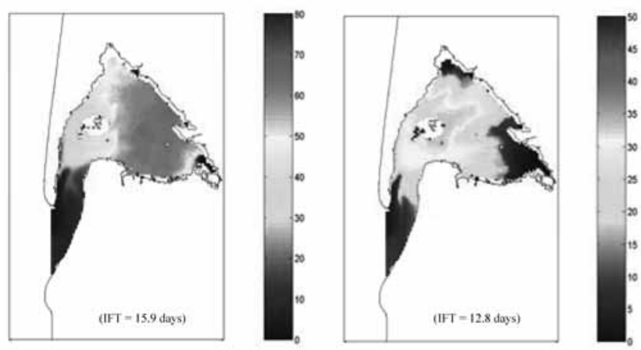

Figure 2 Calculated local flushing times (days) for the Arcachon lagoon during the summer (left) and a winter period (right). The integrated flushing times are reminded on each figure.

The water renewal appears logically faster in Marennes-Oléron than in Arcachon, with an IFT ranging 6 to 12 days for the former and 13 to 16 days for the latter (Figure 2). Impact of winds on flushing times was found important for both lagoons, and showing similar trends : northern and westerns winds favour the renewal whilst southern winds tend to confine the waters inside the lagoons. The freshwater inputs, even when representing small volumes in comparison with OV (as it is the case for Arcachon), seem to have a relatively strong impact on the flushing time, and specially for the innermost parts of the lagoon (Figure 2).

Table 1. Morphological general characteristics of Marennes Oléron and Arcachon lagoons.

	Arcachon	Marennes-Oléron
Surface (km^2)	174	187
Mean depth	4.6	3.6
Intertidal surface (km^2)	117 (67%)	102 (55%)
Cr Min -max tidal amplitude (m)	0.8-4.6	1.5-6.1
Mean volume (10^6 m^3)	616	804
Mean OV (10^6 m^3)	384 (62%)	602 (75%)
Communication with ocean	1	2
Freshwater inputs (10^6 m^3/year)	813	2200

Acknowledgements

This work was supported by the French National Program on Coastal Environment EC2CO-PNEC "Littoral Atlantique".

References

Bolin, B., Rohde, H., 1973. A note on the concepts of age distribution and transit time in natural reservoirs. Tellus 25: 58-62.

Brooks, D.A., Baca, M.W., Lo, Y.-T., 1999. Tidal circulation and residence time in a Macrotidal Estuary: Cobscook Bay, Maine. Estuarine, Coastal and Shelf Science 49: 647-665.Borja, A., V. Valencia, J. Franco, I. Muxika, J. Bald, M. J. Belzunce, O. Solaun, 2004b. The water framework directive: water alone, or in association with sediment and biota, in determining quality standards? Marine Pollution Bulletin, 49: 8-11.

Deleersnijder, E., Campin, J.-M., Delhez, E.J.M., 2001. The concept of age in marine modelling. I. Theory and preliminary results. Journal of Marine Systems 28: 229-267.

Delhez, E.J.M., Campin, J.-M., Hirst, A.C., Deleersnijder, E., 1999. Toward a general theory of the age in ocean modelling. Ocean Modelling 1: 17-27.

Delhez, E.J.M., Deleersnijder, E., 2002. The concept of age in marine modelling. II. Concentration distribution function in the English Channel and the North Sea. Journal of Marine Systems 31: 279-297.

Dronkers, J., Zimmerman, J.T.F., 1982. Some principles of mixing in tidal lagoons. Oceanologica Acta, Proceedings International Symposium on coastal lagoons, SCOR/IABO/UNESCO, Bordeaux, France, 8-14 September 1981, pp. 107-117.

Koutitonsky, V.G., Guyondet, T., St-Hilaire, A., Courtenay, S.C., Bohgen, A., 2004. Water renewal estimates for aquaculture developments in the Richibucto Estuary, Canada. Estuaries 27 (5): 839-850.

Lazure, P., Jegou, A.-M., 1998. 3D modelling of seasonal evolution of Loire and Gironde plumes on Biscay Bay continental shelf. Oceanologica Acta 21: 165-177.

Monsen, N.E., Cloern, J.E., Lucas, L.V., Monismith, S.G., 2002. A comment on the use of flushing time, residence time and age as transport time scales. Limnol. Oceanogr. 47: 1545-1553.

Oliveira, A., Baptista, A.M., 1997. Diagnostic modelling of residence times in estuaries. Water Resources Research 33: 1935-1946.

Salomon, J.-C., Breton, M., 1996. Arcachon. L'hydrodynamique par la modélisation mathématique. Ifremer report DEL/HS 12-96 (in French), 22 pp.Takeoka, H., 1984. Fundamental concepts of exchange and transport time scales in a coastal sea. Continental Shelf Research 3: 322-326.

Shen, J., Haas, L., 2004. Calculating age and residence time in the tidal York river using three-dimensional model experiments. Estuarine, Coastal and Shelf Science 61: 449-461.

Zimmerman, J.T.F., 1976. Mixing and flushing of tidal embayments in the Western Dutch Wadden Sea, Part I: distribution of salinity and calculation of mixing time scales. Netherlands Journal of Sea Research 10: 149-191.

A 3D numerical study of the water circulation in the corner of the Bay of Biscay

Arnel German[a], Manuel Maidana[a], Manuel Espino[a] and Jordi Blasco[b]

Introduction

The hydrodynamics of the corner of the Bay of Biscay (Fig.1) is studied by using a three dimensional finite element numerical model. The objective is to perform a numerical simulation of the wind stress and the horizontal density gradient induced current that occur in the domain of interest.

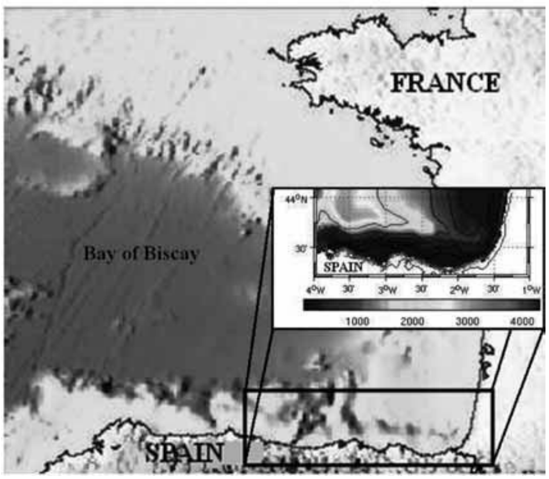

Figure 1 Location of the study area.

The numerical model used is named HELIKE (Maidana, 2007) and it has been developed to study the non-hydrostatic circulation in coastal regions. Its hydrodynamic formulation is based on the three components of the non-hydrostatic Navier-Stokes equation and it also takes into account the two components of the Coriolis acceleration (tangent and normal to the Earth's surface), density gradients, turbulence, bottom friction, surface wind stress and the free surface height. The use of finite element discretization and non-structured mesh allows the numerical model greater flexibility especially when dealing with complex geometry of the coastline and sea bed. It is also well-posed for domains with open contours. A pressure stabilization technique (Blasco and Codina, 2001) is employed to stabilize the finite element solution and a backward Euler implicit time stepping method is used to solve the non-hydrostatic Navier-Stokes equation which allows large time step and it avoids the stability constraint criteria. The kinematic equation is used to compute the free surface height.

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Hydrodynamic Model

A three-dimensional domain Ω is considered in order to study the dynamics of water in coastal regions. The motion of an incompressible fluid is governed by the three dimensional unsteady, incompressible Navier-Stokes equations expressed in a rotating coordinate system.

$$\frac{\partial \mathbf{u}}{\partial t}+(\mathbf{u}\cdot\nabla)\mathbf{u}+\mathbf{k}\times\mathbf{u}+\nabla P-\frac{\partial}{\partial x}\left(\nu_H\frac{\partial \mathbf{u}}{\partial x}\right)-\frac{\partial}{\partial y}\left(\nu_H\frac{\partial \mathbf{u}}{\partial y}\right)-\frac{\partial}{\partial z}\left(\nu_V\frac{\partial \mathbf{u}}{\partial z}\right)$$
$$=-\mathbf{g}\nabla_H\left[\int_z^\eta(\rho-\rho_0)/\rho_0 d\varsigma\right]-\mathbf{g}\nabla_H\eta \quad \text{in } \Omega\times(0,T) \qquad (1)$$

$$\nabla\cdot\mathbf{u}=0 \quad \text{in } \Omega\times(0,T) \qquad (2)$$

where u=(u,v,w) is the velocity of the fluid in the three axes and P=(x,y,z,t) is the fluid kinematic pressure which is defined as the pressure divided by the fluid density ρ_0. The unknowns **u** and P are functions of the spatial coordinates ($x,y,z,$)εΩ and time t ε $(0,T)$, with T>0 a given final time. The three-dimensional gradient operator is ∇=(∂/∂x,∂/∂y,∂/∂z)while k=(0,b,f), where f= 2ωsin(Φ) and b= 2ωcos(Φ) are the normal and tangential Coriolis parameters, respectively, ω is the Earth's angular velocity and (Φ) the latitude of the region of interest; ν_H and ν_V are the horizontal and vertical turbulent eddy viscosities, respectively; and **g** = (0,0,g), and g is the gravitational acceleration.

The evolution of the free-surface elevation η with respect to the reference level is given by the kinematic equation:

$$\frac{\partial \eta}{\partial t}+u\frac{\partial \eta}{\partial x}+v\frac{\partial \eta}{\partial y}=w \quad \text{in } S\times(0,T) \qquad (3)$$

where S represents the surface of the domain.

The continuity equation (2) was not integrated vertically along each column of the fluid and equation (3) was solved as it is without any further approximation.

In order to have a well-posed problem, boundary and initial conditions have been specified. Equation (1) is enforced weakly by multiplying it with test functions, then integrating on Ω and making use of Green's formula:

$$\int_\Omega \frac{\partial \mathbf{u}}{\partial t}\tilde{u}\,d\Omega+\int_\Omega(\mathbf{u}\cdot\nabla)\mathbf{u}\tilde{\mathbf{u}}\,d\Omega+\int_\Omega(\mathbf{k}\times\mathbf{u})\tilde{\mathbf{u}}\,d\Omega+\nabla P\tilde{\mathbf{u}}\,d\Omega \qquad (4)$$
$$+\int_\Omega\left(\nu_H\frac{\partial \mathbf{u}}{\partial x}\frac{\partial \tilde{\mathbf{u}}}{\partial x}+\nu_H\frac{\partial \mathbf{u}}{\partial y}\frac{\partial \tilde{\mathbf{u}}}{\partial y}+\nu_V\frac{\partial \mathbf{u}}{\partial z}\frac{\partial \tilde{\mathbf{u}}}{\partial z}\right)d\Omega$$
$$=-\mathbf{g}\int_\Omega\nabla_H\left[\int_z^\eta(\rho-\rho_0)/\rho_0 d\varsigma\right]\tilde{\mathbf{u}}\,d\Omega-\mathbf{g}\int_\Omega\nabla_H\eta\tilde{\mathbf{u}}\,d\Omega$$
$$+\int_{\Gamma_s}\left(\tau_s^x\tilde{u}+\tau_s^y\tilde{v}\right)d\Gamma_s+\int_{\Gamma_b}\left(\tau_b^x\tilde{u}+\tau_b^y\tilde{v}\right)d\Gamma_b+\int_{\Gamma_b}\mathbf{n}_v\nabla w\tilde{w}\,d\Gamma_b$$

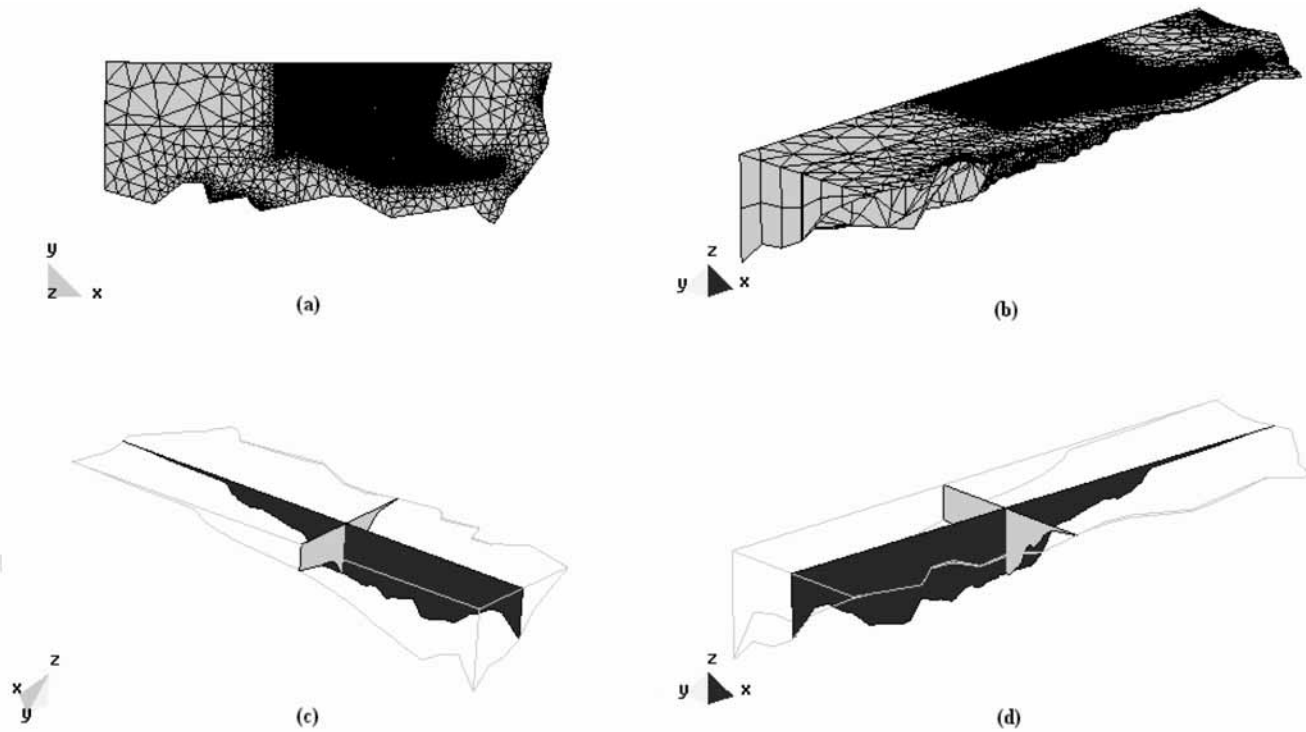

Figure 2 The part of the Bay of Biscay that serves as the area of study: (a). Computational mesh; (b) Isometric view of the computational mesh; (c) Rear cross section; (d) Front cross section

Equations (2) and (3) are also enforced weakly by multiplying it by the test functions q and μ, respectively, and integrating on Ω to yield:

$$\int_{\Omega} (\nabla \cdot \mathbf{u}) q d\Omega = 0 \tag{5}$$

$$\int_S \frac{\partial \eta}{\partial t} \mu d\Gamma + \int_S u \frac{\partial \eta}{\partial x} \mu d\Gamma + \int_S v \frac{\partial \eta}{\partial y} \mu d\Gamma = \int_S w \mu d\Gamma \tag{6}$$

Numerical mesh and first results

The corner of the Bay of Biscay is the subject of the case study wherein Helike was applied to simulate the current forcing by wind and horizontal density gradient. The domain considered is the lower portion of the Bay of Biscay bounded approximately by latitudes 43 to 44 N and longitudes 1 to 4 W.

Figure 2 shows the computational mesh used for the simulation. It has 19,635 nodes and 25,590 elements. The numerical results obtained show the applicability, accuracy and efficiency of the model in simulating coastal processes.

Acknowledgements

This document represents the extensive support and collaboration of many organizations and institutions. The authors wish to acknowledge AZTI-Tecnalia for providing the pertinent input data about the study area and the assistance given by CIMNE for the GID meshing tools.

This study was performed under MODEGG project frameworks funded by the Spanish Ministry of Science under grant number CTM2005-05410-C03-01/MAR.

References

Blasco, J., R. Codina, 2001. Space and time error estimates for a first order, pressure stabilized finite element method for the incompressible Navier-Stokes equations. *Applied Numerical Mathematics*, 38: 475-497.

Maidana, M. A., (2007). Desarollo de un modelo numérico 3D en elementos finitos para las ecuaciones de Navier-Stokes. Aplicaciones oceanográficas. *Doctoral Thesis, Universidad Politécnica de Catalunya.*

A Hybrid Funwave-SPHysics Model for dangerous events on Galician coast generated by large waves

Crespo, A.J.C.,*[a] Gómez-Gesteira, M.[a] and Dalrymple, R.A.[b]

The periodic passage of storm near Iberian Peninsula gives rise to dangerous waves on the shore line during winter time. The study of these events cannot be analyzed by means of a single model due to the presence of multiple scales both in time and in space. The present study considers the use of different models to generate and propagate the wave field from the open sea to the coastal region. In particular, the interaction between high waves and coastal structures is considered.

Introduction

The Continental Atlantic Margin of the Iberian Peninsula suffers the effect of strong waves due to storms. In particular, the situation lived at certain areas of the Atlantic and Cantabrian coast has been especially dangerous during the winter of 2005, with persistent northern winds and waves of 9 and 10 meters. Thus, some coastal protection elements were overflowed by waves and part of the fleet was forced to remain tied to port.

Surface waves can be approached in open sea by means of models in which a series of simplifications have been considered. However, when the waves come near the coastline or when they flood areas previously dry, the interaction of the wave with the local topology and man-made structures makes the flow three-dimensional. The simulation of this type of flows is an arduous task, which can be attacked only by means of a high computational cost, especially in time. So this type of phenomena can not be studied in real time, at least with the present technology, about the imminent arrival of this type of event. In particular, it is necessary to highlight the appearance of breaking processes observed in areas with important variations of the bathymetry, as well as the processes of reconstruction of the flow after the interaction between a wave and the vicinities of an obstacle, either surrounding or surpassing it.

The aim of present study will to show how the whole evolution of a wave field, from the generation in open sea to the arrival at the coast, can be analyzed by coupling different numerical models.

The method

A variety of oceanography models using different numerical and physical approaches have been developed to handle wave propagation and different types of wave transformations as refraction, diffraction, breaking, runup and overtopping. Recently, research is focused on coupling models with different numerical and mathematical approaches (Nie et al. (2004) and Sitanggang et al. (2006)). These models have several advantages and limitations, but the primary goal of such an approach is to combine the advantages of the individual models in a single model, thus increasing the accuracy, efficiency and regime of validity.

A hybrid method is developed starting from two existing wave propagation models. The model couples the finite difference Boussinesq FUNWAVE (Wei et al. (1995)) to SPHysics (http://wiki.manchester.ac.uk/sphysics), a Smoothed Particle Hydrodynamics (SPH) model.

Fully nonlinear extensions of Boussinesq equations are derived to simulate surface wave from deep water with accuracy and with satisfactory results both in the open ocean and in near shore areas but they do not provide information about the possibility of flooding in coastal areas. So a 2D version of SPHysics model is considered to analyze the nature of coastal structures overtopping since SPH has been used for wave impact studies on offshore structures (Gomez-Gesteira and Dalrymple, 2004; Gómez-Gesteira *et al*., 2005; Crespo *et al.*,2007) showing good agreement between numerical and experimental results.

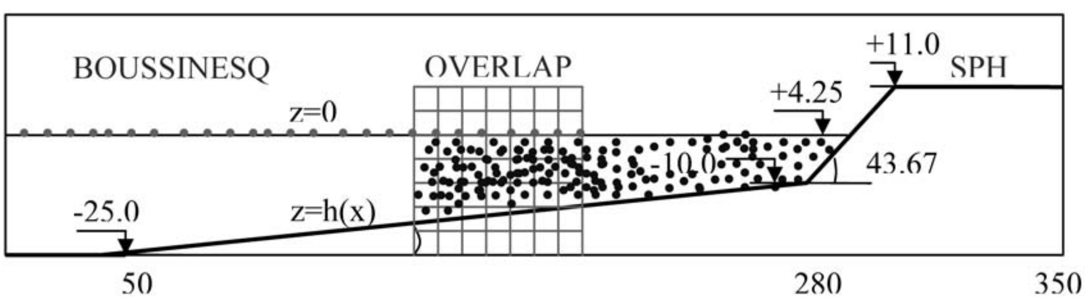

Figure 1.: Numerical tank

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This hybrid approach employs FUNWAVE for wave propagation in the offshore region and uses SPHysics to handle wave breaking, runup and overtopping in the domain close to coastal structures. The numerical tank and a scheme of the domain is shown in Figure 1.

Here the model will be applied to a geometry that mimics a dock. This case, although is still simplified compared to extremely complex coastal structures, was designed with dimensions close to the real ones (bed and dock are similar to the typical ones in the Galician region in Spain) proving the capability of the model to deal with more realistic problems. Valuable information about overtopping (maximum water height and water velocity) is provided.

The dimensions and slope of the dock were taken from real coastal structures at the Galician coast. The bed shows a constant slope (3.73º) till the base of the coastal structure, this chosen bottom slope was estimated by the admiralty charts of the coast. It corresponds to areas over sandy beds, where the depth decreases progressively landward.

Hybrid model provides significantly improved predictions of wave heights, velocities, breaking points and overtopping information.

Results

Wave propagation at open sea and near shore area is a well known process (see references above), so we will only show here images from the last step of the method (SPH modeling). The initial condition for this step is the output of the previous ones.

Testcase: Starting from setup represented in Fig. 1, overtopping was analyzed using the hybrid model. One instant of the water overtopping can be observed in Figure 2. At t= 46.3 s water overtops the dock, the first frame corresponds to the position of the particles and the second one to the velocities.

Velocities were calculated at different instants during the overtopping at the front of the deck (X=302 m) and at different heights. Maximum velocities close to 10 ms^{-1} were observed at the first level (Z=11.6 m) at t=46.0 s.

References

Crespo, A. J. C., Gómez-Gesteira, M. And Dalrymple, R.A. (2007). 3D SPH Simulation of large waves mitigation with a dike. Journal of Hydraulic Research 45(5), 631-642

Gómez-Gesteira, M. And Dalrymple, R.A. (2004). Using A 3d Sph Method For Wave Impact On A Tall Structure. Journal Of Waterway, Port, Coastal And Ocean Engineering 130(2), 63- 69.

Gómez- Gesteira, M., Cerqueiro, D., Crespo, C. And Dalrymple, R.A. (2005). Green Water Overtopping Analyzed With A Sph Model. Ocean Engineering 32, 223- 238.

Nie, X. B., Chen, S. Y., E, W. N., and Robbins, M. O. (2004). A Continuum and Molecular Dynamics Hybrid Method for Micro- and Nano- Fluid Flow. Journal of Fluid Mechanics, 500, 55–64.

Sitanggang, K. I., Lynett, P. J., and Liu, P. L.-F. (2006). Development of a Boussinesq – RANS VOF Hybrid Wave Model. In J. M. Smith, editor, Proceedings of the International Conference Coastal Engineering 2006, volume 1, pages 24–35.

Wei, G., Kirby, J. T., Grilli, S. T., and Subramanya, R. (1995). A Fully Nonlinear Boussinesq Model for Surface Waves. Journal of Fluid Mechanics, 294, 71–92.

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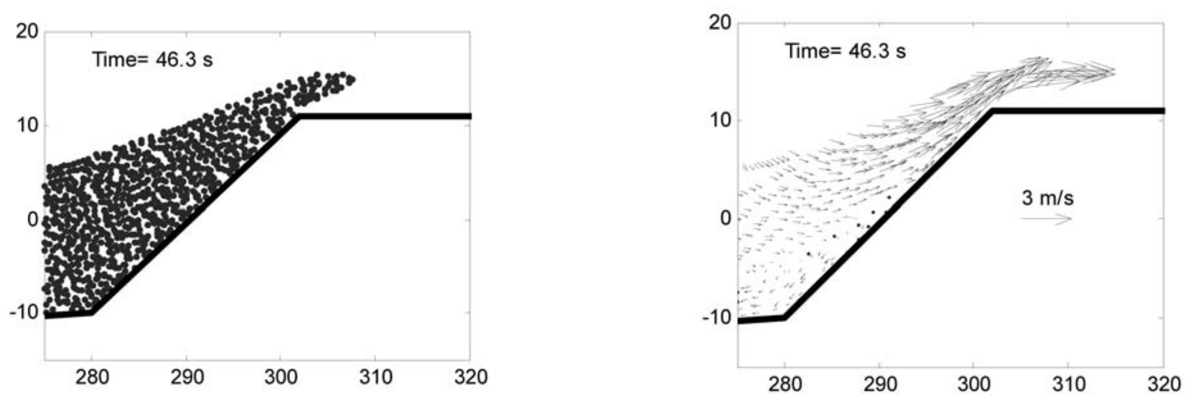

Figure 2: Interaction between an extreme wave and a dock

Short-lived radioisotopes (^{234}Th, ^{7}Be, ^{210}Pb) as tracers for particle transport in the Gironde fluvial-estuarine system (France)

Hanna-Kaisa Saari,*[a] Sabine Schmidt[a], Patrice Castaing[a], Benoit Sautour[a] and Gerard Blanc[a]

Introduction

On the continental shelf of the Bay of Biscay, estuaries are the main source of fine sediments (Castaing et Allen, 1981). The Gironde Estuary (South-west France) (Fig. 1) was estimated to contribute to 60% of this input (Jouanneau et al, 1999). Such a sediment linkage between river catchment and the ocean could be also important from a quality perspective. Although this system drains one of less urbanized/industrialized watersheds in Europe, it is polluted by heavy metals (e.g. Cd, Zn, Cu, Pb, Hg) (Schäfer et al., 2006; and references herein), forbidden the oyster and mussel production within the estuary. This pollution is due to former mining and ore treatment activities since the late 19th century in the upper reaches of a tributary (Lot River) (Fig.1), having a strong effect on estuarine and coastal systems.

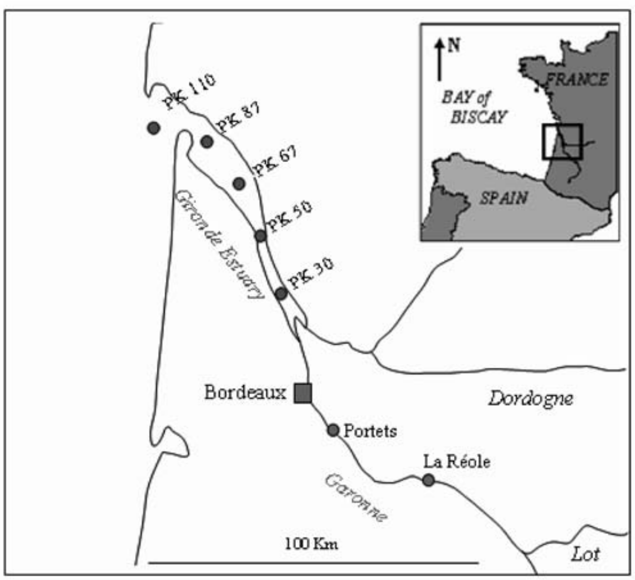

Figure 1 The location map of the Gironde fluvial-estuarine system showing the main rivers and the sampling sites (PK= point kilometre from Bordeaux city).

Such context justifies the growing interest in understanding the mechanisms controlling the transport of sediments and associated contaminants along the Gironde fluvial-estuarine system. Many chemically reactive contaminants are associated with particles, as are the naturally-occurring radioisotopes ^{234}Th, ^{7}Be and ^{210}Pb. These radioisotopes of different half-lives and origins are potential tracers for short-term particle transport from land to sea.

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In this study, we report the results of ^{234}Th, ^{7}Be and ^{210}Pb activities in suspended particle matter (SPM) collected in the Gironde Estuary in 2006-2007. The objective is to estimate ages of suspended sediment and to improve the knowledge of time scales associated in transport processes of sediment to coastal sea.

Radioisotopes as tracers for particle transport

Both ^{7}Be (half-life = 53.3 days) and ^{210}Pb (half-life=22.3 years) are delivered continuously to the landscape by atmospheric fallout where they become strongly bound to particulate matter. Thus, the activities of ^{7}Be and ^{210}Pb in suspended sediments are a measure of the time since the particles were tagged. The ^{7}Be/^{210}Pb$_{xs}$ activity ratio (AR), expected to be much less variable than either isotope individually, can be used as an indicator of the age of SPM or of the fraction of "new" sediments (Matisoff et al., 2005). Decreases of this ratio in SPM can be caused by two factors: - time, since ^{7}Be decays faster than ^{210}Pb$_{xs}$ or - dilution with resuspended ^{7}Be-deficient sediments.

^{234}Th (half-life = 24.1 days) is continuously produced *in situ* by ^{238}U, and is efficiently removed from the dissolved phase onto particles in aqueous systems. ^{238}U presents stable and significant activities in the Garonne and behaves conservatively in the Gironde Estuary (Saari et al., in press); thus the distribution of ^{234}Th can be used to estimate particle residence times.

Study area and methods

The Gironde Estuary is the largest fluvial-estuarine system (71,000 km^{2}) which drains to the Bay of Biscay. It is a partially mixed to well-mixed macrotidal estuary with tidal amplitudes from 1.5 to 5.5 m. This estuary is marked for its maximum turbidity zone (MTZ) with SPM concentrations in surface water higher than 1 g l^{-1} (Castaing, 1981), which results from tidal wave progression. In the Garonne River the upstream limit of the dynamic tidal zone is at La Réole.

One site (La Réole) in the Garonne River and four sites (PK30, PK50, PK67, PK87) in the estuary were sampled monthly in 2006-2007 (Fig. 1). Additionally, Portets site in the Garonne River and PK 110 site at the mouth of the estuary were sampled occasionally in 2007. Immediately after sampling, SPM were separated from river samples by centrifugation and from estuarine samples by decantation or filtration (Millipore membrane: diameter 142 mm, 0.45 µm pore size). The dried SPM were measured using a low background-high efficiency well type γ-counter to determine the activities of ^{234}Th, ^{210}Pb, ^{7}Be and ^{226}Ra. ^{238}U was measured on selected particles by α-counting after radiochemistry. Excess ^{234}Th (^{234}Th$_{xs}$) and ^{210}Pb (^{210}Pb$_{xs}$)

were calculated by subtracting the activity supported by their respective parent isotope, ^{238}U and ^{226}Ra, from the total activity in particle. ^{234}Th and ^{7}Be values were corrected for radioactive decay that occurred between sample collection and counting

Results and discussion

$^{234}Th_{xs}$ activities show large spatio-temporal variations, from negligible values up to about 600 mBq g^{-1}. The highest levels and variations are observed in the downstream estuary where the change of ocean and fluvial waters is the largest. In the upstream estuary the variations of $^{234}Th_{xs}$ are linked to the ones of fluvial discharge. These changes could be ascribed to differences of particle residence times in the river channels and in the estuary.

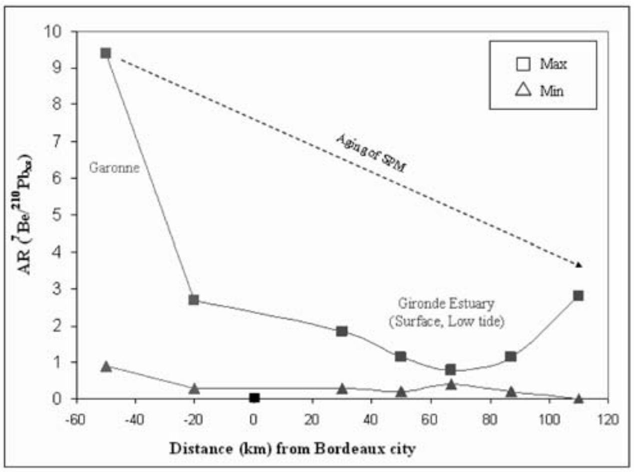

Figure 2. Range of particulate $^{7}Be/^{210}Pb_{xs}$ AR (max-min) observed in 2006-2007 at the different sites of the Garonne – Estuary continuum.

The $^{7}Be/^{210}Pb_{xs}$ AR decreases from upstream to downstream and varies significantly at each site (Fig. 2). These variations depend on the flow rate. In the estuary the maximum low tide AR values are observed during the high fluvial discharge periods (up to 5000 m^{3} s^{-1}). During such events, particle transport is fast: the MTZ is dispersed and the old sediments are transported out of the estuary. During low fluvial discharge periods (100-200 m^{3} s^{-1}) low tide AR are usually low: particle transport is slower and the MTZ rises from the middle estuary to the upstream. Its influence is well marked in the decreasing values of AR in the upstream estuary until to the Portets site. During these periods the AR is occasionally higher for downstream sites probably due to faster transport of SPM in surface layers from the rivers through the estuary or due to marine inputs. Whatever the sampling period, sediment retention is always observed but in different parts of the estuary, depending on the position of the MTZ.

On a tidal cycle time scale, short-lived radioisotopes exhibit also large variations in activities, as illustrated by the situation sampled in November 2006 during weak fluvial discharge (350 m^{3} s^{-1}) (Fig. 3). In this example, $^{7}Be/^{210}Pb_{xs}$ AR of SPM are rather low and almost constant in surface and bottom samples of site PK 30. Thereafter, there is a gradual increase in the AR downstream toward PK87 (Fig. 3). During this tidal cycle, the MTZ is located in the upstream area, associated with particles of low AR and therefore old particles. The increase amplitude of AR in the downstream sites results from different processes: the oscillation of MTZ during the tidal cycle, a fast surface sediment transport and marine inputs.

Aging of particles, derived from $^{7}Be/^{210}Pb_{xs}$, ranges from few days to several weeks depending of flow discharge and season. Such constraints on timescales associated with particle transfer would help to better understand the processes and mechanisms that control the fate of particle associated contaminants in the Gironde estuary.

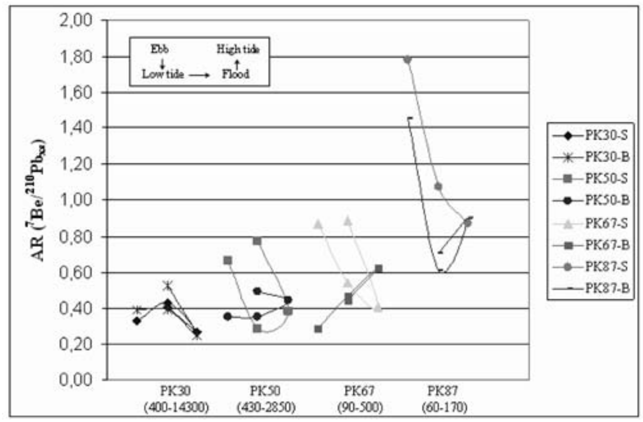

Figure 3. Evolution of $^{7}Be/^{210}Pb_{xs}$ AR in surface (S) and bottom (B) particles collected at the main sites of the Gironde estuary during a tidal cycle in November 2006. The associated variation of SPM (mg l^{-1}) is reported below each site labels.

Acknowledgements

This work was supported by the ACI ARTTE, SOMLIT and SOLAQUI programs. We thanks Georges Oggian, Hervé Derriennic and the equip GEMA for their contribution to field work.

References

Abril, G., Nogueira, M., Etcheber, H., Cabeçadas, G., Lemaire, E., Brogueira, M.J., 2002. Behaviour of organic carbon in nine contrasting European estuaries. *Estuarine, Coastal and Shelf Science,* 54: 241-262.

Castaing, P., Allen, G.P., 1981. Mechanisms controlling seaward escape of suspended sediment from the Gironde: a macrotidal estuary in France. *Marine Geology*, 40: 101-118.

Jouanneau, J.M., Weber, O., Cremer, M., Castaing, P., 1999. Fine-grained sediment budget on the continental margin of the Bay of Biscay. *Deep-Sea Research II*, 46: 2205-2220.

Matisoff, G., Wilson, C.G. and Whiting, P.J., 2005. The $^{7}Be/^{210}Pb_{xs}$ ratio as an indicator of suspended sediment age or fraction new sediment in suspension. *Earth Surface Processes and Landforms,* 30(9): 1191-1201.

Saari, H.-K., Schmidt, S., Huguet, S., Lanoux, A., Spatiotemporal variation of dissolved ^{238}U in the Gironde fluvial-estuarine system (France). *Journal of Environmental radioactivity,* In press.

Schäfer, J., Blanc, G., Audry, S., Cossa, D., Bossy, C., 2006. Mercury in the Lot–Garonne River system (France): Sources, fluxes and anthropogenic component. *Applied Geochemistry,* 21: 515-527.

Dynamics of a moderate-energy rip current over a Transverse Bar and Rip morphology: Biscarrosse 2007 field experiment (Aquitanian Coast, France)

Bruno Castelle*[a], Rafael Almar[a], Natalie Bonneton[a], Philippe Bonneton[a], Patrice Bretel[a], Stéphane Bujan[a], Nicolas Bruneau[a,b], Jean-Paul Parisot[a], Rodrigo Pedreros[b] and Nadia Sénéchal[a]

Introduction

Rip currents are narrow, intense and seaward-flowing currents that originate from the surf zone and broaden seaward of the breakers. Rip currents have received increasing attention during the last decade (MacMahan et al., 2006) as they shape the sandy shoreline (Thornton et al., 2007), play a key role in sandy beach dynamics (Wright and Short, 1984) and are a major hazard for swimmers (Luschine, 1991).

Rip currents are observed all along the double-barred sandy beaches of the French Aquitanian Coast (Castelle et al., 2007). Investigations on those rip currents have only been attempted recently on the inner bar system (Castelle et al., 2006; Castelle and Bonneton, 2006; Bonneton et al., 2006). Bonneton et al. (2006) showed that very low frequency pulsations of the circulation associated to the rip current are observed most of the time. Castelle et al.(2006) and Castelle and Bonneton (2006) showed that rip currents are strongly tidally modulated and are favoured by shore-normal long period waves. The study outcomes strongly suffer from the lack of measurements in the rip. To pave this knowledge gap, a five day field measurement has been undertaken at Biscarrosse beach over a well-developed Transverse Bar and Rip (TBR) morphology exposed to moderate energy shore-normal wave conditions.

Biscarrosse 2007 field experiment

Location and settings

Biscarrosse Beach is located on the French Aquitanian Coast a few kilometres southward of the Arcachon Lagoon inlet. This beach, representative of most of the Aquitanian Coast beaches, is a high energy beach, in a meso- macrotidal setting, where tidal currents are not significant in comparison with wave-induced currents. The beach is double-barred with the outer bar exhibiting persistent crescentic patterns and the inner bar exhibiting most of the time a TBR morphology

Instrument deployment

Instruments were deployed over a well developed TBR morphology. Only the sensors used in this study are shown on Fig. 1. Drifters were also used during the first day of the field experiment with superimposed trajectories shown on Fig. 1. The rip channel was narrow and a little down-longshore drift (southward) oriented. Directional offshore wave conditions were provided by an ADCP located in 9 m depth at low tide seaward of the field measurement area.

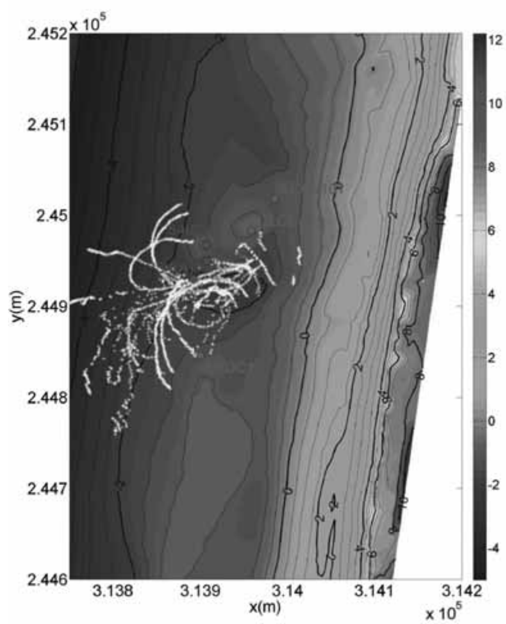

Figure 1 Location of the currentmeters deployed over the Transverse Bar and Rip morphology during the Biscarrosse 2007 field experiment. The S4 location changed 3 times during the campaign (A,B1,B2)

Results

During the experiment, Biscarrosse beach was exposed to two distinct wave events (Figure 2). The first one was characterized a long peak wave period (Tp≈10 s), shore normal wave with a significant wave height Hs ranging from 0.8 to 1 m with a very low energy SW wind sea. The second one was a relatively high energy wave and windy event with a high directional spreading. Therefore, the first event was chosen for this rip current study and was splitted in two parts A and B (Fig. 2).

During part A, drifters and the S4(A) (in red on Fig. 1) were deployed. During part B, most of the currentmeters were deployed (in green on Fig. 1). During the first tidal cycle of the experiment (part A on Fig. 2), the S4 was placed in the northern side of the channel where rip current velocities were the most intense. As shown on Fig. 1 all the drifter trajectories passed about above the S4 location. These trajectories also clearly show the two circulation cells associated with the rip current which appear as a pairing of opposite sign vortices. Some of these trajectories extend more than a hundred of meters from the rip neck and highlight how rip currents, even under low to moderate energy offshore wave conditions, can

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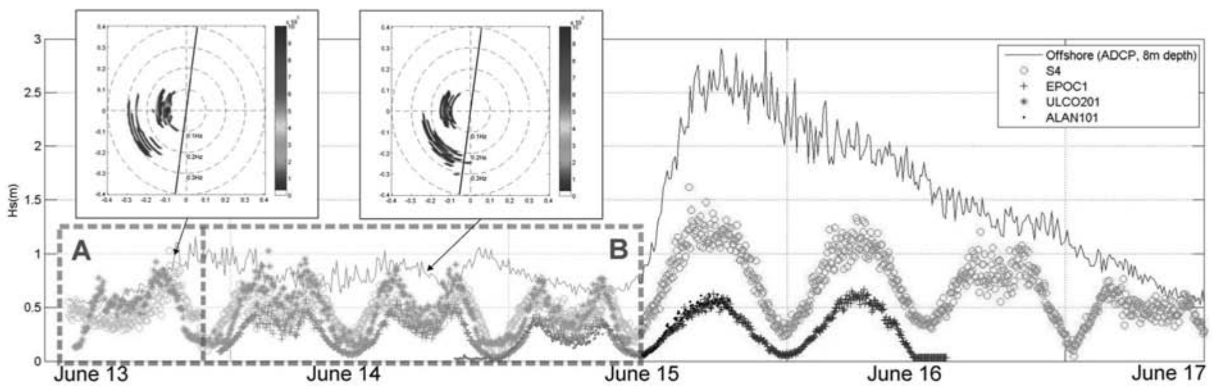

Figure 2 Time series of significant wave height (Hs) during Biscarosse 2007 field experiment, measured by the offshore ADCP, and at the sensor locations given in Fig. 1, with indication of the offshore directional spectrum shape and the 2 periods of interest (A and B) of this study.

quickly carry a swimmer offshore. The high velocities are even easier to assess on Fig. 3 which displays time series of water depth and rip velocities during part A. Results show that, during the falling tide (coinciding with slightly increasing offshore Hs), mean rip velocities reach 0.8 m/s and is maximum between low and mid-tide which is in agreement with the modelling exercises of Castelle and Bonneton (2006). Cross wavelet transform and wavelet coherence (Grinsted et al., 2004) have been computed to better understand the rip cell behaviour (not presented in this paper). The bottom panel of Fig. 3 shows the wavelet analysis of rip current velocities and reveals that most of the flow energy is located in the far-infragravity band with very low motion periods on the order of 30 minutes, while the infragravity band contribution is not significant. During part B of the experiment, the circulation cells were also captured in the field, using the large number of deployed currentmeters (not presented here).

Conclusions

The rip current system investigated during the three first days of the field experiment showed interesting features such as strong far-infragravity pulsations and a non significative to a weak infragravity band contribution. The use of wavelet analysis provides a unique tool to assess the temporal evolution of the rip flow energy spectrum over a tide cycle. The dataset also shows once again the strong tidal modulation of the rip current: when the rip current is active, mean rip flow velocities can reach 0.8m/s for only 1 m offshore significant wave height which highlights how hazardous rip currents can be even during fair weather conditions. The high quality dataset collected in this study will be very useful for calibrating phased-averaged and Boussinesq-type models.

Acknowledgements

The authors wish to thank everybody involved in the Biscarrosse 2007 campaign. The wavelet computations in this paper were based on the software developed by C. Torrence, G. Compo, A. Grinsted and co-workers. We sadly dedicate this work to our colleague and friend Denis Michel who tragically passed away during this field experiment.

References

Castelle, B., P. Bonneton, N. Sénéchal, H. Dupuis, R. Butel, D. Michel, 2006. Dynamics of wave-induced currents over an alongshore non-uniform multiple-barred sandy beach on the Aquitanian Coast, France. *Continental Shelf Research*, 26(1), 113-131.

Castelle, B., P. Bonneton, 2006. Modélisation du courant sagittal induit par les vagues au-dessus des systèmes barre/baïne de la côte aquitaine (France). *C.R. Geoscience*, 338, 711-717.

Castelle, B., P. Bonneton, H. Dupuis, N. Sénéchal, 2007. Double bar beach dynamics on the high energy meso-macrotidal French Aquitanian Coast : A review. *Marine Geology*, 245(1-4), 141-159.

Bonneton, N., P. Bonneton, N. Sénéchal, B. Castelle, 2006. Very Low Frequency rip current pulsations during high energy wave conditions on a meso-macro tidal beach. In: Proc. Of the 30th ICCE, San Diego, ASCE, Vol. 1, pp. 1087-1096

Grinsted, A., J.C. Moore, S. Jevrejva, 2004. Application of the cross wavelet transform and wavelet coherence to geophysical time series. *Nonlinear Processes in Geophysics*, 11, 561-566.

Luschine, J.B., 1991. A study of rip current drownings and weather related factors. *Natl. Weather Dig.,* 13-19.

MacMahan, J.H., E.B. Thornton, A.J.H.M. Reniers, 2006. Rip current review. *Coastal Engineering*, 53(2-3), 191-208.

Thronton, E.B., J. MacMahan, A.H. Sallenger, 2007. Rip currents, mega-cusps, and eroding dunes. *Marine Geology*, 240(1-4), 151-167

Wright, L.D., A.D. Short, 1984. Morphodynamic variability of surf zones and beaches: a synthesis. *Marine Geology*, 70, 251-285.

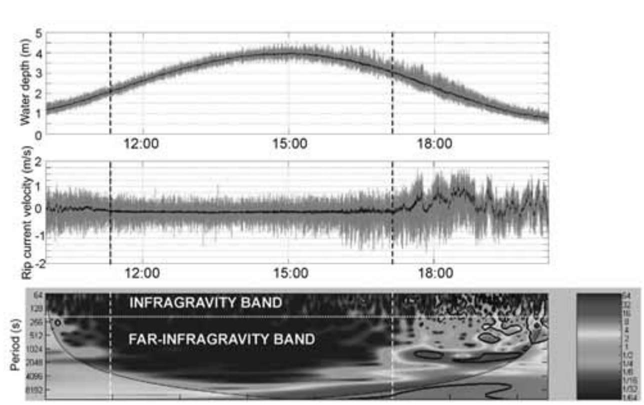

Figure 3 Time series of instantaneous (green) and 5 minute filtered (black) water depth and rip velocity measured by the S4(A) (Fig. 1) during part A (Fig. 2). The bottom panel display the wavelet analysis showing most of the flow energy is located in the far-infragravity band

Implementation and validation of a SFEK data assimilation application for an hydrodynamic model of the Tagus Estuary

Ângela Canas*[a], Aires dos Santos[a] and Paulo Leitão[b]

Introduction

Estuaries are important areas both in ecological and economic terms, namely because of their high biological productivity and as their banks are preferred areas for human populations and economic activity settings. Because of economic and social pressure, estuaries are currently in a worldwide scale being affected by water quality problems.

The European Water Framework Directive (2000/60/EC) stresses the estuarine vulnerability to human pressure and, in the context of surface water, advocates the monitorization of the water quality, using not only measurements analysis but also operational modelling.

The Tagus Estuary (38º44'N, 9º08'W), one of the largest in west coastal Europe, is located near the portuguese capital Lisbon in the most populated area of Portugal and particularly sensible to water pollution. It is the object of an water quality pre-operational model (Riflet *et al.*, 2007) explored by Instituto Superior Técnico (Technical University of Lisbon) producing useful results for several water and waste water management entities in the Lisbon area.

This model is presently under improvement. One of the major difficulties experienced is the water level prediction, very degraded in the Tagus river channel areas where grid resolution is unsufficient to resolve the bathymetry, affecting negativelly local hydrodynamics and water quality results. Data assimilation of water level *in situ* measurements provides an interesting solution for this problem (Mourre *et al.*, 2006) while avoiding the expensive increase of grid resolution.

In this work is presented the implementation and validation of a first data assimilation application for an hydrodynamic model of the Tagus Estuary, paving the way for the use data assimilation tests of real measurements at this estuarine site.

Methods

Hydrodynamic model

The hydrodynamic model used in this work is an improved version of the operational model of Tagus Estuary. It is accomplished with the Mohid Water Modelling System (Miranda *et al., 2000;* Martins *et al.*, 2001; Leitão *et al., 2005)*, a modular system developed by Instituto Superior Técnico and Hidromod with a primitive equations hydrodynamic module with hydrostatic and Boussinesq aproximations. It consists in a two barotrophic 2D domains: a larger domain containing the Portuguese and Galician coast providing tidal boundary conditions for a smaller domain containing the Tagus Estuary and adjacent coastal area. The model is forced with tidal solution, spatially variable wind fields and average flows for the Tagus River, Sorraia and Trancão rivers.

Data assimilation

Given the characteristics of the hydrodynamic model and the study area, the data assimilation method chosen is the SFEK filter, the fixed correction base version of the Singular Evolutive Extended Kalman (SEEK) filter (Pham *et al.*, 1998; Brasseur *et al.*, 1999), a suboptimal scheme of the Kalman filter which considers a reduced dimension of the model solution error covariance matrix, informed by the dominant Empirical Orthogonal Functions (EOF) of model estimate error covariance.

The filter is implemented in Mohid Water Modelling System in a specific new module, allowing the future expansion to other data assimilation schemes. For practical reasons the generation of initial covariance structure is in a specially designed preprocessing tool, allowing its use also in general EOF analysis studies and the reconstruction of analysed data with the calculated EOFs.

Validation

The validation of the application consists in the evaluation of the performance of the data assimilation scheme in the framework of a *twin test* (e.g. Pham *et al.*, 1998). As the *true model* is considered the hydrodynamic model application described before and the *wrong model* is obtained by the perturbation of the mean sea level imposed at the larger domain boundary with a 0.1m standard deviation white noise, producing a non-biased model error.

A set of assimilation trials are performed considering as state variables the water level and velocity meridional and zonal components of velocity in every grid cell for a two months period, where the *true model* results for water level at 5 tide gauges locations inside and outside the estuary are assimilated every 6 hours in the *wrong model* nested domain state using a SFEK filter, with the initial covariance structure based on *wrong model* historical error or on *wrong model* historical state. These trials consist in a sensibility analysis of the forgetting factor value and the use of objective analysis at the beginning of simulation. It is considered a EOF correction basis composed of the 4 dominant EOFs.

A first part of the work consists in the validation of EOF analysis made for *twin model*s nested domain without assimilation results, sampled every 6 hours for 2 months,

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contrasting the original data used for EOF analysis and the respective reconstructed data in terms of variability. The second part of the work consists in the assessement of results of the assimilation trials, contrasting the *true model*, *wrong model* without assimilation and the *wrong model* with assimilation and assessing filter performance in measurement locations and other 6 tide gauges locations.

Results and Discussion

The EOF analysis of the twin models historical results reveals that the dominant 5 EOFs represent about 95% and 85% of the total variance of model state, respectively for the *true model* and *wrong model*. The 2 dominant EOFs seem to be linked to tide, as semidiurnal periodic oscillation is visible in expansion coefficients. The high representability of a small set of EOFs highlight the simple dynamics of the 2D model, while the discrepancy in explained variance in both models should the result of an increase of complexity in dynamics due to the perturbation imposed on mean sea level. Contrast between the original and reconstructed states points that the explained variance is non uniform in state variables, suggesting the presence of noise accumulation/generation areas in model domain.

As for the *wrong model* historical error fields, the EOF analysis finds a similar explained variance for the 5 dominant EOFs to the one of *wrong model* historical fields but the tidal influence is no longer visible and velocity fields seem to be better described relatively to water level field, possibly the result of normalization in EOF analysis.

The assimilation trials performed using the *wrong model* error covariance structure for the forgetting factor values of 0.5, 0.75 and 1.0 (perfect model assumption) for the first 15 days of simulation resulted in improvements in the range 2% - 45% of centered RMSE in the water level values both at measurements or non measurement locations, which are more significative with smaller forgetting factor value. Contrastingly, the velocity fields are generally degraded by assimilation in all trials except the one with forgetting factor 1. A detail inspection of model results reveals that assimilation in most locations improves velocity results in the first 5 days of simulation but after begins to produce bad results. This is though to result from highly variable representativity of the fixed correction basis in SFEK scheme, error accumulation in domain and also from decrease covariance of model prediction error since the beginning of simulation, as the situation is dependent on forgetting factor value. Objective analysis has, comparatively to forgetting factor, a smaller effect in model predition error reduction.

Considering the initial covariance structure derived from the historical states of *wrong model* instead of the historical *wrong model* error provides similar results in qualitative terms, although quantitatively the water level improvements and velocity degradations tend to be more expressive. This behaviour seems to be the result of the higher initial covariance obtained from historical states, increasing the filter sensibility to innovation change, and the worse capability of the correction EOF basis in describing error behaviour, penalizing the velocity field.

Conclusions

The SFEK data assimilation scheme was implemented in Mohid Water Modelling System code sucessfully. The preprocessing tool for EOF analysis was validated and was found to be very useful in assessing patterns of model variability for the 2D hydrodynamic model for the Tagus Estuary in a simple *twin test* case.

A SFEK filter using a correcting basis of 4 EOFs, derived from model error covariance or model state covariance, and assimilating water level measurements has been capable to provide useful correction of water level predictions of the Tagus Estuary 2D hydrodynamic model in most of the tide gauge locations studied in a period of 15 days simulation. However, velocity prediction is generally degraded, possibly due to weak representability of the EOF basis and the accumulation of errors in the model domain over the simulation period.

These results suggest that a SEEK filter will have to be developed if an operative filter is to be used to improve predictions of the Tagus Estuary hydrodynamic model.

Acknowledgements

Special thanks to Ibrahim Hoteit, which provided EOF analysis code that was used as the basis for this work, and to George Triantafyllou and his colleagues from the HCMR for useful discussion on research results and state of the art on EOF analysis and SEEK filtering.

This work was financed by a grant from Fundação para a Ciência e Tecnologia, for the Ph.D. studies of Ângela Canas, under contract SFRH / BD / 14185 / 2003 and by the European Commission through the project INSEA (http: //www.insea.info/) under contract SST4-CT-2005-012336.

References

Brasseur, P., J. Ballabrera-Poy, J. Verron, 1999. Assimilation of altimetric data in the mid-latitude oceans using the Singular Evolutive Extended Kalman filter with an eddy-resolving, primitive equation model. *Journal of Marine Systems*, 22: 269-294.

Leitão, P., H. Coelho, A. Santos, R. Neves, 2005. Modelling the main features of the Algarve coastal circulation during July 2004: A downscalin approach. *Journal of Atmospheric & Ocean Science*, 10 (4): 421-462.

Martins, F., P. Leitã o, A. Silva, R. Neves, 2001. 3D modelling in the Sado estuary using a new generic vertical discretization approach. *Oceanologica Acta*, 24 (1): 551–562.

Miranda, R., F. Braunschweig, F. Leitão, F. Martins, A. Santos, 2000. MOHID 2000 – a coastal integrated object oriented model. *Hydraulic Engineering Software*, VIII.

Mourre, B., L. Crosnier, C. Le Provost, 2006. Real-time sea-level gauge observations and operational oceanography. *Philosophical Transactions of the Royal Society*, 364: 867-884.

Pham, D., J. Verron, M. Roubaud, 1998, A singular evolutive extended Kalman filter for data assimilation in oceanography. *Journal of Marine Systems*, 16: 323-340.

Riflet, G., P. Leitão, R. Fernandes, R. Neves, 2007. Assessing the quality of a pre-operational model for the portuguese coast. *Geophysical Research Abstrac*ts, 9, EGU2007-A-09979.

Tidal Distortion in the Arcachon Basin

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Introduction

Acceptable levels of water quality are often at risk in coastal lagoons worldwide. The causes are numerous, ranging, for instance, from (i) the direct discharge of pollutants through rivers, surface runoff or the ocean, to (ii) the acute or chronic local anthropogenic stress, to (iii) eutrophication produced by poor water exchange with the ocean and large residence times.

In particular, the Arcachon basin (Figure 1), a mesotidal triangular-shaped coastal lagoon in the French Atlantic coast (Lafon et. al, 2002), presents episodic invasions of toxic algae (dynophisis), which seriously hampers the local oyster industry. In addition, the active morphology of the inlet, dominated by a strong littoral drift, waves and ebb and flood currents, influences the circulation inside the lagoon and affects the transport of matter.

In order to address this problem, this study was designed to contribute in the understanding of the lagoon hydrodynamics, and this work presents the results related to the tidal propagation inside the system, and its implications in the general circulation and the inlet stability.

Methods

In order to characterize the Arcachon Lagoon circulation, a field campaign was designed to collect relevant data. Indeed, two Acoustic Current Profilers were installed during one lunar cycle in the two channels of the inlet (North Pass and South Pass). In addition, an Acoustic velocimeter was also deployed upper in the lagoon, in a secondary channel near the town of Cassy (Figure 1). Finally, water surface elevation (WSE) data from the Eyrac Pier (in the Arcachon town) and wind data, were obtained for the same period, from the French Navy (SHOM) and the weather agency (Météo France), respectively.

In this study we present the results of the water surface elevation data harmonic analysis.

Based on the concepts of flood and ebb dominance (e.g., Boon and Byrne, 1981; Friedrichs and Aubrey, 1988), the relative phase of the M_2 and M_4 tidal constituents, and the non-astronomic tide, the general circulation patterns are investigated.

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Figure 1 Arcachon Lagoon with location of current profilers (crosses) at the inlet, current velocimeter (crossed circle) at the upper channel site, and SHOM tide gage (filled circle) at the pier. Image from NASA.

Results

Harmonic analysis of the water surface elevation (not shown) and current speed (Figure 2) at the three sites, shows that:

- The tides are strongly distorted as they enter the system,
- Both inlet passes are ebb dominant throughout the lunar cycle. However, regarding the lagoon as a "multiple inlet system" (justified in part by the existence of a large, emerged, sand bank in the centre of the inlet), the dominance concept has to be regarded with caution (see Salles, et. al, 2005).
- The interior of the lagoon (WSE data for the Arcachon site, and both WSE and current data for the upper channel site) is flood dominant during neap tide, and ebb dominant during spring tide.
- The South Pass is a net importer of water and sediment, and the North Pass is a net exporter.

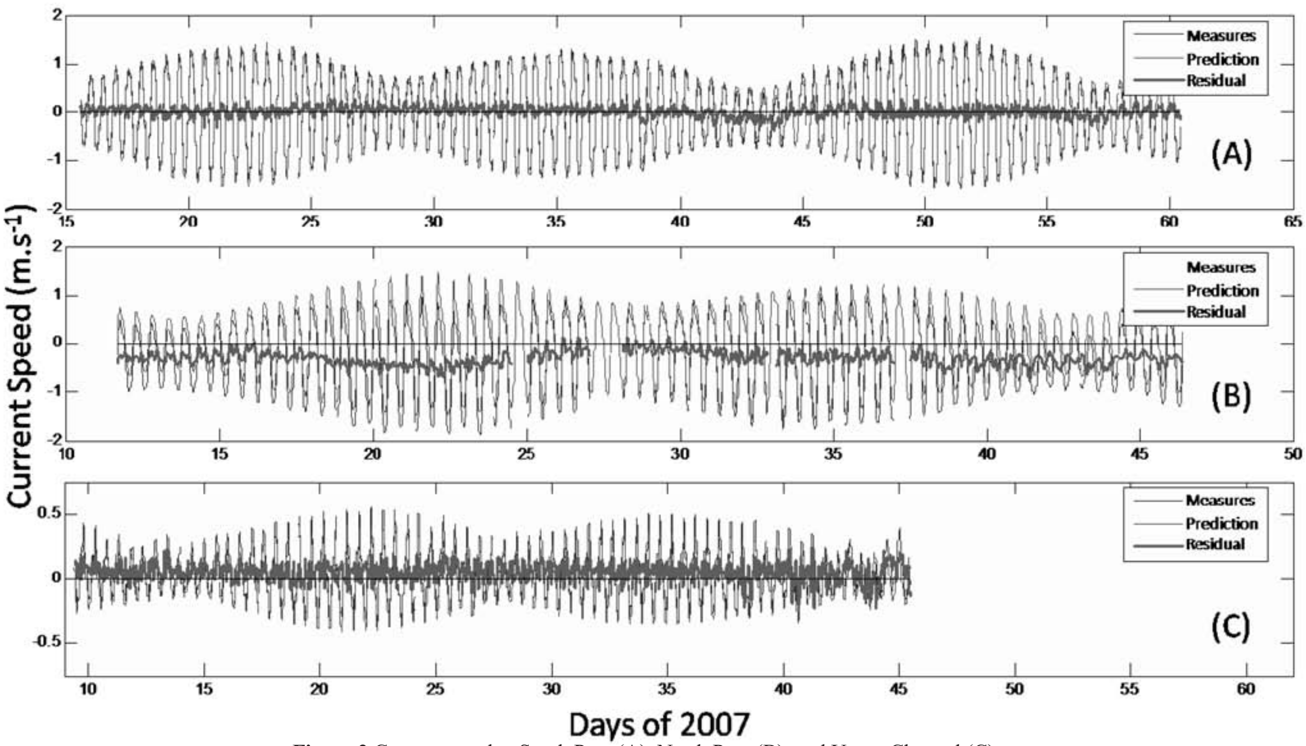

Figure 2 Current speed at South Pass (A), North Pass (B), and Upper Channel (C).

Conclusions

The results presented above suggest that the system can naturally flush oceanward pollutant matter (in this case, toxic algae) during spring tide, but the situation is more critical during neap tide, when the upper reaches of the system seem to have a tendency of retaining mass. Besides, the Inlet North Pass appears to be capable to maintain stability, even with a strong littoral drift from the North.

Acknowledgements

This work was partially supported by the French PNEC Littoral Atlantique Program, the University of Bordeaux, the French BRGM, and the National University of Mexico.

References

Boon, J. D. I. and Byrne, R. J., 1981. On Basin Hypsommetry and the Morphodynamic Response of Coastal Inlet Systems. Marine Geology, 40: pp 27-48.

Cayocca F., 2001. Long-term morphological modeling of a tidal inlet: The Arcachon Basin, France, Coast. Eng. 42 (2001) 115–142.

Friedrichs, C. T. and Aubrey, D. G., 1988. Nonlinear Tidal Distortion in Shallow Well-Mixed Estuaries: A Synthesis. Estuarine, Coastal and Shelf Science, 27: pp 521-545.

Salles P., G. Voulgaris, D. G. Aubrey, 2005. “Contribution of non-linear mechanisms in the persistence of multiple tidal inlet systems”. Estuarine, Coastal and Shelf Science, Vol. 65, pp 475-491

From regional to local modelling in the Bay of Biscay

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Abstract

An Operational Oceanography System established for the Bay of Biscay from a numerical viewpoint is presented here. The aim of this system is to provide tools in order to follow phenomena such as sediment transport, oil spills, river plumes, fish eggs and larvae, and routine activities such as maritime traffic, structure design, or coastal water quality. Numerical modelling results at several scales are compared with observational data. The main results show the suitability of numerical models to explore the physics of both oceanic and coastal areas.

Introduction

The main objectives of the *Operational Oceanography* is to obtain organised and long-term routine measurements of the seas, oceans and atmosphere, and provide their rapid interpretation and dissemination (Dahlin *et al.*, 2003; Flemming *et al*., 2002; Behrens *et al.*, 1997). Variables such as marine currents, sea temperature and salinity, wave height and period, wind stress, heat fluxes between atmosphere and ocean, evaporation and precipitation, and river runoff, are fundamental to obtaining an accurate description of the marine and atmospheric environment; therefore, the working of an efficient Operational Oceanography System. This information can be obtained by means of appropriate instrumentation together with numerical models, which must be previously calibrated and validated with field data.

Numerical models, fed by appropriate atmospheric forcing, can provide accurate description of the past, present and future states of the sea (hindcast, nowcast and forecast, respectively), mainly through the current, temperature and salinity fields. Their results are input to dispersion models (Eulerian or Lagrangian type), which permit the description of particle transport (sediments, oil spills, river plumes, fish eggs and larvae, etc.). In shallow waters and harbours, these tools are fundamental, from a technical perspective (management and design of dredging activities, maritime traffic, structure design, etc.) as well as for environmental analysis (coastal water quality, pollutant events management, etc.).

Marine science is profiting greatly from both operationally acquired data and long-term time series of oceanic variables and modelling at several scales. The information obtained in the Bay of Biscay during the *Prestige* event and the last decade, with instrumentation and numerical models, has demonstrated this fact (Borja and Collins, 2004). This information is contributing to the development of new mathematical models that will allow more precise forecast of oceanic and coastal processes than nowadays possible. The accuracy of the predictions depends, to a great extent, on the quality of the input data required by the models (climatological and atmospheric fields, initial conditions, bathymetric information, etc.).

Methods

Regional Ocean Modeling System (ROMS) is an evolution of the S-coordinate Rutgers University Model (SCRUM) described by Song and Haidvogel (1994). It was expanded to include a variety of new features: high-order advection-schemes; accurate pressure gradient algorithms; several subgrid-scale parameterizations; atmospheric, oceanic, and benthic boundary layers; biological modules; radiation boundary conditions; and data assimilation. Currently ROMS does not designate a single model, but a variety of versions developed in an open mode by different institutions. The numerical aspects of the ROMS model are described in detail by Shchepetkin and McWilliams (2005).

ROMS model within the Bay of Biscay is used with several horizontal resolutions; from 0.1º in regional domains to 30 m in local areas. Vertically, the water column is divided in several sigma coordinate levels (from 5 to 40, as a function of the study area), concentrated at the surface where most of the variability occurs, and in order to keep a good resolution of the sea surface processes. The bathymetry of the model is obtained by interpolation, after an optimization analysis, of ETOPO2, Gebco and IBCM data; which is smoothed to ensure stable and accurate simulations. In local areas such as the Bilbao harbour, topography is provided by a Seabat Multibeam Sonar System.

The aim of the model is to provide information in real time and forecast the physical structure of the ocean using forcing and climatological data sets. The surface atmospheric forcing has information about winds and air temperature at 10 and 2 m height above mean sea level, respectively, precipitation rate, relative humidity, and long and short wave radiation fluxes. These variables permit the air-sea heat and momentum fluxes calculation. For the tidal forcing, data from the OSU TOPEX/Poseidon Global Inverse Solution version 5.0 (TPXO.5) are used. The conditions used on the open boundaries are a combination of outward advection and radiation and flow-adaptive nudging towards prescribed external conditions, provided by the climatological data sets. This information is used for the initialization of variables within the model simulation.

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Results and discussion

As a result of the modelling with ROMS in the Bay of Biscay, an operational oceanography system has been obtained, from a numerical viewpoint. This system provides daily output information for 72 hour forecast. This information, consisting of sea surface images and animations of the 3-hourly averaged main variables (currents, temperature and salinity), is transferred to the website (www.azti.es). For instance, the sea surface temperature field obtained on 30th November 2007 is shown in Figure 1. Model results are in good agreement with the real time data obtained by two WaveScan buoys located in front of Matxitxako and Donostia, at approximately 600 m depth.

In local domains, such as the Bilbao harbour, boundary and initial conditions are provided by the output of the regional model for the Bay of Biscay, following a downscalling process. Inside the Bilbao harbour, the main factors which control the dynamics are the tides and the river discharges. Charasteristic features, such as topographic eddies and vertical water mass movements on the breakwaters, have been simulated for periods in which observational data are available. Figure 2 shows an example of the velocity field at 4 m depth during a flood tide in Bilbao harbour.

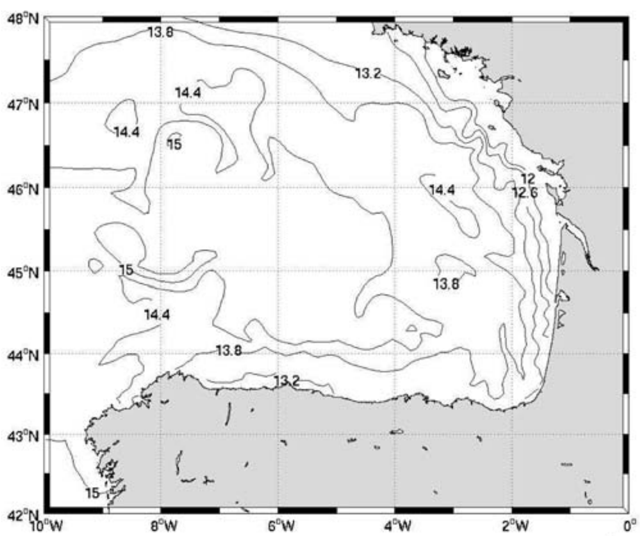

Figure 1. Sea surface temperature field for the Bay of Biscay, on 30th November 2007.

Conclusions

This contribution shows results of an Operational Oceanography System established for the Bay of Biscay from a numerical viewpoint. Observational data from oceanic and coastal stations are compared with the numerical modelling outputs derived from the ROMS model (Regional Ocean Modeling System), at several scales. The reasonably good similitude between field data and estimations derived from ROMS, demonstrates the suitability of the model to reproduce the physics of the ocean. The combination of observational data and numerical modelling provides tools for monitoring several phenomena in real time.

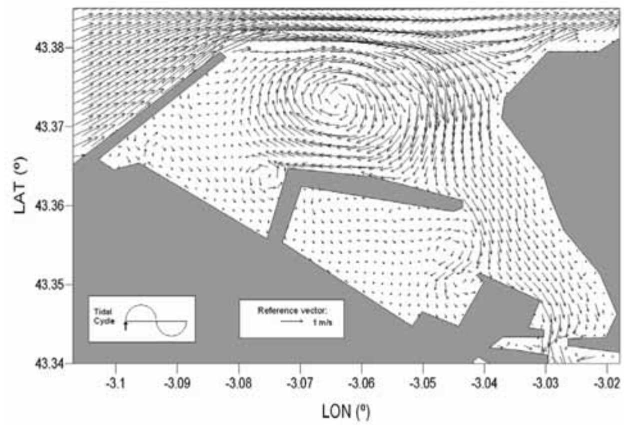

Figure 2. Velocity field at 4 m depth in Bilbao harbour, during a flood tide.

Acknowledgements

This work has been carried out with financial support from different sources of the Basque Government (*Eusko-Jaurlaritza*): Dpto. Industria, Comercio y Turismo (Etortek); Dpto. Transportes y Obras Públicas; Dpto. Agricultura, Pesca y Alimentación; Dpto. Medio Ambiente y Ordenación del Territorio; and Dpto. Educación, Universidades e Investigación (PI-2003-17).

References

Behrens, H.W.A., J.C. Borst, J.H. Stel, J.P. van der Meulen, L.J. Droppert, 1997. Operational oceanography, *Proc. First Int. Conf. on EuroGOOS*, 7-11 October 1996, The Hague, The Netherlands, Elsevier Oceanography Series, 62, 757p.

Borja, A., M. Collins, 2004. Oceanography and marine environment in the Basque Country, Elsevier Oceanography Series, 70, 640p.

Dahlin, H., N.C. Flemming, K. Nittis, S.E. Petersson, 2003. Building the European capacity in operational oceanography, *Proc. Third Int. Conf. on EuroGOOS*, 3-6 December 2002, Athens, Greece, Elsevier Oceanography Series, 69, 714p.

Flemming, N.C., S. Vallerga, N. Pinardi, H.W.A. Behrens, G. Manzella, D. Prandle, J.H. Stel, 2002. Operational oceanography: implementation at the European and regional scales, *Proc. Second Int. Conf. on EuroGOOS*, 11-13 March 1999, Rome, Italy, Elsevier Oceanography Series, 66, 572p.

Shchepetkin, A.F., J.C. McWilliams, 2005. The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model, *Ocean Model.*, 9: 347-404.

Song, Y.T., D.B. Haidvogel, 1994. A semi-implicit ocean circulation model using a generalized topography following coordinate system, *J. Comp. Phys.*, 115: 228-244.

Modelling the transport of metals and organometals associated to the turbid plume of the Adour Estuary (Basque Coast)

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Introduction

The behaviour and speciation of metals in estuaries play a major in their biogeochemical cycling, an understanding of which is essential in order to assess the impact of metal pollution in coastal and marine ecosystems.

Trace metals and organometals generally exist in two phases in estuarine waters, i.e., in the dissolved phase in the water column and in the particulate phase adsorbed on the sediments. The behaviour of trace metals in the aquatic environment is strongly influenced by adsorption to organic and inorganic particles (Turner et al., 2002). The dissolved fraction of the trace metals may be transported through the water column via the processes of advection and dispersion, while the adsorbed particulate fraction may be transported with the sediments, which are governed by sediment dynamics. The partition of a trace metal between its dissolved and adsorbed particulate fractions depends on the physical and chemical characteristics of the suspended particles, together with various ambient conditions, such as: salinity, pH, type and concentration of organic matter (Santschi et al. 1997).

The Adour estuary (south-western French Atlantic coast) has a moderate pollution level, short water residence time, efficient water mixing and low trace metals concentration levels(Point et al. 2006). In addition, the downstream section of the Adour estuary has an important urban and industrial area (Bayonne city district) that may contribute significant anthropogenic inputs to estuarine waters, e.g. metallic contaminants (Point et al. 2006, Stoichev et al. 2006).

The work presented here has attempt to adress this question by combining different objectives:

- spatial distribution (vertical and longitudinal) of particles associated to the plume of the Adour estuary to describe dynamics of the fresh water and of the SPM plumes and the role of each forcing mechanisms.

- distribution and abundance of metals associated to the turbid plume to determine the reactivity of metals species: partitioning between dissolved and particulate phases, species transformations (mercury methylation, butyltin debutylation)

More generally, the study aims to further our understanding of the reactivity and cycling of metals in macrotidal estuaries, and attempts to define the physical and chemical conditions that favour either adsorption and/or desorption of trace constituents in such environments.

The spatial distribution of metals and organometals species will be incorporated into a 3-dimensional hydrodynamic model for the purposes of calculating dissolved and particulate fluxes into and out of the plume taking into account transformation potentials of each species.

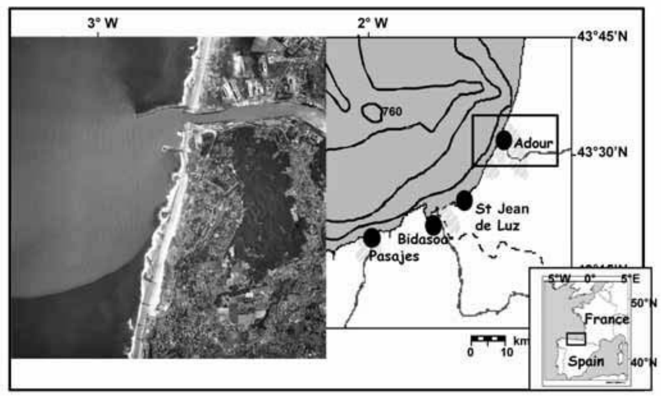

Figure 1: The turbid plume of the Adour estuary

Methods

Hydrodynamic of the Adour Estuary

Located in the south-west of France, the Adour estuary is flowing into the Gulf of Biscay (Atlantic Ocean). The estuary is collecting freshwaters from a whole drainage basin with a cumulated area of 16.380 km^2 and a total population of less than one million inhabitants, mainly located in several medium size cities arranged along the main rivers continuum. The particulate material transported by the Adour River is exported into the coastal zone by the strong ebb currents and its fate depends on the currents off the estuary generated by the tides, the local wind and the waves and modulated by the regional circulation. Inside the estuary the tide and the river discharge dominate the flow. The tide generates velocities of the order of 2 m.s^{-1} limiting the depositional regions to very narrow areas along the banks and the high river discharge (average 300m^3.s^{-1} observed during the last 20 years, up to 2800 m^3.s^{-1} during brief flood events and 50 m^3.s^{-1} during summer months) generate a strong residual flow (with velocities of the order of 15cm.s^{-1}), which exports particulate material to the coastal area. The coarse material is deposited off the mouth and fine particles are transported further off. The fate of the course material deposited off the mouth of the estuary depends mostly on the Bayonne port dredging needs. The fine material

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is deposited mostly off the navigation channel and its fate depends on deposition/res-suspension process determined by the instantaneous flow. The local wind is very weak leaving the lead to surface waves propagating from offshore and to the general circulation in the area.

The fate of the metals depends on the fate of fine particulate matter and on its interaction with the ocean water. MOHID (*www.mohid.com*) is used for simulating the hydrodynamics, the fine material transport and the fate of metals (Fig.2). The settling velocity is computed as a function of the concentration (Mehta, 1988) and the interaction of the sediments with the bottom uses the concept of the fluff layer for simulating the consolidation of the sediments (Fernandes, 2005). The interaction between the dissolved and the particulate faction of the metals is simulated using a partition coefficient (e.g. Johansson et al., 2001).

The model is used on a diagnostic perspective assessing the relative importance of each forcing type, nesting a local model into a regional model. Tide for the regional model are provided by FES2004 (Lyard et al, 2006) and climatological density distribution and schematic wind fields were used.

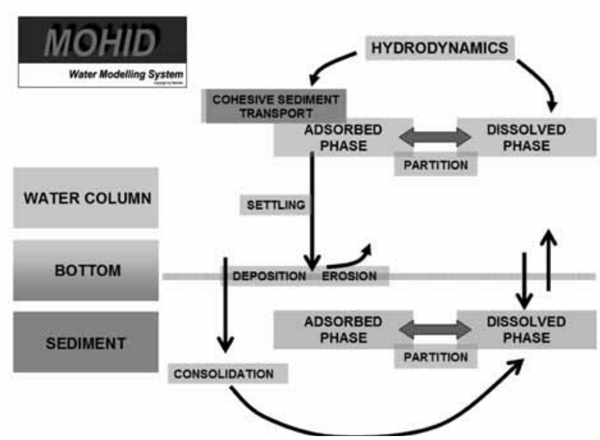

Figure 2 Mohid Modelling system.

Sampling strategy for the model calibration

The integrated model was calibrated against a set of data provided during a campaign (METADOUR2, 7th and 13th April 2007) aboard the French research vessel "Côte de la Manche" (CNRS/INSU). Water column was sampled during this cruise for both metal and organometal partitioning. A total of 14 stations were sampled for determination of metals and organometals concentrations in surface water in the Adour plume. 3 characteristic stations of the mixing zone were sampled at different depths.

Water samples were collected using an acid-cleaned 5 L Teflon lined Go-Flo bottle (General oceanic, USA). The collected samples were filtrated (0.45 µm PVDF filters) under a portable laminar flow hood (ADS Laminaire) to avoid in-situ contamination. Filtered water was poured into Teflon bottles and acidified with HCl to 1% v/v and stored at 4°C in the dark until analysis. The filters were digested with HNO_3 under microwave radiations. Metal analyses were carried out by ICPMS. Speciation analysis of mercury and butyltin compounds were performed using propylation-CGC-ICPMS. GF/F glass fibre filters (0.7 µm, Whatman) were used to sample suspended particulate matter (SPM), particulate organic carbon (POC) and phytoplankton pigments measurements (chloro *a*).

For all the stations, depth profiles of hydrological parameters were determined using a CTD probe (Seabird SBE-25).

Vertical dispersion of the Adour estuary

Measurements of the Adour River plume were done with a bottom-tracking ADCP during the campaign METADOUR and in June 2005. The ADCP datas and tide level datas were used to calibrate the 3D model and obtain consistant informations on the vertical dispersion of the Adour plume.

Acknowledgements

This research was performed in the framework of the project "Panache Adour" from the Réseau Recherche Littoral Aquitain funded by the Aquitaine Région. P. Anschutz, H. Etcheber and D. Poirier (EPOC UMR CNRS/Univ Bordeaux 1) are acknowledged for providing us with hydrological parameters measurements.

References

Fernandes, L., 2005. Modelling arsenic dynamics in the Tagus estuary, MSc Thesis in Ecology, Management and Modelling od the Marine Environment, Instituto Superior Técnico, Technical University of Lisbon.

Johansson, H., Lindstrom, M., Hakanson, L., 2001. On the Modelling of particulate and dissolved fractions of substances in aquatic systems – sedimentological and ecological interactions, *Ecological Modelling*, 137: 225-240.

Lyard, F., Lefevre, F., Letellier, T., Francis, O., 2006. Modelling the global ocean tides: modern insights from FES2004, *Ocean Dynamics*, 56: 5-6.

Maron, P., Reeve D. .E., Rihouey, D., Dubranna J., 2005. Transverse and Longitudinal Eigenfunction Analysis of a Navigation Channel Subject to Regular Dredgings: The Adour River Mouth – France, *Journal of Coastal Research* in press.

Mehta, A. J., 1988. Laboratory Studies on Cohesive Sediment Deposition and Erosion, Physical Processes in Estuaries, Springer-Verlag, Berlin Heidelberg New York, Job Dronkers and Wim van Leussen (Editors)

Point, D., G., Bareille, D., Amouroux, H., Etcheber, O.F.X., Donard, 2007. Reactivity, interactions and transport of trace elements, organic carbon and particulate material in a mountain range river system (Adour River, France), *Journal of Environmental Monitoring*, 9:157-167.

Santschi, P.H., Lenhart, J.J., Honeyman, B.D., 1997**.** Heterogeneous processes affecting trace contaminant, distribution in estuaries: The role of natural organic matter *Marine Chemistry*, 58(1-2):99-125.

Stoichev, T., D. Amouroux, M. Monperrus, D. Point, E. Tessier, G. Bareille, O.F.X. Donard, 2006. Methyl mercury in surface waters of the Adour river estuary (South West France*). Chemistry and Ecology,* 22(2):137-148.

Turner, A., Millward, G.E., 2002. Suspended particles: Their role in Estuarine biogeochemical cycles *Estuarine, Coastal and Shelf Science*, 55(6):857-883.

Presentation of the Bay of Biscay and English Channel operational model. *II.* Validation of circulation on the shelf.

Chifflet M.[a], Lazure P.[b], Vrignaud C.[c], Herry C.[d], Petitgas P.[e]

Introduction

In a previous study, the MARDS3D operational model of the Bay of Biscay and English Channel, developped at IFREMER, has been validated in term of temperarure and salinity (Lazure *et al.*, this symposium). A first assessment of the ability of the model to reproduce the main hydrological features of the Bay and Biscay has been performed. To complete this qualitative assessment, a quantitaive validation has been done by comparison of simulated temperature and salinity with satellite SST images and *in situ* temperature and salinity measurements.

In this work, our major objective is to validate the simulated Lagrangian transport over the shelf. This study has been performed to increase the ability of fish larvae IBM coupled to Lagrangian drifters to accuracy predict fish recruitment. Hence, uncertainty in the transport of biological particles needs to be assessed. In a second time, eulerian simulated circulation over the shelf is validated using ADCP measurements.

Methods

Lagrangian drifters

The Lagrangian data set used in this study for the model validation was collected during several cruises in the northeastern Bay of Biscay: the MODYCOT cruises (SHOM-IFREMER) from 1997 to 2002, and the PELGAS (spring) and JUVAGA (autumn) cruises (IFREMER) in 2004 and 2005. The SURDRIF type drifters (satellite positioning system) were drogued at 60 m for the MODYCOT cruises, and 75 m for PELGAS and JUVAGA. They are thus representative of a water layer located beneath the Ekman layer, outside the direct influence of the wind. The available data set for this study is composed of 44 drifters, which trajectories have already been validated by the SHOM for MODYCOT cruises, and distributed according to the seasons as following: 5 in winter, 15 in spring, 6 in summer and 16 in autumn.

ADCP data

Acoustic Doppler Current Profiler (ADCP) measurements are available from mid-March to mid-July 2002 at the geographical position 47º31N / 3º29W, over the continental shelf, in the northeastern Bay, near "Belle-Isle" (France). Current measurements are available between 5 and 65 m.

Model

The coastal 3D hydrodynamical Model for Applications at Regional Scale (MARS3D) was developed at IFREMER (Lazure and Dumas, 2007; Lazure and Jégou, 1998). The model computes the variations in tides, momentum, and heat and salt fluxes, and takes into account the combined effects of tides, wind, river discharges and surface heat flux. In our configuration, the model extends from the French and Spanish coasts to the abyssal deep, to the south of United Kingdom (about 52°N) and the 8°W meridian. MARS3D for Bay of Biscay computes the primitive equations on a 4-km grid in the horizontal (computed from a 1-km MNT, SHOM) and 30 no-equally distributed σ levels grid in the vertical. A 16-years simulation from 1990 to 2005 has been performed.

Particle tracking is achieved by following Lagrangian trajectories, calculated on-line. The depths of simulated particles are fixed during all the simulation in order to compare them to real drifters: 60 m and 75 m, depending on the drifter origin cruise. Passive particles were released in the model at the same dates than real drifters and same depth but (*i*) along a 19-particles transect passing through the drifters and (*ii*) in a 1000-particles patch at the same geographical positions than drifters. The first case (transects) will be used for qualitative comparison for each season, and the second one (patches) for quantitative validation.

Results

The qualitative and quantitative validation of Lagrangian trajectories is explored and analysed per season to show up the seasonal tendencies and a time scale of confidence of the model.

Lagrangian transport

We first examine the observed Lagrangian trajectories from drifters compared to simulated ones, distributed according to the seasons (Fig. 1). The model reproduces the seasonal tendency of the sub-surface Lagrangian circulation over the shelf. In spring, retention or southward tendency are observed and simulated (Fig. 1a). Nevertheless, the current velocities appears always low, even when southward transport is observed. The model tends to overestimate the velocities for this season, especially near the slope where a southeasthwrad current is often simulated. A special event in spring 2000 (northwestward transport) is underesrimated in the model, even if simulated particles the most close to the coast tend to be transported northwestward. In summer, southeastward tendency is simulated and observed (Fig. 1b). Nevertheless, a northwestward current is observed and reproduced by the model in summer 1997 but the trajectories are very short (less than 2 weeks). In autumn, a strong and recurrent north-westward current along the coast is observed and very well

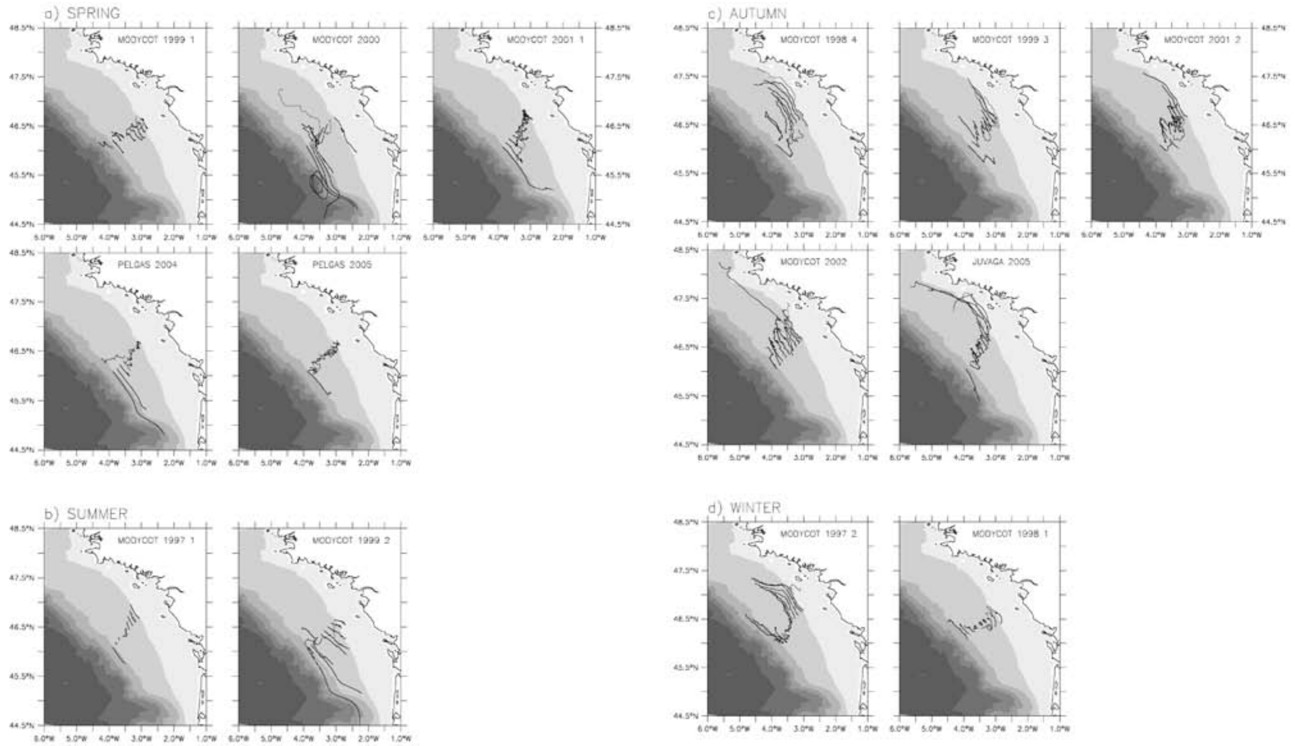

Figure 1 Compared Lagrangian simulated (black lines) and observed (color lines) trajectories, in the sub-suface layer, over the shelf of the Bay of Biscay in (a) spring, (b) summer, (c) autumn and (d) winter.

reproduced by the model (Fig. 1c). Finally, winter appears to be an intermediate season between autumnal northwestward tendency and spring retention (Fig. 1d).

The qualitative comparison between observed and simulated trajectories shows that the model reproduces de global tend of seasonnal Lagrangian circulation. Nevertheless, a quantitative approach needs to be developped in order to assess the model ability to predict Lagrangian transport in purpose of fisheries applications. Hence, to quantify the differences between *in situ* and simulated trajectories, we have also (*i*) estimated the distance between the simulated patches barycentre and the real drifter (fig. not shown here) and (*ii*) calculated the Lagrangian time and space scales for simulated and observed trajectories. This work is still in progress and will be synthetized.

Eulerian circulation

Eulerian simulated current has been compared to ADCP measurements for the u and v components (Fig. 2).

This comparison shows a good agreement between measured and simulated eulerian current for direction as well for velocity magnitude, over all the 4-months period. For example, strong northwestward current, due to wind regime, is observed and simulated at end of March and beginning of April. An other strong southwesterly wind event has occurred at the beginning of July and induced a southeastward surface current, well reproduced by the model. More weak but deeper events, as in mid-May, are simulated too. Nevertheless, the model tends to slightly overestimate the velocity magnitude.

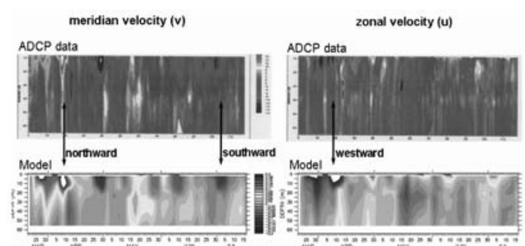

Figure 2 Compared meridian (left) and azimuthal (right) current velocities measured by ADCP (upper panels) and simulated (lower panels). Scale varies between -0.18 and 0.18 m s^{-1}. Measurements and simulation cover a 4-months period from mid-March to mid- July 2002.

Conclusion

It appears essential to validate Lagrangian transport in a 3D hydrodynamical model to use it for fisheries applications as eggs and larvae transport. In this study, qualitative validation has been performed in a first step, but quantitative method is also developped to estimate a potential error in the model and assess its time scale of confidence for Lagrangian transport.

References

Lazure P., Dumas F., 2007. An external-internal mode coupling for 3D hydrodynamical model for applications at regional scale (MARS). Adv. Wat. Res. (in press)

Lazure, P. and A.-M. Jégou, 1998. 3D modelling of seasonnal evolution of Loire and Gironde plumes on Biscay Bay continental shelf. *Oceanologica Acta*, 21:165:177.

Observations of nearshore vortex structures. Example of the Aquitaine coast

Natalie Bonneton[a] and Jean-Marie Froidefond[b]

Flows nearshore are forced by a combination of wave breaking, winds, tide and topographic effects. Exchanges between the surf-zone and water farther offshore are thought to occur mainly via large-scale horizontal vortices. These horizontal structures can put on again sediment in suspension and transport them offshore. That's get in the wider scope of beach erosion.

There are an increasing number of observations of these vortices in the nearshore, which are associated with rip currents. These currents are narrow, seaward-directed currents that extend from the inner surf zone out through the line of breaking wave. SMITH *et al* (1995) have observed that as the seaward directed jet expands laterally, a mushroom-shaped structure (vortex pair) develops at the head, with counter rotating eddies that may or may not be of equal size. Field measurements suggest that the pulsations occur over 10-20 minute interval through the rip system and are correlated to both water level gradients and wave energy variations. CALLAGHAN *et al* (2004) suggests that rip current pulsations can be driven by fluctuation mass transport over the shore parallel inner bar. BONNETON *et al* (2006) analysed data acquired during an in-situ field experiment on Truc Vert beach, on the Aquitaine coast. This beach was exposed to high energy wave conditions during a spring tide cycle and has high tidal range and gentle slope. They observed very low frequency motions within the surf zone, with a characteristic frequency of 6 10-4 Hz which corresponds to a 27 minute period. These VLF motions were associated with high velocity. This paper also suggests that wave groups might have generated these VLF pulsations. These pulsations can generate nearshore vortices. The quasi 2D organization of the observed vortices could be explained by vertical confinement in shallow water (see BONNETON *et al*). The problem is still opened and complementary studies have to be done.

We present herein French Aquitaine observations of macro nearshore turbid structures induced by high energy swell environment, underlying vortex structures from both aerial photographs and satellite images.

French Aquitaine coast is a 230 km long, sandy coast. Its slope is gentle. The depth of 100 m is reached 34 km offshore, giving an average slope of 3/1000. This shelf has no important irregularities and is covered by quartz sand with a grain size between 0.25 and 0.5 mm. The tidal range is about 4m. The coast is dominated by a high energy wave regime. Storm wave heights more than 10m are not uncommon. Aerial photographs and SPOT images show the common presence of a crescentic bar along the Aquitaine coast (FROIDEFOND *et al.,* 1990). The suspended particulate matter concentrations at the sea surface are generally 1-10 mg/l.

In this context the objective of the present study is to collect and to analyse several examples of vortex structures from aerial photographs and satellite images. This is for a better understanding of the generation and the hydrodynamic of these structures.

Different aerial photographs and satellite images were analysed. Geometrical shape indices were selected: 1) mushroom shaped structures (vortex pair), 2) vortex size, 3) vortex distance from the shoreline, 4) Distance between 2 vortices. These observations are completed with data relating hydrodynamics conditions during remote sensing acquisitions: wave height, tidal coefficient, wind speed and orientation, topographic features.

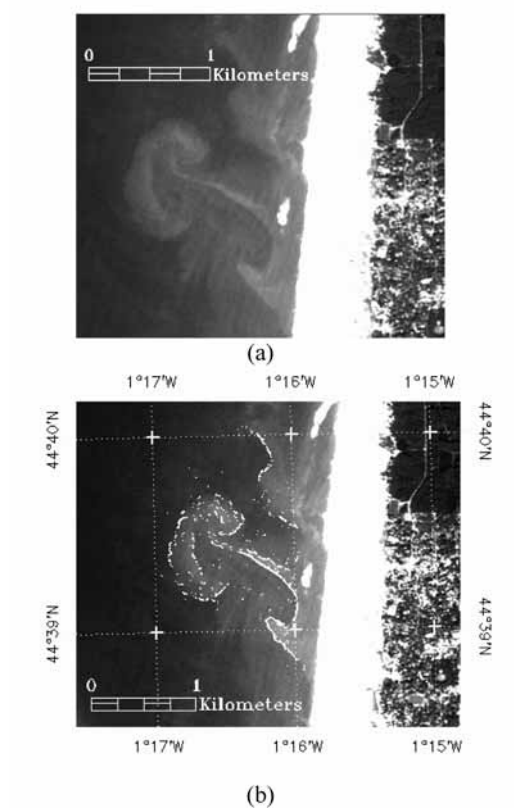

Figure 1. Wave-induced vortex , 8/10/2006 (a) SPOT-5 XS1 Cnes @ Spotimage, (b) detection gradients method

A detection method of the gradients of water colour (convolution filters using non-linear enhancement operators)

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has also been developed to improve the observation of the vortex structure front. About twenty aerial photographs were collected and several SPOT images show these types of structure. Figure 1 shows a typical wave-induced vortex structure observed on October 8th 2006. We will also present the head vortex structure velocity measurement obtained from two MODIS images which were taken on March 14th 2006 at 11:00 and at 13:00

References

BONNETON, N., BONNETON, P., SENECHAL, N. and CASTELLE, B , 2006, Very low frequency rip current pulsations during high-energy wave conditions on a meso-macro tidal beach, *Proc. 30th Int. Conf. on Coastal En*, **1,** 1087-1096.

BONNETON, N., SOUS, D., BONNETON, P. and SOMMERIA, J., 2003. Dynamics of large-scale vortices in the near shore. *Journal of Coastal Research*, SI 39

CALLAGHAN D.P., BALDOCK T.E., NIELSEN P., HANES D.M., KAAS D.M., MACMAHAN J.H., 2004, Pulsing and circulation in rip current system, *Coastal Engineering*, pp1493-1505

FROIDEFOND J. M., GALLISAIRES J.M. and PRUD'HOMME R. 1990, *Journal of Coastal Research*, 6, pp927-942,

A preliminary implementation of a wind-wave prediction model for the Bay of Biscay.

Santiago Gaztelumendi*[a b], Joseba Egaña[a b], Ivan R. Gelpi[a b] and Kepa Otxoa de Alda[a b]

Abstract

A preliminary implementation of a wind-wave forecast model has be done for the Bay of Biscay area. In this paper a brief presentation of system characteristics is done. The wave model used is Wavewacht III, with three nested grids. System runs, once daily, using previous execution fields and last available winds from GFS global model and operational EUSKALMET mesoscale prediction system.

Introduction

A preoperational system has been implemented for wave prediction over the Bay of Biscay area. System is based in version 2.22 of the full-spectral third-generation wind-wave model. The required input data for gridded depth fields are derived from bathymetry data of 2-minute grid spacing obtained from the National Geophysical Data Center. Input wind fields, at 10 meters above the mean sea level, are obtained from NCEP´s Global Forecast System and from Basque Meteorology Agency (EUSKALMET) operational mesoscale system (based on MM5 model). System is executed automatically on a real time daily basis, some graphical preliminary products are automatically generated.

Wave model description

WAVEWATCH III (Tolman 2002) Version 2.22, has been developed by the Environmental Modeling Center (EMC) of the National Centers for Environmental Prediction (NCEP). This model solves the spectral action density balance equation for wavenumber-direction spectra. Parameterizations of physical processes (source terms) include wave growth and decay due to the actions of wind, nonlinear resonant interactions, dissipation and bottom friction are included. The propagation scheme used is a third-order accuracy scheme in space and time. The wind-wave interaction term is based on Tolman and Chalikov (1996) source term package, nonlinear wave-wave interactions are based on discrete interaction approximation, wave-botton interactions are considered from JONSWAP bottom friction formulation.

Three domains have been defined. First domain with 0.9º resolution cover North Atlantic area (151x78 grid points, 100ºW-35ºE , 0º-69.3ºN). Second domain, with 0.3º resolution, cover European North Atlantic area (133x88 grid points, 29.8ºW-9.8ºE , 34.9ºN-61ºN). Third domain cover Bay of Biscay with 0.1º resolution (151x103 grid points, 15.1ºW-0.1ºW , 41.8ºN-52ºN). The bathymetry is obtained interpolating Global Digital Elevation Model data (ETOPO2) 2-minute resolution, for each domain grid (see figure 1).

Initial conditions for each domain come from restart files, when a previous execution is available (usually), if not, the model is initialized with a parametric fetch-limited spectrum based on the initial wind field. Forecasted wind fields (from GFS and MM5 wind data) with different resolutions are considered every 3 hour.

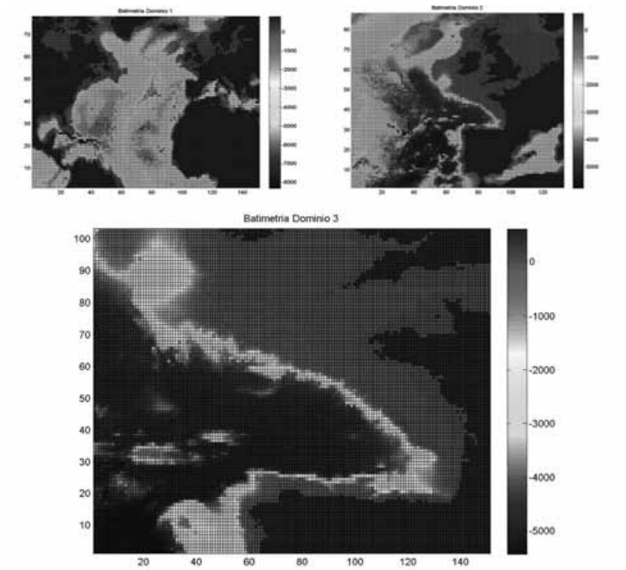

Figure 1. Bathymetry used in different domains.

The number of frecuencies and directions considered are 25, and 24 respectively, the frecuency increment factor is 1,1 Hz and the first frecuency 0,04118 Hz. The global time step, by which the entire solution is propagated in time, and at which intervals input winds and currents are interpolated is 900 seconds for each domain, time step for spatial propagation goes from 3600 to 900 seconds for the differents domain. Time step for intra-spectral propagation are 1200, 900 and 300 respectively, time step for the integration of the source terms goes from 3600 to 300 seconds.

Meteorological models description

As we mention in previous chapter we use GFS and MM5 wind data. The NCEP Global Forecast System (GFS) is a spectral model with a horizontal spectral triangular 254 (T254)

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resolution, Gaussian grid roughly equivalent to 0.5º X 0.5º, 64 unequally-spaced sigma levels, enhanced resolution near the bottom and the top. The GFS solve primitive equations with vorticity, divergence, logarithm of surface pressure, specific humidity, virtual temperature, and cloud condensate as dependent variables. This model is run in NCEP, four times a day (NMC Staff, 1988, Caplan et al.,1997). The PSU/NCAR MM5 mesoscale model is a limited-area, nonhydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation (Grell et al., 1995). The main characteristics of the model are the multiple-nest capability, nonhydrostatic dynamics and several physics options. At present, MM5 EUSKALMET system consists on 81, 27, 9, 3 km, "two-way" nested grid with 24 vertical sigma levels and MRF, Force/restore, Explicit Dudhia´s Moisture and Grell Schemes. Terrain and surface properties are fixed from USGS DEM and different assigned land-use data. (Gaztelumendi et al 2007).

Two different wind fields are used in current implementation. A 10 m wind fields interpolation from GFS grid to domain1 and domain2 and a interpolation form second MM5 operational domain grid to wavewatch domain3. The spatial and temporal interpolation (if needed) are done through the REGRID capabilities in such a way that 10 m wind field is available for 108 hours each 3 hour for each grid.

Conclusions and future work

System is running each day automatically with last data available in the early morning. All the pre-operational system runs once a day automatically on a Linux environment. A set of GrADS and Imagemagick scripts are used for graphical outputs. Another set of shell scripts manage files and images and moves them to archive site and to the web server. Graphical outputs for Hs, Dm, Tm, peak wave period and direction, wind sea peak period and direction, wind speed and direction are available for users in http://www.euskalmet.euskadi.net (see figure 2).

Present system can not describe wave conditions over the coastal areas with sufficient detail due to resolution, on the other hand Wavewatch III basic assumptions imply that the model should be applied on spatial scales (grid increments) larger than 1 to 10 km, and outside the surf zone. Future work must be done in order to improve wave forecast in basque coastal area, probably integrating SWAM model in the system.

A first and preliminary validation has be done based on pre-operational results and some comparisions with the Pasajes oceano-meteorological station wave data and others operational data available for the area. Further validation efforts must be done using data from Basque country coastal network and deep water buoys available at present day.

All aspects mentioned above and others future works will be developed in next two years in the frame of ITSASEUS project an AZTI-EUVE investigation and development project aproved in the Basque Government ETORTEK program.

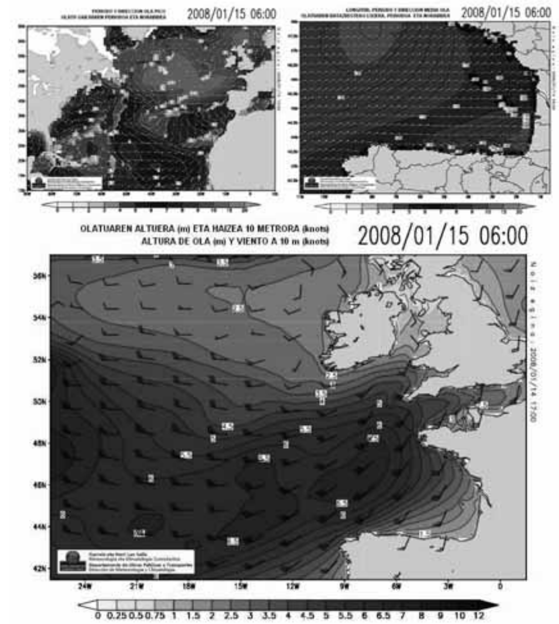

Figure 2. Some graphical output examples.

Acknowledgements

The authors would like to thank Department of Transport and Public Works of the Basque Government and specially Meteorology and Climatology Direction staff for financial support.

Many thanks to all Free Software community and to all institutions that maintain and support availability of free of charge data, models and tools for scientific community.

References

Gaztelumendi, S, Gelpi, I.R. Egaña, J. Otxoa de Alda, K. 2007 "Mesoscale numerical weather prediction in Basque Country Area: present and future ", EMS7 & ECAM8, 1-5 Octubre 2007, El Escorial, Madrid.

Borja, A., M. Collins, 2004. Oceanography and marine environment in the Basque Country, Elsevier Oceanography Series, 70, 640p.

Tolman, H. L., 2002: User manual and system documentation of WAVEWATCH-III version 2.22. NOAA / NWS / NCEP / MMAB Technical Note 222, 133 pp.

Behrens, H.W.A., J.C. Borst, J.H. Stel, J.P. van der Meulen, L.J. Droppert, 1997. Operational oceanography, Proc. First Int. Conf. on EuroGOOS, 7-11 October 1996, The Hague, The Netherlands, Elsevier Oceanography Series, 62, 757p.

Dahlin, H., N.C. Flemming, K. Nittis, S.E. Petersson, 2003. Building the European capacity in operational oceanography, Proc. Third Int. Conf. on EuroGOOS, 3-6 December 2002, Athens, Greece, Elsevier Oceanography Series, 69, 714p.

Song, Y.T., D.B. Haidvogel, 1994. A semi-implicit ocean circulation model using a generalized topography following coordinate system, *J. Comp. Phys.*, 115: 228-244.

Caplan, et al, 1997: Changes to the 1995 NCEP Operational Medium-Range Forecast Model. Wea. Forecasting, 12, 581-594.

NMC staff, 1988: Documentation of the research version of the NMC medium-range forecasting model. NWS/NCEP, 244 pp. [Available from NCEP/Environmental Modeling Center, 5200 Auth Road, Camp Springs, MD 20746.]

Grell, G. A., J. Dudhia, and D. R. Stauffer, 1995: A description of the fifth-generation Penn State/NCAR Mesoscale Model (MM5). NCAR Technical Note TN-398+STR, 122 pp.

SST warming trend along the continental coast of the Atlantic Arc (1985 – 2005)

Moncho Gómez-Gesteira*[a], Maite deCastro[a], Inés Alvarez[a], José Luís Gómez Gesteira[a,b] and Alejandro J.C. Crespo[a]

Introduction

Understanding sea surface temperature (SST) changes is critical to determine scenarios and policies to mitigate anthropogenic effects on climate. Unfortunately, monitoring becomes an arduous task due to technical problems inherent to measurements at sea and to the vast extension of the area to be covered. Developments in satellite technology have provided a valuable tool to calculate SST trends. Detailed analysis have shown the consistency of these satellite data with the oceanographic data previously described.

All previous studies allow concluding that a considerable global warming in SST has occurred over the last century no matter the considered data set. This global warming is far from being uniform during the 20th century. Global SST time series show two distinct warming periods during the past 100 years. The first occurred during the period 1920 to 1940 and was followed by a period of cooling; the second warming period began during the 1970s. In addition, global warming is not uniformly distributed all over the world, being the Atlantic Ocean the ocean that contributes most to the increase in the heat content. These differences among macroscopic areas (hemispheres and oceans) are even more marked at regional scales where some areas warm at higher or lower rates than others. Changes in coastal areas are of large economic and ecologic importance. On the one hand, about 20% of global fish catch is obtained in near shore regions, especially in those areas affected by costal upwelling events. On the other hand, coastal ecosystems have shown to be highly vulnerable to global climate changes (e.g. SST increase and sea level rise). Thus, warming can have profound impacts on biological production of coastal areas.

Methods

Coastal warming was analyzed by means of weekly night-time satellite derived SST along the continental part of the Atlantic Arc extending from 37ºN to 48ºN for the period 1985-2005.

Data have a spatial resolution of 4km. For each grid point, an SST value is computed as the average of all cloud-free multi-channel measurements available for one week. A discrete set of points placed at 20 km from coast were generated along the area under scope (Figure 1). Twenty-eight points along the French coast (empty circles), 31 along the Cantabrian coast (full circles) and 35 along the west coast of the Iberian Peninsula (WIP) (empty triangles).

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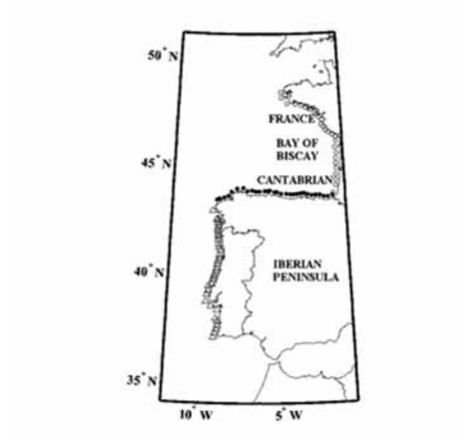

Figure 1 Area under scope.

Results and Discussion

The trend of coastal SST anomaly along the area of study for the period 1985 - 2005 is shown in Figure 2.

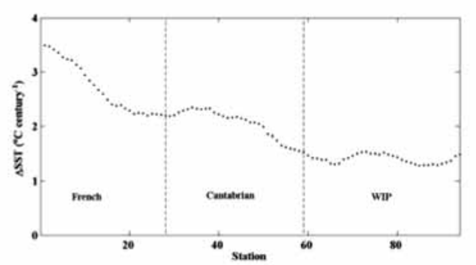

Figure 2 Coastal SST anomaly trend (ΔSST) along the area under study for the period 1985-2005. A running average to the 9 nearest spatial neighbours was considered for the sake of clarity. Only points with 90% significance in the T-test were considered in this running average.

Positive ΔSST values were observed along the coast, although with noticeable changes both in latitude and longitude. The highest ΔSST is observed at the northernmost part of the French coast (3.5ºC $century^{-1}$) and the lowest one at the southernmost part of the WIP coast (1.3ºC $century^{-1}$). The mean and the standard deviation of ΔSST show a monotonically SST warming decrease from the French coast (2.7±0.5 ºC) through the Cantabrian coast (2.1±0.3 ºC) to the WIP coast (1.2±0.1 ºC).

Spatial variability of coastal warming reflects the warming trend observed in the eastern North Atlantic Ocean (Figure 3).

Positive ΔSST values are observed in the entire area under scope, reaching maximum values over 7.0 ºC $century^{-1}$ in the open sea. There is a clear increase of ΔSST with latitude and a clear decrease in longitude from 50ºW to 15ºW, with a further increase from 15ºW to 0 due to the more pronounced warming observed at high latitudes.

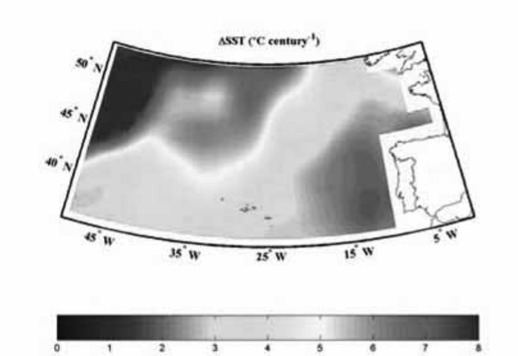

Figure 3 SST anomaly trend (ºC century^{-1}) of the north Atlantic area extending from 35 to 55 ºN and from 0 to 55º W for the 1985- 2005 period of time. Original data corresponding to a 4 km × 4 km × 1 week scale were averaged to 1.5º × 1.5º × 1 month scales prior to anomaly calculation.

The observed rates of warming are higher than the long-term values obtained by other authors for the last half century in the ocean. For a brief summary on other studies focused on global and regional SST trends see Table 2 in Casey and Cornillon [2001]. In addition, Levitus *et al.*, [2000] found a warming trend close to 0.6ºC century^{-1} for the first 300m of the world ocean for the period 1948-1998 and Arbic and Owens [2001] found values of 0.5ºC century^{-1} for the mid-depth layer (1000- 2000 db) for the Atlantic from 32ºN to 36ºN from the 1920s to 1990s. However, González-Pola *et al.* [2005] observed that the evolution of the intermediate water masses within the south-eastern corner of the Bay of Biscay shows a warming rate between 2ºC century^{-1} and 3ºC century^{-1} from 1991 to 2003. The different warming trends depend on the considered period. For instance, the high warming rates observed in González- Pola *et al.* [2005] and in the present study reflect the acceleration in climate warming observed during the last two decades of the 20th century. Notice that the 10 warmest years of the historical record have occurred after 1988 according to the Intergovernmental Panel on Climate Change [2001].

The seasonal trends of coastal SST anomaly along the area of study for the period 1985 -2005 are shown in Figure 4. Only spring (a) and summer (b) are represented because their significance level is higher than 90%. The observed warming trends are dependent on the season, although they are macroscopically similar to the annual trend. In general, spring ΔSST is higher than summer ΔSST along the entire coast and both show a trend higher than observed in the annual fitting. Once again, the mean ΔSST shows a monotonic decrease in warming from the French coast to the WIP coast.

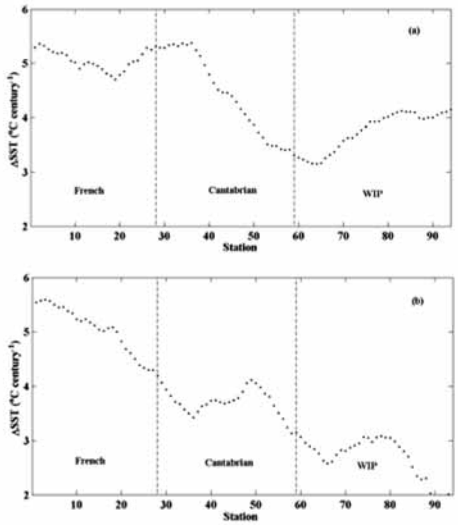

Figure 4 Spring (a) and summer (b) coastal SST anomaly trends (ΔSST) along the area under study for the period 1985-2005. Data treatment as in Figure 2.

Conclusions

An inhomogeneous warming trend was observed in coastal SST increasing monotonically from the WIP coast to the French coast.

Differences in coastal warming reflect oceanic trends observed in the north Atlantic, which is characterized by a north-western increment in ΔSST.

Coastal warming is not constant all year long. Warming is only significant during spring and summer, following a macroscopic pattern similar to the annual one.

The coastal warming, even if lower than observed in the open ocean, can produce an important biological and economic impact in the area under scope, characterized by a high productivity. Changes that range from 1.2 to 3.5 ºC century^{-1} will presumably have a negative impact on coastal marine communities, especially in some marketable species like mussels, oysters, clams or cockles. A general increase in water temperature can alter the normal reproductive cycle of these bivalves and be involved in high summer mortalities.

References

Arbic, B.K., W.B. Owens, 2001. Climate warming of Atlantic intermediate waters, *Journal of Climatology,* 14: 4091- 4108.

Casey, K.S., P. Cornillon, 1999. A comparison of satellite and in situ based sea surface temperature climatologies. *Journal of Climate* 12**:** 1848–1863.

González-Pola, C., A. Lavin, M. Vargas-Yañez, 2005. Intense warming and salinity modification of intermediate water masses in the southeastern corner of the Bay of Biscay for the period 1992- 2003, *Journal of Geophysical Research*, 110, C05020, doi: 10.1029/2004JC002367.

Intergovernmental Panel on Climate Change, 2001. *Climate Change 2001: The Scientific Basis: Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change,* edited by J.T. Houghton et al., 944 pp., Cambridge Univ. Press, New York.

Levitus, S., J.I. Antonov, P.B. Timothy, C. Stephens, 2000. Warming of the World Ocean, *Science*, 287: 2225- 2229.

Temperature variability in the Bay of Biscay during the past 30 years, from an in situ analysis and a 3D regional simulation

Sylvain Michel and Frédéric Vandermeirsch[a]

Introduction

Many observations sources show high temperature variations in the Bay of Biscay, both in terms of year-to-year oscillations and decade-long trends (Koutsikopoulos et al., 1998). However we still need to quantify this variability and examine its geographic distribution. We also have to identify the causes of variations, in particular by separating the influences of atmosphere (direct effect of climate change) and those of ocean (changes in oceanic circulation and properties).

The Bay of Biscay is affected by various physical processes, which act on a wide range of space scales. At large scales, the main causes of variability are the water masses intrusions (from the North Atlantic Drift, Mediterranean Water and Nordic Seas) and the atmospheric modes of variability (North Atlantic Oscillation, Eastern Atlantic mode, etc.). At smaller scales, some of the relevant mechanisms are coastal upwellings, mesoscale eddies (SWODDIES, Pingree and Le Cann, 1991), continental slope currents (Garcia-Soto et al., 2002), river plumes (Lazure and Jegou, 1998), tidal mixing and wind-driven circulation.

Because of this complexity, 3D general circulation models are very useful to improve the description of temperature changes and understand their origins. Here, we combine an in situ analysis and outputs from a high-resolution simulation. First, we describe the observed temperature variability and assess the simulation reliability. Then we compute a complete heat budget from the simulation, in order to estimate the contribution of each process at play.

Methods

In situ analysis

The interannual analysis “BoBy” starts in 1950 and is based on in situ measurements by bottle samples, CTDs and XBTs (see the poster by F. Vandermeirsch et al. for details). This collection forms the most complete dataset in this particular region, containing ~55% more data than the World Ocean Database (Levitus et al., 2004). The data are aggregated into annual means, which accuracy is estimated to be better than 0.2°C. In this study, we focus on two particular layers: near surface (0-50 m) and intermediate water (50-200 m).

Regional simulation

The simulation was designed within the DRAKKAR project. It is based on the OPA/NEMO ocean model, using a Z vertical coordinate with partial steps and a linearised free surface (Barnier et al., 2006). We use the AMEN configuration, covering the whole North Atlantic at a 1/4° resolution (from 30°S to 80°N), enhanced with a grid refinement at 1/12° in the north-eastern sector (31°N-55°N/30°W-0°E) using the AGRIF 2-way coupler. The vertical grid contains 64 vertical, separated by 6 to 20 m in the upper 200 meters. The surface forcing consists in radiations and precipitations from satellite data, river runoffs from a monthly climatology and turbulent fluxes from the CORE bulk formula (Large et al., 2004) combined with meteorological variables from the ERA40 reanalysis.

Results

We compare the temperature evolution from the regional BoBy analysis and from the global World Ocean Database. We also confront these observations with two simulations: the AMEN regional configuration (1/12° resolution) and the ORCA025 global configuration (1/4° resolution). All datasets exhibit a strong warming starting from the mid 1970’s (Figure 1), at least from the surface down to the 800-meter depth (not shown). In all layers, this warming appears stronger in the regional analysis and too weak in the coarse simulation. High oscillations are superimposed on this slow trend, with a 6 to 10-year frequency and an amplitude decreasing rapidly with depth.

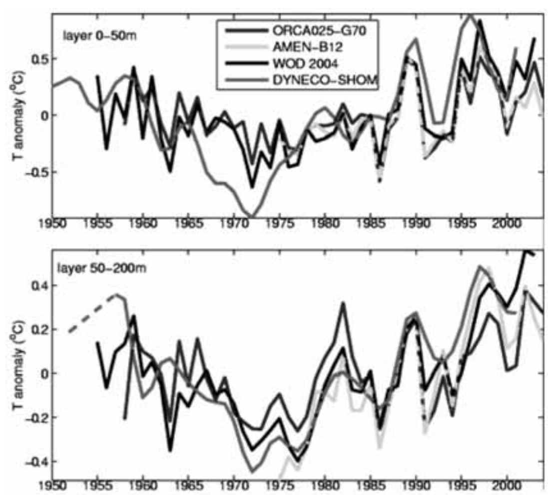

Figure 1 Interannual anomaly of temperature from 1950 to 2004, in two layers (top: 0-50m, bottom: 50-200m), from observations (red: BoBy analysis, black: World Ocean Database) and simulations (blue: ORCA, green: AMEN).

Table 1 Statistics of annual temperature from 1975 to 2001 in the Bay of Biscay (43°N-50°N/15°W-0°E), from the two in situ analyses (Bay of Biscay and World Ocean Database) and from the two simulations (global ORCA and regional AMEN).

Statistic	Layer	BoBy	WOD	ORCA	AMEN
Linear trend	**0-50m**	+0.35	+0.30	+0.15	+0.20
(°C/decade)	**50-200m**	+0.27	+0.23	+0.07	+0.25
RMS residual	**0-50m**	0.25	0.25	0.26	0.26
(°C)	**50-200m**	0.11	0.13	0.16	0.17

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The observed trends and oscillations are in best agreement with the AMEN simulation (Table 1). To further validate this simulation with respect to the BoBy analysis, we compare statistically these two datasets :

- the simulation bias is less than +0.1°C in the surface layer and +0.5°C in the intermediate layer,
- the RMS difference ranges from 0.3°C in the surface layer to 0.1°C in the intermediate layer,
- the temporal correlation reaches 90% and 72% in the intermediate and surface layers, respectively.

As the AMEN simulation leads to the best agreement with regional observations, we use it to compute the simulated heat budget and to map the geographical distribution of temperature change and. The simulation (Table 2) shows that the main heat input is provided by oceanic currents and the main heat loss occurs through air-sea exchanges. Also, a significant loss is due to diffusion across the domain boundaries and a low input is produced by precipitations and rivers.

Budget term	Mean flux	Linear trend	RMS residual
Unit	W/m²	W/m²/decade	W/m²
Total transport	+13.2	+3.1	6.1
Surface heat flux	-9.0	+0.5	6.0
Freshwater flux	+0.3	+0.06	0.1
Elevation change	+0.003	-0.008	0.03
Lateral diffusion	-4.0	-2.3	1.5
Temperature change	+0.5	+1.3	8.9

Table 2 Heat budget from the AMEN simulation during 1981-2000, over the Bay of Biscay and the surrounding ocean (40°N-55°N/15°W-0°E, see Figure 2), in terms of mean heat flux, linear trend and RMS of the non-linear residuals

As a result of all these contributions, the upper layer temperature increases in almost all the domain (Figure 2), except in the upwelling area located to the West of the Iberian Peninsula (-0.1°C/decade). The temperature is almost stable along the northern Spanish coasts, while it increases rapidly over the French part of the Bay of Biscay shelf (+0.25°C/decade). The temperature increase is even higher in the central part of the English Channel and in the whole Irish Sea (+0.4°C/decade). Above the abyssal plain, the increase is generally stronger than over the shelf break, particularly in the central part of the Bay of Biscay (+0.3°C/decade). However, the distribution of this simulated temperature change has not been validated yet using the BoBy observations, thus we have consider it with caution.

Conclusions

The comparison of temperature interannual variations shows a high consistency between the regional and global in situ analyses. A better agreement is obtained with the higher resolution simulation, due to a more energetic circulation over the shelf and stronger cross-slope exchanges. This simulation allows to investigate the spatial and vertical distribution of multi-year oscillations, supposedly linked to atmospheric modes, as well as the decadal trend, probably related to slowly varying oceanic circulation.

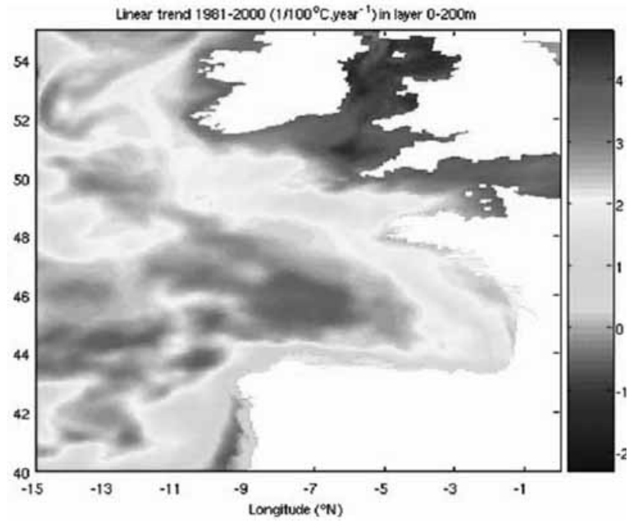

Figure 2 Spatial distribution of the temperature trend (in 1/100°C/year), averaged in the 0-200m layer, from 1981 to 2000, in the AMEN simulation.

The heat budget calculation enables to estimate the relative contributions of ocean versus atmosphere, currents (large scale to mesoscale) versus mixing processes (unresolved scales). These preliminary results help to understand why temperature variations associated with climate change are far from homogene in Bay of Biscay, both horizontally and vertically. This heterogeneity is due to a variety of balances between processes characterised by very different scales, as atmospheric fluxes, oceanic currents and submesoscale eddies account with similar intensities.

Acknowledgements

We thank the SHOM for having authorized us to use their data within the framework of this study. We also thank the DRAKKAR project team for providing us with outputs of the ORCA025 and AMEN simulations.

References

Barnier, B. and the DRAKKAR group, 2006. Impact of partial steps and momentum advection schemes in a global ocean circulation model at eddy permitting resolution. Ocean Dynamics, 56: 543-567.

Garcia-Soto, C., R. D. Pingree, L. Valdés, 2002. Navidad development in the southern Bay of Biscay : climate change and swoddy structure from remote sensing and in situ measurements. Journal of Geophysical Research, 107 (C8): 28-1 -28-29.

Koutsikopoulos, C., P. Beillois, C. Leroy, F. Taillefer, 1998. Temporal trends and spatial structures of the sea surface temperature in the Bay of Biscay. Oceanologica Acta, 21, 2: 335-344.

Large, W.G., 2007. CORE forcing for coupled ocean and sea-ice models. Flux News, newsletter of the WCRP workgroup on surface fluxes, 3, 2-3, January 2007.

Lazure, P., A.M. Jegou, 1998. 3D modelling of seasonal evolution of Loire and Gironde plumes on Biscay Bay continental shelf. Oceanologica Acta, 21(2): 165-177.

Levitus, S., J. Antonov, T. Boyer, 2005. Warming of the World Ocean: 1955-2003. *Geophysical Research Letters*, 32, L02604.

Pingree, R.D., B. Le Cann, 1991. Three anticyclonic Slope Water Oceanic eDDIES (SWODDIES) in the Southern Bay of Biscay in 1990. *Deep Sea Research*, 39, 7/8: 1147-1175.

T/S relationships for Eastern North Atlantic Central Water in the Basque coast (N Spain). Recent changes induced by climate anomalies.

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Introduction

Eastern North Atlantic Central Water (ENACW) is a winter Mode Water formed by winter cooling and deep convection (Pollard *et al.*, 1996). Climatological variations, such as the annual anomalies of heat and freshwater exchanges in the surface layer, modify the accumulation of salt and heat content in the mixed layer and define, in late winter, the main yearly T/S relationships for some reference densities (Pérez *et al.*, 1995; 2000). Below the seasonal thermocline these properties remain with little changes, at least, along the year of the water mass formation. Nevertheless, in shelf and slope waters some additional variations can be expected because of *in situ* modifications and for changes related with the advection from the main oceanic areas of water mass formation. The last factor includes seasonal changes of the sub-types of the ENACW advected. For example for the Bay of Biscay, southwesterly advection of $ENACW_T$ in autumn-winter followed by northerly advection of $ENACW_P$ in spring-summer (*sensu* Ríos *et al*., 1992; Valencia *et al*., 2004).

Typical vertical distribution of the T/S relationships for ENACW is an almost isopycnal straight line between a shallow salinity maximum and a deeper salinity minimum, with relatively small changes in density because of the simultaneous decrease of temperature and salinity. Nevertheless, the pattern of the formation of the pycnostads of the yearly mode water is variable, depending on the meteorological conditions during autumn and winter, modifying the T-S relationship and the water column thickness for each density interval.

A well documented example of sharp changes in the T-S relationships for the ENACW was recorded in early nineties (Pérez *et al.*, 1995; 2000; Pollard *et al*., 1996). Strong winter mixing in 1991 and 1992 translate to the $\sigma - t = 27.1$ and $\sigma - t = 27.2$ isopycnal layers of the ENACW the accumulated climatic anomalies of the late eighties (temperate and dry) and produce a warm and very saline mode water.

Recently, very cold winters in 2005 and 2006 produce also a very deep winter mixed layer (> 250 meters in the slope waters off the Basque coast). Changes in the T-S relationships for the ENACW are presented in this contribution and discussed in relation with meteorological and hydrological data representative of heat and water balances in the study area. This contribution updates some topics from Fontán *et al*., (in press) evaluating the influence of recent seasonal climatic anomalies on the T-S relationships for the ENACW throughout the winter mixing.

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Methods

A brief description of available data set, including its source, record length, and sampling rate is listed in Table 1.

Table 1. Description of the main dataset used, including its source and record length.

Data	Location	Source	Record Lentgh
Daily SST	San Sebastián	Oceanographic Society of Gipuzkoa	1947-2007
Monthly Meteorological Summaries	San Sebastián	INM Meteorological Observatory	1986-2007
6 hours Vectorial wind data	45º N, 2º W	PFEL-NOAA	1967-2007
Daily River flow	Gironde	Bordeaux Port Authority	1952-2007
Daily River flow	Adour	HYDRO	1967-2007
Monthly Hydrographical data	Basque shelf and slope	AZTI Foundation	1986-2007

Moreover, since 1986, AZTI Foundation has been carrying out monthly hydrographical surveys over the Basque continental shelf (Valencia, 1993; Valencia *et al*., 1989, 1996, 2003, 2004), in front of Pasaia. Research has been undertaken into short-term and long-term variability at meso- and local scales. As a result of this pluriannual sampling programme, the main oceanographic variables are represented by two decades of observations (1986-2005) for the Basque coast; they constitute a time series of monthly temperature and salinity values over a water column of about 100 m depth.

Results and Discussion

Accumulated anomaly of the air temperature in San Sebastián from November 2004 until March 2005 was – 6.3°C and - 7.5°C for the same period of the 2005-2006. Moreover, unusually high winter upwelling indices for the Basque coast and for the French coast of the SE Bay of Biscay indicate strong prevalence of the northerly and easterly cold winds. These factors, in conjunction with a moderate-low input of freshwater, allow strong losses of heat in the water column and the formation of an unusually homogeneous and deep winter mixed layer in winter 2005. The water balance (in terms of accumulated anomalies of precipitation minus evaporation and river flows) was favourable for increase the salt content in the water column. In fact, average salinity increases in autumn-winter 2004-2005. Nevertheless, cooling was prevalent, and T-S values for the σ-t = 27.1 layer was 11.71±0.05°C and 35.585±0.015 PSU, approximately 0.1°C and 0.020 PSU lower and around 80 m shallower than in 2004.

Similar pattern was recorded in autumn-winter 2005-2006. Additional data an seasonal variation can be observed in the multiyear TS diagram (Figure 1).

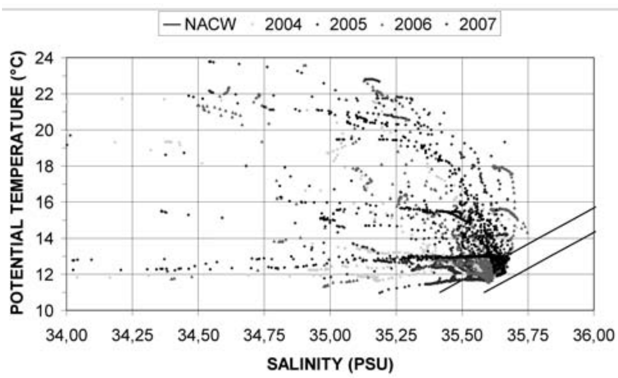

Figure 2. TS diagram for shelf and slope waters off the Basque coast. Data shared by years. Straight lines are the reference lines for NACW.

Acknowledgements

The Meteorological data were obtained from the Observatory of San Sebastián (National Institute of Meteorology). The daily sea surface temperature data were provided by the Aquarium of San Sebastián (Oceanographic Society of Gipuzkoa). The Gironde River and the Adour River data were furnished by the Bordeaux Port Authority and the National database on hydrometry and hydrology (HYDRO), respectively. The calculation of the Upwelling Index was undertaken on the basis of vectorial data furnished by the NOAA-PFEL. The Basque Government (Department of Agriculture, Fisheries and Food) has funded the project "VARIACIONES" that includes acquisition of the *in situ* data and the review of external time-series. We are very grateful to the sampling staff of the Marine Research Division (AZTI-Tecnalia), for the high quality of the work performed since 1986. N. Goikoetxea is being supported by a research grant ("*Oceanografía y Recursos Marinos*") from the Fundación Centros Tecnológicos, Iñaki Goenaga.

References

Pérez, F.F., Ríos, A.F., King, B.A., and Pollard, R.T., 1995. Decadal changes of the θ-S relationship of the Eastern North Atlantic Central Water. *Deep-Sea Research I,* 42: 1849-1864.

Pérez, F.F., Pollard, R.T., Read, J.F., Valencia, V., Cabanas, J.M., and Ríos, A.F., 2000. Climatological coupling of the thermohaline decadal changes in Central Water of the Eastern North Atlantic. *Scientia Marina,* 64: 347-353.

Pollard, R.T., M.J. Griffiths, S.A. Cunningham, J.F. Read, F.F. Pérez and A.F. Ríos, 1996. Vivaldi 1991- A study of the formation, circulation and ventilation of Eastern North Atlantic Central Water. *Progress in Oceanography*, 37: 167-192.

Ríos, A.F., F.F. Pérez and F. Fraga, 1992. Water masses in the upper and middle North Atlantic Ocean east of the Azores. *Deep-Sea Research I*, 39: 645-658.

Valencia, V., 1993. Estudio de la variación temporal de la hidrografía y el plancton en la zona nerítica frente a San Sebastián. Resultados 1988-1990. *Informes Técnicos (Departamento de Agricultura y Pesca, Gobierno Vasco)*, 52: 1-105.

Valencia, V., L. Motos and J. Urrutia, 1989. Estudio de la variación temporal de la hidrografía y el plancton en la zona nerítica frente a San Sebastián. Informes Técnicos (Departamento de Agricultura y Pesca, Gobierno Vasco) 20, 1-81.

Valencia, V., Borja, Á., and Franco, J., 1996. Estudio de las variaciones, a corto y largo término, de varios parámetros oceanográficos y meteorológicos de interés para las pesquerías del Golfo de Bizkaia. *Informes Técnicos Departamento de Agricultura y Pesca, Gobierno Vasco)*, 75: 1-232.

Valencia, V., Borja, A., Fontán, A., Pérez, F.F., and Ríos, A.F., 2003. Temperature and salinity fluctuations in the Basque Coast (SE Bay of Biscay) from 1986 to 2000 related to the climatic factors. *ICES Marine Science Symposia*, 219: 340-342.

Valencia, V., Franco, J., Borja, Á., and Fontán, A., 2004. Hydrography of the southeastern Bay of Biscay. In: Borja, A. and Collins, M. (Eds.), *Oceanography and Marine Environment of the Basque Country*. Elsevier Oceanography Series nº 70, Elsevier, Amsterdam, pp. 159-194.

Warm and saline upper Ocean intrusions north of Spain in 2006

Bernard Le Cann[a] and Alain Serpette[b]

Introduction

The autumn-winter period in 2006-2007 was exceptionally warm over Europe (e.g. Luterbacher et al, 2007), and this included the Bay of Biscay area. During this period, this region was also marked by a strong « Navidad » event (Pingree and Le Cann, 1992), that is the intrusion of warm surface waters along the northern coast of Spain (Figure). Compared to monthly means from September to December over the 1982-2006 period, SST values were more than 1°C higher in 2006. From CTD measurements on a short transect near 6°W, Llope et al (2006) described the hydrological evolution over the upper slope, notably saline intrusions over the upper slope. Here, we further characterise the 2006 event, notably its temperature and salinity structure from hydrological measurements collected during a CONGAS cruise in December 2006, and the structure of the currents from Lagrangian and ADCP data.

Methods

In December 2006, a cruise was conducted to sample the hydrological structure over the slope and outer shelf north of Spain. 25 CTD stations were performed along 3 transects (Figure). Several acoustic floats, profiling floats and drifting buoys were also deployed, and ADCP data were collected from the ship.

Results and Discussion

CTD measurements depict the structure of the intrusion as a warm water tongue (maximum > 16°C) extending over the shelf and upper slope, down to ~100-150 m. Beneath and seaward of this warm structure, a saline water tongue (maximum > 35.8 psu) is observed, extending roughly from 70 to 250 m, and decaying eastward.

Lagrangian measurements exhibit the complexity of the flow structure in the area, with (mostly) poleward currents over the upper slope and shelf, and (mostly) westward currents over the outer slope. This current system is seen to be marked by reversals and instabilities.

An analysis in terms of windstress and JEBAR (« Joint Effect of Baroclinicity and Relief ») forcings is proposed.

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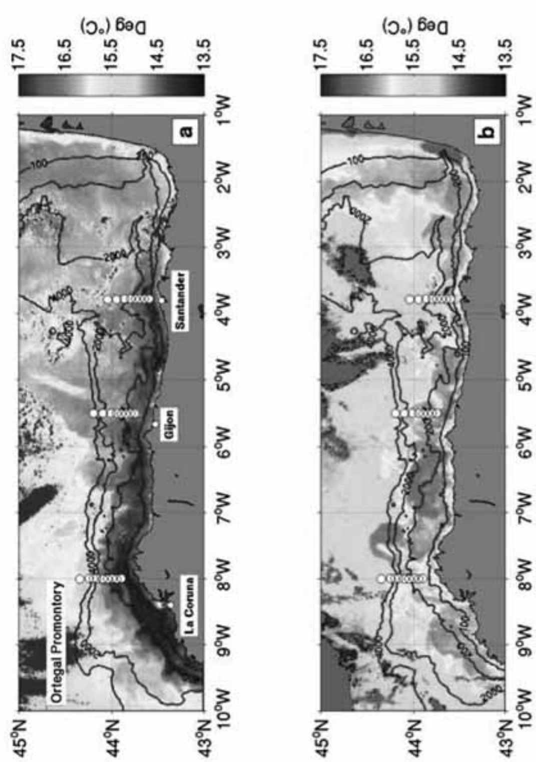

Figure 1: Satellite evidence of a warming event along the northern Spanish coast at the end of 2006. a) NOAA15 AVHRR Channel 4, 29th of November. b) NOAA17 AVHRR Channel 4, 14th of December. Images have been obtained through the AVHRR HRPT reception station of the SHOM, in Brest. CONGAS CTD station locations at 8°W, 5°30'W and 3°47'W are plotted as white circles.

Acknowledgements

This study is funded by SHOM and CNRS.

References

Llope, M., R. Anadón, L. Viesca, M. Quevedo, R. González-Quirós, and N. C. Stenseth, 2006. Hydrography of the southern Bay of Biscay shelf-break region: Integrating the multiscale physical variability over the period 1993-2003, *J. Geophys. Res.*, *111*, C09021, doi:10.1029/2005JC002963.

Luterbacher, J., M. A. Liniger, A. Menzel, N. Estrella, P. M. Della-Marta, C. Pfister, T. Rutishauser, and E. Xoplaki , 2007. Exceptional European warmth of autumn 2006 and winter 2007: Historical context, the underlying dynamics, and its phenological impacts, *Geophys. Res. Lett.*, *34*, L12704, doi:10.1029/2007GL029951.

Pingree, R. D., and B. Le Cann, 1992. Anticyclonic eddy X91 in the Southern Bay of Biscay, May 1991 to February 1992, *J. Geophys. Res.*, *97*(C9), 14,353-14,367.

Estimating turbidity indicators and total suspended matter in the Bay of Biscay using MODIS 250-m imagery

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Introduction

The European Water Framework Directive (2000/60/EC) is intended to have a strategic constructive role in water policy and proposes to conserve and restore the state of freshwater and coastal waters. It is based upon the status of biological, hydromorphological and physico-chemical quality parameters such as the transparency and the turbidity of the water. The Basque coastal area, located near the Adour mouth, is subjected to direct impact of freshwater runoff and submitted to wide variations on turbidity. Conventional sampling methods often fail to characterize turbidity dynamics because of the limitations in temporal and spatial sampling. Several studies (e.g., Miller and McKee, 2004) have shown that remote sensing techniques constitute a promising alternative to these traditional methods.

We developped a methodology in order to map turbidity in coastal water using a 250-m resolution images from the Moderate Resolution Imaging Spectroradiometer (MODIS) on board the NASA's Aqua satellite. As turbidity can be defined as a decrease in the transparency of a solution due to the presence of suspended and some dissolved substances, the estimation of Total Suspended Matter concentration (TSMc) was also performed. To achieve these objectives, an oceanographic survey in the Adour coastal waters (called BATEL-1) was carried out to measure *in-situ* turbidity indicators (turbidity by nephelometry, transmittance, and the attenuation coefficient of light *K*), and TSMc. Using regression models, empirical relationships were established between simulated 250-m MODIS-Aqua bands 1 (B1, 620-670 nm) and 2 (B2, 841-876 nm) and the water properties.

Methods

The survey BATEL-1 took place between the 4th and the 14th of June 2007. Ninety-six stations have been realized on the study area, which extended along-shore between the land coast and the Fontarabie Bay, and cross-shore between the estuarine and the marine waters (Figure 1). Thus, the water sampling covered a wide gradient of turbidity and TSMc. At each station, *in-situ* biogeochemical and optical parameters have been measured: 1) Remote sensing reflectance (Rrs) measurements with a TriOS spectroradiometer, which comprised an irradiance sensor and a radiance sensor simultaneously performing measurements with a step of 5 nm between 350 and 950 nm. We used the methodology developed by Froidefond and Ouillon (2005) with reflectance measurement just below the surface. 2) Samples of 1 litre of surface water with Niskin Bottles to measure the turbidity in Nephelometric Turbidity Units (NTU, using nephelometer Turb 430IR) and the TSMc by gravimetry (filtration through membranes of 0.47 µm porosity). 3) Optical water properties measurements with a CTD water profiler instrument, measured every 1 m within the first 13-m depth, except for lower deep stations (for instance, in the Adour River and river mouth). Two optical properties were determined: percent light transmission, or transmittance, and the Photosynthetically Active Radiation (PAR). The transmittance, which is the percentage of light in sea water that is transmitted at a certain depth, was measured by a transmissometer at 660 nm. At each site, descending irradiance Ed(z,PAR), at the spectral region of PAR, was measured at different depths (*z*) with a spherical quantum sensor Li-Cor. The spectral diffuse attenuation coefficient of light K(λ) is defined as the rate at which the natural logarithm of the descending irradiance at wavelength λ, Ed(*z*, λ), is attenuated with depth following the Beer–Lambert law. It depends on the concentration of the optically active constituents of water (Gohin et al., 2005). To calculate *K*(PAR), the vertical profiles of Ed(PAR) were, therefore, assumed to follow an exponential attenuation of irradiance with depth. The values of *K*(PAR) for each profile were determined as the slope of the regression between depth and $\ln(Ed_z/Ed_0)$.

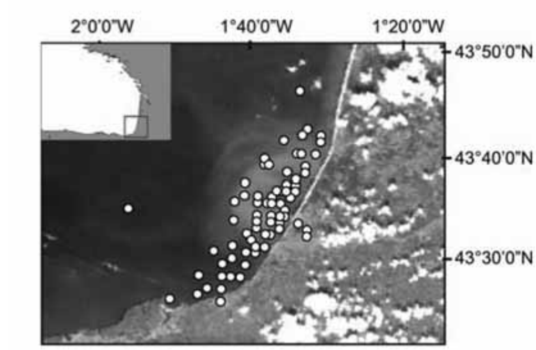

Figure 1: Study area and localisation of the stations of the survey BATEL-1.

Rrs spectra from field measurements were used to compute the simulated Rrs in the MODIS Bands 1 and 2 by weighting *in-situ* Rrs with the relative spectral responses of MODIS-aqua corresponding bands (URL: http://modis.gsfc.nasa.gov/).

The relationship between water properties (turbidity, transmittance at 1-m depth, *K*(PAR), and TSMc) and the *in-situ* Rrs spectra, i.e. simulated MODIS-Aqua B1 and B2, was determined using linear, exponential, logarithmic, polynomial (2nd order) and power regression models. At least, seventy pairs of observations were used. The mean error (%) between observed and estimated water properties was calculated to find the best regression model.

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Results and discussion

The Survey BATEL-1 acquired optical and geochemical data for three types of water masses: water of Adour estuary, water under the influence of Adour plume and water not or less affected by the plume (marine water). The Rrs measured *in-situ* increases strongly with the turbidity and TSMc, presenting also small variations observed in the marine waters (Figure 2). This increase is particularly important in the yellow band (500-600 nm, close to the MODIS B1) as observed by Froidefond and Doxaran (2004) in the Gironde estuary for the same range of TSMc. A second increase is also observed at NIR wavelengths, between 750 and 850 nm, corresponding to MODIS B2.

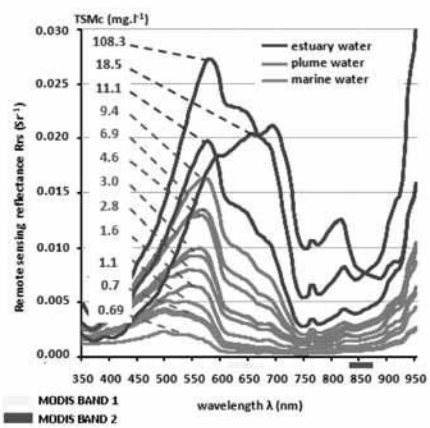

Figure 2: *In-situ* Rrs and corresponding TSMc measured for the three types of water mass.

Regression analyses have been performed from 0 to 70 NTU (corresponding to a 0-50 mg.l^{-1} TSM concentration range) because only a few concentrations larger than 50 mg.l^{-1} have been measured during the survey. The determination coefficients of regression models for the four water properties are shown in Table 1. For MODIS B1, the best relationships were obtained with linear and polynomial regression for turbidity and linear, polynomial and power regression for TSMc. For the Rrs_{B2}, the best R² for turbidity and TSMc were obtained with polynomial regressions. The reflectance ratios showed lower predictive power. All models for transmittance and *K*(PAR) presented low coefficients of determination. Transmittance was best predicted by B1 with a polynomial model (R^2=0.43). The attenuation coefficient *K*(PAR) was best predicted by B1 with a polynomial model (R^2=0.39). Although, the turbidity properties of water strongly varied with depth as a consequence of freshwater river discharge in the sea, our results do not permit to disentangle whether Rrs measurements provide information on sea surface layer or on the first meters of water column.

The Band 1 had low relationship with *K*(PAR) and very high with TSMc in the Adour-influenced coastal waters. This is in disagreement with Woodruff et al. (1999) who, using reflectance at 630 nm, obtained a stronger relationship with *K*(PAR) (R^2=0.72) than with TSMc, in estuarine waters, Pamlico Sound estuary (North Carolina). A possible explanation is that transmittance and *K*(PAR) measured here may be affected by the boat shadow within the first meters of measurements.

Table 1: Determination coefficient (R²) of the regression models tested. The values of R² of the regression models selected are indicated in bold. ns: non significant (with p = 0.01 as the criterion).

	regression model	Rrs_{B1}	Rrs_{B2}	Rrs_{B1}/Rrs_{B2}
Turbidity (< 70 NTU)	**Linear**	0.896	0.727	0.500
	Exponential	0.487	0.558	0.661
	Log	0.429	0.400	0.347
	Polynomial 2	**0.963**	0.917	0.770
	Power	0.789	0.690	0.703
TSMc (< 50 mg.l^{-1})	**Linear**	0.944	0.787	0.572
	Exponential	0.645	0.703	0.780
	Log	0.487	0.437	0.401
	Polynomial 2	**0.972**	0.927	0.824
	Power	0.874	0.760	0.753
Transm. (1 m)	**Linear**	0.369	0.359	0.016 (ns)
	Exponential	**0.438**	0.399	0.018 (ns)
	Log	0.413	0.342	0.165
	Polynomial 2	0.428	0.381	0.428
	Power	0.397	0.323	0.163
***K*(PAR)**	**Linear**	0.274	0.220	0.014 (ns)
	Exponential	0.199	0.185	0.014 (ns)
	Log	0.235	0.197	0.095
	Polynomial 2	**0.294**	0.251	0.240
	Power	0.252	0.218	0.096

Conclusions

The results obtained here showed that simulated MODIS-Aqua Band 1 and 2 are appropriate for prediction of turbidity and TSMc using polynomial regression models. In contrast, MODIS Band 1 and 2 had low predictive power for percent light transmission at 660 nm near sea surface (1-m depth) and for attenuation coefficient of light *K* across water column at PAR wavelength region. The regression models can be applied to the atmospherically-corrected MODIS estimate surface reflectances in the Band 1 (MODIS product of level 2) to map turbidity and TSMc distribution.

Acknowledgements

This research was supported by the Lyonnaise des eaux of Biarritz, the Ministry of Education and Science (Spanish Government, Ref.: ESP2006-10411) and by the Funds for Aquitania–Euskadi cooperation (Basque Government and Aquitaine Region).

References

Froidefond, J.M. and Ouillon, S., 2005. Introducing a mini-catamaran to perform reflectance measurements above and below the water surface. *Optics Express*, 13: 926-936.

Froidefond, J.M. and Doxaran, D., 2004. Teledetection optique appliquée à l'étude des eaux côtières. Télédétection, 4, n° 2: 579–597.

Gohin, F., S. Loyer, M. Lunven, C. Labry, J. M. Froidefond, D. Delmas, M. Huret, and A. Herbland. 2005. Satellite-derived parameters for biological modelling in coastal waters: Illustration over the eastern continental shelf of the Bay of Biscay. *Remote Sensing of Environment*, 95: 29-46.

Miller, R.L. and McKee, B.A. 2004. Using MODIS Terra 250 m imagery to map concentrations of total suspended matter in coastal waters. *Remote Sensing of Environment*, 92: 259-266.

Woodruff, D. L., R. P. Stumpf, J. A. Scope, and H. W. Paerl. 1999. Remote estimation of water clarity in optically complex estuarine waters. *Remote Sensing of Environment*, 68: 41-52.

Interannual variability of river plumes in the southern Bay of Biscay during spring

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Introduction

The Bay of Biscay is a complex system influenced by diverse hydrographical processes, such as poleward slope currents (Iberian Poleward Current), river plumes, cyclonic and anticyclonic eddies and coastal upwelling and downwelling events (Valdés and Lavín). The physical environment affects the composition and structure of planktonic communities, and therefore modulates differents aspects of ecosystem functioning and dynamics (Paffenhoffer, 1980, Landry et al. 2001).

Among all of the mesoscale processes, river plumes and their associated haline fronts are an important factor that determine the dynamics of the pelagic community, from planktonic organisms to fishes. River plumes promote vertical stratification and produce nutrient enrichment of the surrounding waters, thus fueling high levels of primary and secondary production (Labry et al. 2001a 2001b). These characteristics make that the areas influenced by plumes can provide a suitable environment as a nursery for most of pelagic fish species (Uriarte et al. 1996). Thus, The study of the interannual variability of such hydrographic features is necessary to gain a better understanding and to improve the management of the pelagic community.

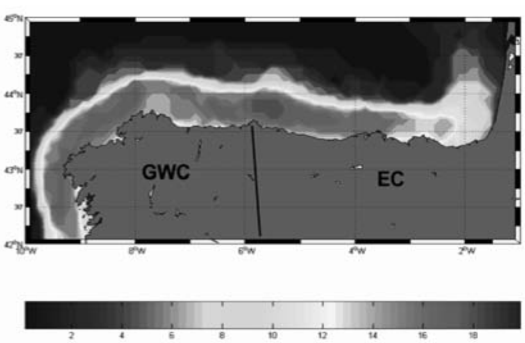

Figure 1: Frequency of sampling during the spring cruises carried out from 1987 to 2006. The black line separate the two hydrological domains used in the posteriors analysis: the Galician and West Cantabrian Sea (GWC) and East Cantabrian Sea (EC) regions respectively.

Methods

From 1987 to 2006, 19 cruises were carried out during spring months along NW and N Iberian shelf. During these cruises, a total of 1984 CTDF casts (conductivity, temperature, depth and fluorescence) were undertaken. Figure 1 shows the density of

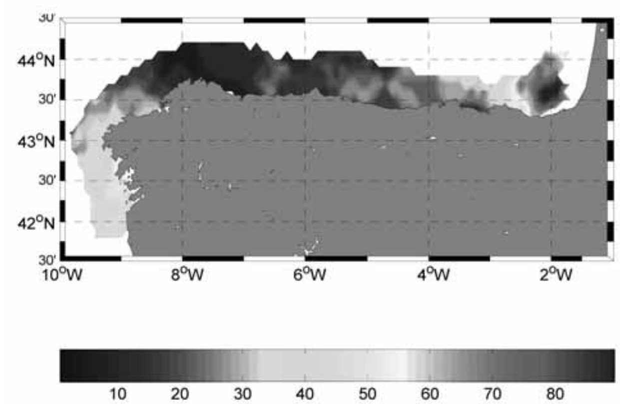

Figure 2: Percentage of presence of river plumes

sampling along the north Spanish shelf, that in most of the cases was higher than 15 cruises. In order to determine de influence of river plumes, we interpolated the salinity at 10 m depth using an objective interpolation method (Haagenson, 1982) that generated a regular and comparable grid for each year. The area influencied by river plumes (PA) was defined by the locations where the salinity gradient was higher than 0.015 nm^{-1}.

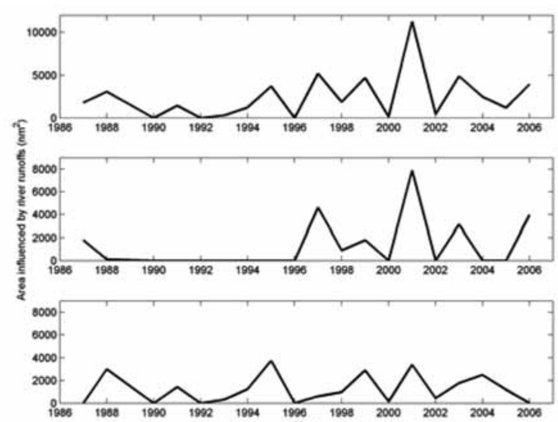

Figure 3: Interannual variation of the area influenced by river plumes (PA) for the whole sampling area (up), and form the Galician and West Cantabrian Sea (middle) and East Cantabrian Sea (bottom) regions separately.

The time series of the monthly mean precipitation rate were obtained from the Climate Prediction Centre of the NOAA (http://www.cpc.ncep.noaa.gov) and used to determine the months that were more relevant for the generation of river plumes during the spring season. We performed a lagged correlation analysis between the 3-monthly averaged time series of precipitation rate (e.g. the value of January is the averaged of the mean precipitation rate of January, December and November) and the time series of PA of each region.

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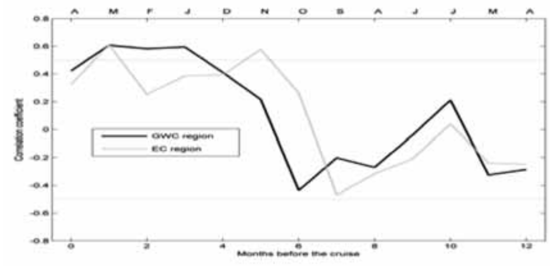

Figure 4: Correlation coefficient calculated using a lagged correlation analysis between the area influenced by river plumes and the 3-monthly mean precipitation rate. Horizontal lines mark the 0.01 significance level.

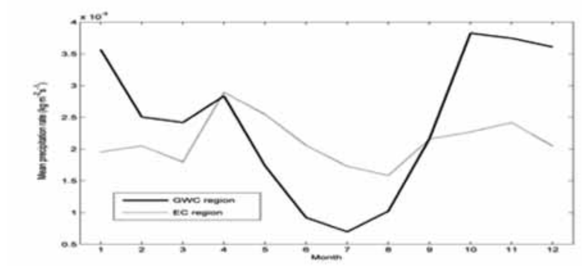

Figure 5: Seasonal cycle of precipitation rate of the GWC region (black line) and EC region (grey line) derived from the monthly mean precipitation rate.

Results and Discussion

According to the distribution of frequency of occurrence of river plumes, we found two areas with relatively high river runoff activity (Figure 2). In the easternmost part of Cantabrian Sea, influenced by runoof from the Adour river, the frequency of presence of plumes was higher than 80%.. The other area was located off the Galician coast, influenced by runoffs from the Rías Baixas and the Miño river, where the frequency of occurrence of plumes reached values of 50-60%. The rest of the studied area was characterized by an sporadic presence of river plumes (<20% of frequency of occurrence).

The time series of the PA was calculates for the whole area, and for the Galician and West Cantabrian Sea (GWC) and the East Cantabrian (EC) regions separately (Figure 3). We found clear differences between these two regions.

In the WGC region, we found two well defined periods. From 1986 to 1996, river plumes were much less intense than in the 1996 to 2006 period. The intensity of the river plumes in this region was positively correlated with the precipitation rate estimated during the winter months (November to march) in this area (Figure 4).

In the case of the EC region, the influence of the plumes was more regular. The PA was positively correlated with the precipitation rate estimated in this area for the months previous to the cruise (January to March), but also with the autumn months (September to November) (Figure 4).

In both regions, the period of correlation between the intensity of the influence of river plumes and the precipitation index coincide with the months with the maximum precipitation values attained seasonally (Figure 5). The differences observed between both regions could be due to the distinct characteristics of the drainage basin (i.e. catchment area, orography) of the rivers affecting each region. For instances, the GWC region is characterized by small catchment areas and orographic features with less than 2000 m height (e.g. Galician Massif and Cantabrian Range), whereas in the EC regions, the rivers have a larger catchment area including orographic features that reach more than 3400 m heigh, thus favouting the accumulation of snow precipitations. This fact will explain the influence of the precipitations occuring in autumn.

Conclusions

In the spring season, we have found two regions which are more frequently affected by river plumes: the Galician Coast and the Easternmost part of the Cantabrian Sea.

The East Cantabrian Sea region was characterized by an almost constant presence of plumes all along the studied perios. In Galicia and West Cantabrian Sea region, we observed two contrasting periods; the one from 1987 to 1996, characterized by the absence of intense plumes, and the other from 1997 to 2006 characterized by intense plumes.

The interannual variability of the area influenced by plumes is correlated with the precipitations of the previous months, and the variability of this process is likely dependent of the characteristics of the catchment area in each of these regions.

Acknowledgements

The authors would like to thank all people that collaborated in the cruises and in the processing of all the data used in this work. G. G-N is a recipient of a pre-doctoral fellowship from the ‘Consejería de Educación y Cultura del Principado de Asturias’.

References

Haagenson, P. L., 1982. Review and evaluation of methods for objective analysis of meteorological variables, Meteorological. Research. 5: 113-132.

Labry, C., Herbland, A., and Delmas, D.: The role of phosphorus on planktonic production of the Gironde plume waters in the Bay of Biscay, J. Plankt. Res., 24, 97–117, 2001.

Labry, C., Herbland, A., Delmas, D., Laborde, P., Lazure, P., Froidefond, J. M., Jegou, A. M.,and Sautour, B.: Initiation of winter phytoplankton blooms within the Gironde plume waters in the Bay of Biscay, Mar. Ecol. Progres. Ser., 212, 117–130, 2001.

Landry, M.B., Al-Mutairi, H., Selph, K. E., Christensen, S. and Nunnery, S., 2001. Seasonal patterns of mesozooplankton abundance and biomass at station ALOHA. Deep-Sea Research II. 48: 2037-2061.

Paffenhöfer, G.-A., 1980. Zooplankton distribution as related to summer hydrographic conditions in Onslow Bay, North Carolina. Bulleting of Marine Science. 30: 819-832.

Uriarte A., Prouzet P., Villamor B. (1996) Bay of Biscay and Ibero Atlantic anchovy populations and their fisheries. Scientia Marina 60:Suppl. 2, 237–255

Valdés, L. and A. Lavín, 2002. Dynamics and human impact in the Bay of Biscay: an ecological perspective. In K. Sherman and H.R. Skjoldal, eds. Large Marine Ecosystems of the North Atlantic—Changing states and Sustainability. Forthcoming volume, Elseviers. 293-3

Influence of the Bay of Biscay sea surface temperature on the rainfall in NW of Iberian Peninsula

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Introduction

The role of the sea surface temperature has a main importance in the control of climate due to the processes of evaporation, precipitation and atmospheric heating. In this way, considering seasonal timescales, anomalies in the atmospheric variables are often associated to sea surface temperature anomalies (SSTA). In fact, due to the high inertia of the ocean, SSTA is one of the most convenient variables to be used as climatic predictor. It must be reminded that the atmospheric models precise of its value to produce a suitable seasonal forecast and of course in the climate models the influence of the sea is indispensable.

Previous studies have linked anomalies of sea level pressure and precipitation variability with change in the SST (Rodwell 1998; Rodriguez *et al.*, 2006) and analyze the influence of the global scale sea surface temperature patterns on continental precipitation and temperature.

Globally, the European weather is one of the most difficult to forecast due to the absence of a forcing similar to ENSO where the coupling atmosphere-ocean is very strong. In our study area, previous work have shown the influence and necessity of more than one teleconnections pattern to explain the winter precipitation variability (Lorenzo and Taboada, 2005; DeCastro et al, 2006). In particular, NAO, EA, EA/WR and SCAND are the main patterns to explain this variability.

The main objective of our study is to describe relations between monthly values of rainfall for nortwest of the Iberian Peninsula and concurrent variations in North Atlantic SST in particular with the Bay of Biscay.

Data and Methods

Monthly precipitation data from 1950-2006 were obtained from the database CLIMA of the University of Santiago de Compostela of the National Institute of Meteorology (INM) and the Xunta de Galicia (Consellería de Medio Ambiente) that are distributed throughout Galicia. These series of data underwent a quality control procedure with substitutions made for poor quality and some missing data, similar to the one used in the NCDC (National Climate Data Center, NOAA) for GHCN (Global Historical Climate Network) database (Peterson et al. 1997). Quality control for these series of data gave a result of only 0.01% of missing data and 90% of correlation with neighbour stations.

The SST data were provided by the NOAA/OAR/ESRL PSD, (Smith and Reynolds, 2003; Smith and Reynolds 2004). We have considered the monthly averaged data with a 2.0 degree resolution. Data were taken from 1 January 1950 through December 2006. Data are available monthly SST for the region, 0-70ºN y 100ºW-20ºE. We will focus our study in the area of the bay of biscay. This restriction does not implies that the existence of significant relationships is confined to this area. There might be association between other SSTs, but this influence is out of the scope of this work.

The Pearson product-moment correlation coefficient r was considered to quantify the linear association between the SSTA of each 2.0 x 2.0º grid square and monthly precipitation total. The significance of the coefficient was assessed at the 99.5% by means of Student's t test.

As it is possible to obtain a statistically significant correlation simply by doing correlation between two random number series, we applied a test for field-significance considering the properties of finiteness and interdependence of the spatial grid (Phillips and McGregor, 2002; Phillips and Thorpe, 2006).

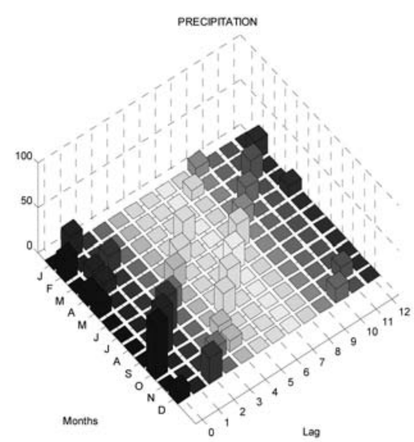

Figure 1. Months and Lags where the percentage of grid squares locally significant at the 99% satisfy the finiteness and interdependence criterion.

Results

The results show an influence of the SST anomalies in the area of North Atlantic in the behaviour of the precipitation troughout some months of the year as it is shown in figure 1. It is particularly remarkable the influence on rainfall in october, one of the wettest months in the year. It can also be seen that considering a period

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of three months of delay as a maximum, the period between September and April has a statistically significant correlation between SSTA and rainfall. This result gives some skill to forecast rainfall anomalies both in autumn, and winter.

Once determined the months and lags significants we analyze the spatial distribution of locally significant correlations. In figure 2, we can see that the pattern of SST anomalies in the NE Atlantic area that gives a certain influence on rainfall of the NW peninsular consists in a positive correlation between the SST in the Biscay Bay and the autumn rainfall.

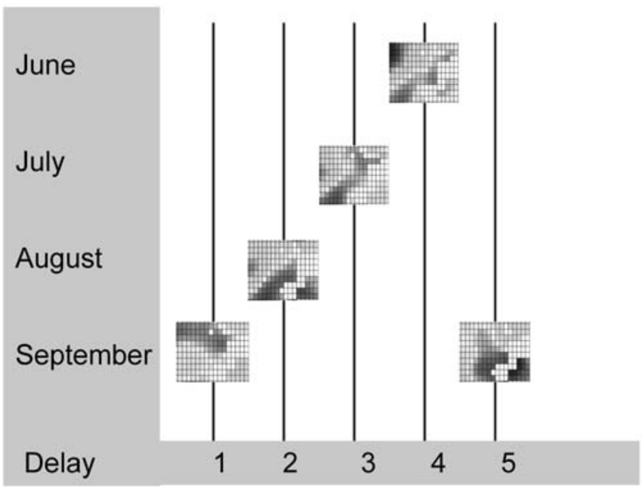

Figure 2 Months and Lags where the bay of Biscay show a strong correlation with the rainfall of the northwest of Iberia.

Conclusions

NW of Iberian Peninsula is a region with numerous climatic influences. This study presents the SST of the bay of biscay as a possible tool to analize the behavior of the precipitation in this area. In this work we correlated the North Atlantic SSTA with monthly rainfall, and the results show that there exists significant influences between the temperature of Bay of biscay in summer months and autumn rainfall in the area of study. There is also some significant correlation among SSTA in autumn and rainfall anomalies in winter. In this way we have found a predictor for the rainfall in the wettest part of the year that must be complemented with anomalies in other parts of the world ocean or even other parts of the climate system, such as teleconnection pattterns or snow cover, to implemente a seasonal forecast.

Acknowledgements

Nieves Lorenzo acknowledges the support by the Ramon y Cajal program.

References

Phillips I.D., McGregor G.R., 2002. The relationship between monthly and seasonal south-west england rainfall anomalies and concurrent north Atlantic sea surface temperatures. *International Journal of Climatology*, 22: 197-217.

Phillips I.D., Thorpe J., 2006. Iceland precipitation- north Atlantic sea surface temperature associations. *International Journal of Climatology*, 26: 1201-1221.

Rodwel, M.J., Rowell D.P., Follan C.K., 1998. Oceanic forcing of the wintertime North Atlantic Oscillation and European climate. *Nature*, 398: 320-323

Rodriguez-Fonseca, B., Polo I., Serrano E., Castro M., 2006. Evaluation of the North Atlantic SST forcing on the European and Northern African winter climate. *International Journal of Climatology*, 26: 179-191.

deCastro, M., Lorenzo, M.N., Taboada, J.J., Sarmiento, M., Álvarez I., Gómez-Gesteira M., 2006. Teleconnection patterns influence on precipitation variability and on river flow regimes in the Miño River basin (NW Iberian Peninsula). *Climate Research,* 32: 63-73.

Lorenzo M.N., Taboada J.J., 2005. Influences of atmospheric variability on freshwater input in Galician Rías in winter. *Journal of Atmospheric and Ocean Sciences*, 10(4): 1-11 (2006)

Smith, T.M., and R.W. Reynolds, 2003: Extended Reconstruction of Global Sea Surface Temperatures Based on COADS Data (1854-1997). Journal of Climate, 16, 1495-1510.

Smith, T.M., and R.W. Reynolds, 2004: Improved Extended Reconstruction of SST (1854-1997). Journal of Climate, 17, 2466-2477.

The Winter-Spring transition off North and Northwest Iberia: comparison between model and observations

Pablo Otero*[a] and Manuel Ruiz-Villarreal[a]

Introduction

Off North and Northwest Iberia, the timing of the spring transition in relation to the period of the spring phytoplankton bloom and the spawning of different species is critical in determining growth and survival (Ruiz-Villarreal el al, 2006). This time depends on the strength of the prevailing oceanographic conditions during winter (river plumes, the presence of the poleward slope current, stratification, etc.) and the time of change of meteorological conditions from downwelling to upwelling favourable.

In this study, model results are compared with a set of survey data from November 2002 to April 2003, an intensively sampled period. Model results allow a detailed description of the variability of the oceanographic processes involved.

Methods

Survey data

Observations come from CTD data sampled by the Instituto Español de Oceanografía during routine fisheries assessment cruises (Pelacus03) and during cruises aimed to study the hydrography, circulation and biochemistry in the area affected by the Prestige oil spill (PrestigePlataforma1202, PrestigePlataforma0103 and Hidro-Prestige0303).

Model setup

The model employed is the Regional Ocean Modelling System in the version with nesting capability (Penven et al., 2006). In our experiment a 10 km spatial resolution domain covering the area of the Eastern Boundary Current System was spun-up for three years, until the eddy kinetic energy converges to a stationary mean value. This experiment was forced and initialized with climatologic fields from Levitus and COADS. Results from this experiment are employed to force boundaries of the target simulation.

The target simulation consists on two grids with 4 km (covering West Iberia from coast to 14ºW and North Iberia from coast to 45ºN) and ~1.3 km of spatial resolution (focused in the western shelf and slope). Vertical discretization is 40 levels with resolution increased near the surface (θ_s=6.0) and the bottom (θ_b=0.2). Simulation started at the end of summer 2002, when run-off is reduced and ran until the end of April 2003. Mean daily estimations for 16 rivers are introduced in the model. Tide is introduced with the main 8 harmonics. Surface forcing consists on 6 hourly data from a high resolution (30 km) meteorological model (HIRLAM; Instituto Nacional de Meteorología).

Results

Figure 1 shows the upwelling index computed from geostrophic winds in a 2º x 2º cell centered at 43ºN 11ºW (Blanton et al., 1984), a first order of characterization of the effect of the large scale winds on the circulation in the area.

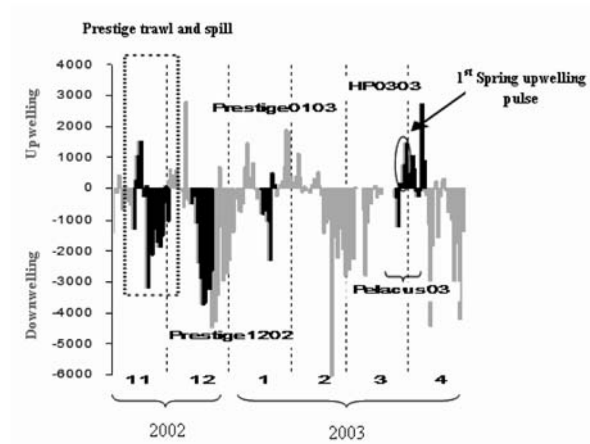

Figure 1. Upwelling index (x10^6 m^3 s^{-1} km^{-1}) with indication of cruises referred in the text.

As observed in previous figure, at the time of the Prestige 1202 cruise (12-22 December), downwelling conditions prevailed in the sampled area (the area covered the shelf and slope from River Miño to A Coruña). The shelf is dominated for river plumes from local rivers with a salinity surface front around the 200 m isobath. The higher freshwater input from River Miño and Rías Baixas is evident off the western coast, contrasting with the region northern Cape Finisterre. Subsurface water present a salinity maximum around 100 db with characteristics of ENACWst. Model results offer reasonable comparisons with previous observations south from Cape Finisterre (see Figure 2 as example of these comparisons). However, north from Cape Finisterre, the modelled slope current occupies most of the shelf extension.

One month later, the PrestigePlataforma0103 cruise (15-22 January) sampled a reduced area between Cape Finisterre and A Coruña. Light downwelling winds prevailed in the area and similar temperature and salinity distributions were observed, although the temperature in upper waters was lower than previous month. The simulation reproduces the maximum salinity signal of the slope current.

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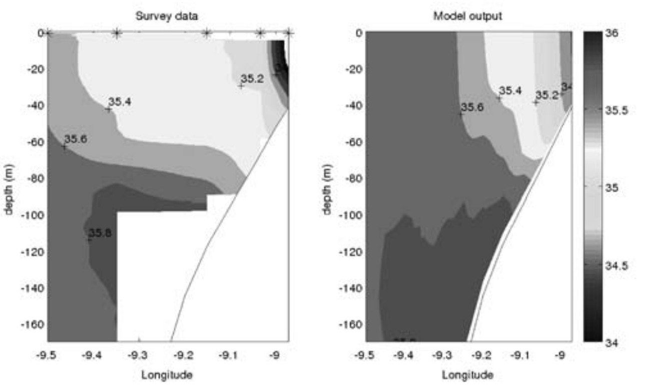

Figure 2. Observed versus modeled salinity along a section at 42.5ºN

The Galician shelf was sampled from 19-29 March during the Pelacus03 cruise. The first upwelling pulse of this year took place during the cruise. Surface salinity was fresher than during previous cruises and the upwelling induced an offshore expansion of river plumes. Saltier waters from the slope current were only observed off western Iberia and not in the Cantabrian domain. Similar conditions were observed off West Galicia during the HidroPrestige0303 cruise (26 March-1 April). Model results reproduce satisfactorily observed river plumes southern Cape Finisterre and also the location of the slope poleward current. Major discrepancies with observations appear off North Iberia where river plumes near the coast are underestimated and the presence of the slope current occupies the most of the shelf.

Discussion

During autumn, when downwelling favourable winds were predominant and river discharge was high, river plumes developed over the shelf and were confined to the coast. During winter, run-off accumulated freshwater over the shelf and contributed to increase the size of the buoyant structure. With the first upwelling pulses during spring, the accumulated freshwater is exported and spreads offshore, getting shallower (e.g., Ruiz-Villarreal et al., 2006). This seasonal variability is properly described in model results, with the advantage that the model resolves the fast response of river plumes —in the scale of hours— to wind event variability (Otero et al., 2008). Main discrepancies with observations appear over the northern shelf of Iberia, where numerous although low-discharge rivers flow along the coastline. Comparisons reveal that model simulations with real daily discharge data are critical for an adequate freshwater budget, specially in the northern shelf.

On other hand, the poleward slope current showed a maximum signal during November and December, weakening toward the spring. At the Cantabrian Sea, the poleward slope current is not observed during spring cruises. Model results also reveals this weakening (see Figure 3), with a stronger presence over the western than the northern slope.

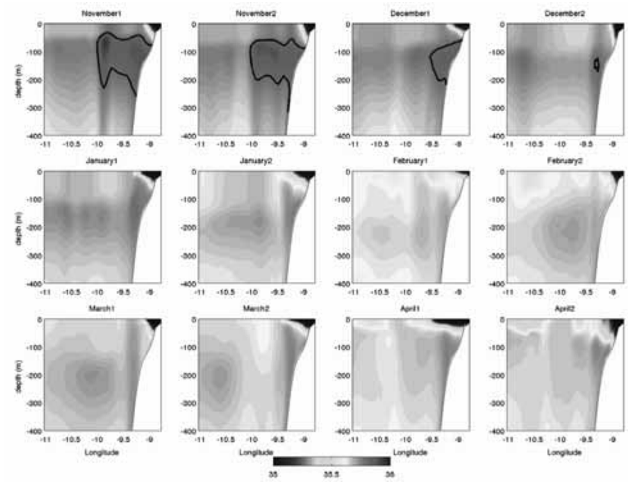

Figure 3. Forthnightly mean salinity sections off Ría de Vigo from November 2002 to April 2003.

Acknowledgements

Pablo Otero is supported by PLATERIAS and REFORZA project (PGIDIT06RMA60401PR), Xunta de Galicia and IEO. Cruises have been funded by the Special Action of the Spanish CICYT 'Reconocimiento oceanográfico en la zona de hundimiento y talud' and project VACLAN, with additional funding from the IEO. We thank all the staff responsible for data acquisition and distribution.

References

Blanton, J. O., L. P. Atkinson, F. Fernández de Castillejo and A. Lavín, 1984. Coastal Upwelling off the Rías Bajas, Galicia, NorthWest Spain. I: Hydrographic Studies. Rapports et Procés Verbaux CIEM, Vol. 183, pp. 79-90.

Otero, P., Ruiz-Villarreal, M. and A. Peliz, 2008. Variability of river plumes off NorthWest Iberia in response to wind events. Journal of Marine Systems. *In Press*

Penven, P., L. Debreu, P. Marchesiello and J. C. McWilliams, 2006. Evaluation and application of the ROMS 1-way embedding procedure to the central California Upwelling System. Ocean Modelling, 12, 157-187.

Ruiz-Villarreal, M., C. González-Pola, G. Díaz del Río, A. Lavín, P. Otero, S. Piedracoba and J. M. Cabanas, 2006a. Oceanographic conditions in North and NortWest Iberia and their influence on the Prestige oil spill. Marine Pollution Bulletin, 53(5-7), 220-238.

Monitoring physicochemical characteristics of coastal water bodies in Cantabria (Biscay Gulf)

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Introduction

One of the main Water Framework Directive's statements consists on the development of monitoring networks which provide information about each aquatic system. For that aim the Littoral Water Quality Monitoring Network was implemented in 2005 to define and control the quality status of estuarine and coastal water masses of Cantabria (Northern Spain, Gulf of Biscay). As a result, an intense study of physicochemical features of coastal water bodies of Cantabria has been developed throughout the last three years within the monitoring network. Such studies have provided information about optical, thermal, nutrient and oxygen conditions of coastal waters, as well as evidences of water pollution incidents, stemming from close estuarine areas.

Methods

Within this monitoring network as a whole, two main zones of study are comprised which are estuarine and coastal water bodies. This work is focused on the study of the latter ones.

The coastal area enlarges upon 211 km, enclosed between Tina Mayor Ria, as west endpoint, and Punta de Covarón, on the eastern side. A total number of 21 sampling stations (Figure 1) were settled along the coast, at the bathymetry of 25 meters and more or less 1-2 miles away from the coast line. Five sampling campaigns were carried out in this area during 2005-2006's period, to describe water column's features.

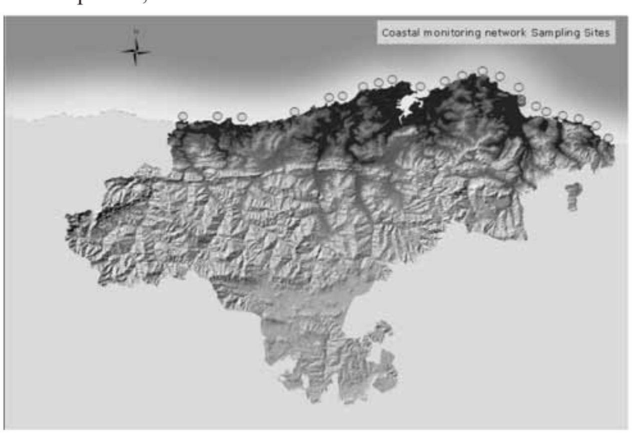

Figure 1.. Study area. Sampling sites located along Cantabrian coast

Physicochemical variables selected to study water quality are shown in Table 1.

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Parameter	Technique	Standarized analitical methods
Temperature	Electrometry	Electrometry
Salinity	Transformation of conductivity measures	UNE-EN-27888
Chlorophyl "a"	Electrometry	Electrometry
	Espectrophotometry	APHA 10200 H
	Fluorometry	APHA 102004 Chlorophyll
Dissolved Oxygen	Yodometry (Winkler method)	UNE-EN 25813
	Electrometry	Electrometry
Radiation (PAR)	Electrometry	Electrometry
pH	Potenciometry	MET APHA 4500-H^+ B
Turbidity	Turbidimetry	UNE-EN-27027
Colour	Colorimetry	Pt-Co colorimetric appraisal
Suspended solids	Gravimetry	UNE-EN-872
Ammonium	Espectrophotometry	APHA 4500 NH_3^- H
Nitrate	Espectrophotometry	APHA 4500 NO_3 F
Nitrite	Espectrophotometry	APHA 4500 NO_2^- A
Total Kjeldahl Nitrogen	Acid-base valoration	UNE-EN 25663
Phosphate	Espectrophotometry	APHA 4500 P F
Total Phosphorous	Espectrophotometry	MET EPA 6020
Total Organic Carbon	Infrared analyser	UNE-EN-1484
Mineral Oils	Espectrophotometry IR	MET APHA 5520 C
Detergents	Espectrophotometry UV	APHA 5540 C
Total Coliforms	Membrane filtration	APHA 9222 B
Fecal Coliforms	Membrane filtration	MET APHA 9222 D
Fecal Streptococci	Membrane filtration	MET APHA 9230 C

Table 1. Parameters measured alt all coastal sampling sites and their analytical methods..

Measurements of these variables were carried out combining Sea-Bird 25 CTD water profiles with sampling at different depth intervals (surface, medium depth and bottom). A 12-place rosette with 5-L Niskin bottles was used for that purpose. Water samples were preserved according to standard methods (Chapman, D. 1996, "Water Quality Assessments") and analyzed using the techniques indicated in Table 1.

Results and Discussion

Natural temperature variations have been recorded during the project's development period. Similarly, trends in water salt concentration were pointed out. Medium Oxygen saturation percentages maintain over 96% at all seasons, which is expected for coastal waters. Winter registered oxygen values are the most homogeneous, due to the complete mixing of the water column. Chlorophyll "a" concentrations range between minimum values of 0,16 mg/L and a maximum of 1,08 mg/L. This values are low, even for Cantabrian coastal waters, which, in general, have limited chlorophyll "a" loads. Slight increases in its concentration usually happen in summer seasons, and specially, in areas closer to plentiful rivers, which probably contribute in an extent way to coastal waters' enrichment in organic matter. Also, these areas are the only ones in where water colour detection boundary is overtaken. As for nutrients, these show low values as a whole, although differences between zones can be pointed out. Concretely, ammonium reaches its higher concentrations in areas closer to frequent sewage discharges (Figure 2), while nitrate appears to be associated to intense basin drainages that mainly occur during wet seasons.

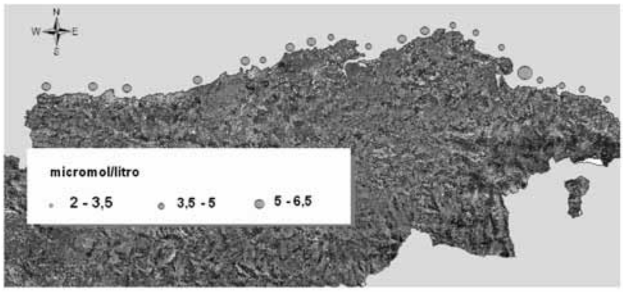

Figure 2. Ammonium concentration along coastal water bodies.

Regarding to Phosphorous concentrations, those are quite low in all campaigns. There is no evidence of oils and detergents contamination, since all values for mineral oils are under 0,3 mg/L and those for detergents remain under detection limits. Finally, to assess fecal contamination in coastal waters, guidelines settled by bathing water's Directive (76/160/EC) have been taken into account. In the study period, mean values of total coliforms don't exceed guide values. The higher values that have been registered are those of November campaigns, which can be associated to intense basin drainages. Fecal coliforms' density remains generally low, although concrete areas show higher values than the rest as a typical trend (Figure 3). Guide value for fecal streptococci is more often exceeded in wet seasons, and their appearance is sometimes related to that of fecal coliforms.

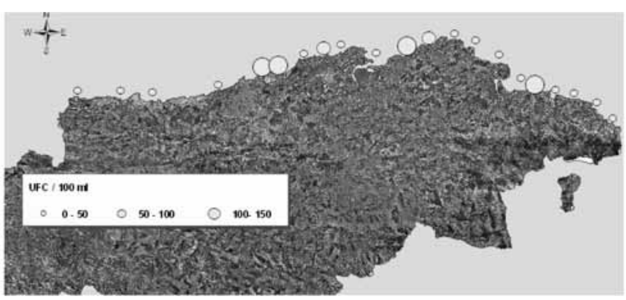

Figure 3. Fecal coliform's density along coastal water bodies.

Conclusions

In general, studies in the quality of littoral water bodies carried out in Cantabria during 2005-2006 period have served as a basis for obtaining an early diagnosis in most relevant physicochemical features related to quality in aquatic systems. The execution of these kind of studies provides great amounts of information, which is essential for designing an adequate systematic monitoring network in Cantabria. Using and analysing collected information has been useful to establish mean reference conditions, in order to detect episodes of water quality alteration, and know as much as possible of their origin.

References

76/160/EEC, Council Directive

2000/60/CEE, W., European Parliament and the COUNCIL, 2000

Aubry, A. and M. Elliott (2006). "The use of environmental integrative indicators to assess seabed disturbance in estuaries and coasts: Application to the Humber Estuary, UK." Marine Pollution Bulletin 53(1-4): 175-185

Bald, J., Borja, A., Muxica, I., Franco, J., Valencia, V. (2005). «Assessing reference conditions and physicochemical status according to the European Water Framework Directive: A case study from the Basque Country (Northern Spain).» Marine Pollution Bulletin 50: 1508-1522

Chapman, D. (1996) «WATER QUALITY ASSESMENTS. A guide to the use of biota, sediments and water in environmental monitoring». UNESCO/WHO/UNEP.

Dworak, T., C. Gonzalez, et al. (2005). "The need for new monitoring tools to implement the WFD." Environmental Science & Policy 8(3): 301-306.

F. Colijn, K.J. Hesse, N. Ladwig, U. Tillmann (2004). "Effects of the large-scale uncontrolled fertilization process along the continental coastal North Sea." Hydrobiología.

Herman, P. M. J. and C. H. R. Heip (1999). "Biogeochemistry of the Maximum Turbidity Zone of Estuaries (MATURE): some conclusions." Journal of Marine Systems 22(2-3): 89-104.

Iriarte. A., d. l. S. A., Orive.E. (1998). "Seasonal variation of nitrification along a salinity gradient in an urban estuary." Hydrobiología.

Johnson, A. (1979). "Estimating Solute Transport in Streams from Grab Samples." Water Resources Research 15(5): 1224-1228.

LA Molot, P. D. (1997). "Colour - mass balances and colour - dissolved organic carbon relationships in lakes and streams in central Ontario." Canadian Journal of Fisheries and Aquatic Sciences 54((12)): 2789-2795.

NOAA, U. S. C. o. O. P. Creating a National Water Quality Monitoring Network: 8. www.noaa.gov

Smith (1996). "Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen." Ecological Applications 8(3): 559-568.

Bay of Biscay's temperature and salinity climatology

Frédéric Vandermeirsch, Romain Charraudeau, Armel Bonnat, Michèle Fichaut, Catherine Maillard, Fabienne Gaillard and Emmanuelle Autret [a]

Introduction

In order to produce a reliable reference for temperature and salinity fields in the bay of Biscay, the IFREMER has decided to collect all the information from all of the profiles available for the zone and use it to produce an atlas composed of a map and numeric files. The resulting climatology is an optimal analysis of all the historical data from the profiles of temperature and salinity from the SHOM (46%), WDCA (35%), IFREMER(17%), UKHO (1%), and MEDS (1%) in the bay of Biscay. The zone of the bay of Biscay extends from 15°W to 1°W in longitude and 50°N to 43°N in latitude. The database covers a long period from 1862 until today with an irregular distribution. Optimal analyses shown in this atlas are limited by the nature of the database (data are scattered in space, especially for high depth), characteristics of the optimal analysis techniques, and the grid used. Annual, seasonal, monthly, interannual analyses have been computed for temperature and salinity. The resulting climatology is unique in two ways; firstly, this database is the first of its kind, indeed no such database has ever been established before for the bay of Biscay. Secondly, this is the first time that different scales have been used in the analysis, thereby reflecting the physical properties of different circulations.

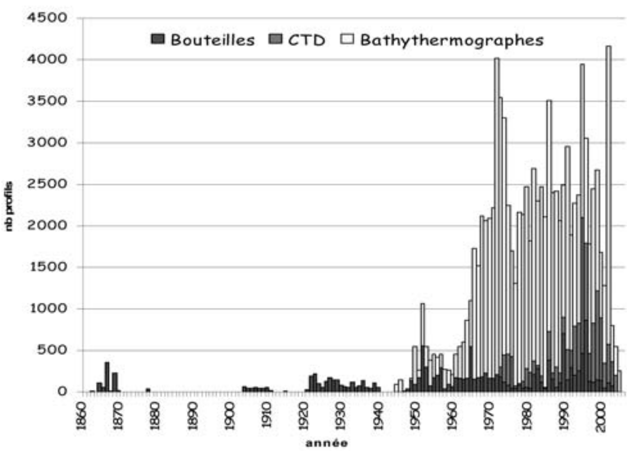

Figure 1. Temporal distribution.

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Methods

Data distribution

Profilers, buoys, bottles, CTD and XBT profiles are used in this project. Quality control has been done by selecting the data in the format and inconsistent measure are eliminated. To have enough data for each level, we have made a vertical interpolation of observed level data to standard levels which are used for our analysis. We have described the data by spatial distribution, distribution by depth after the vertical interpolation and temporal distribution (Figure 1). We have deduced that these analyses are consistent in a spatial order and that they are more representative from the end of the 20th century. Below 2000m, we have got less data, so the maps produced for these depths are less precise.

Optimal estimation method

The analysis is derived from optimal estimation methods as exposed by Bretherton & a, 1976. The solution is resolved as an anomaly relative to a monthly profile's climatology. This profile's climatology is a spatial mean of the data by depth. For each monthly analysis, all the data of the month are collected and converted to anomalies relative to the climatology to build the data vector d. The covariance matrices involved in the equation:

$$x^a = x^f + C_{ao} (C_o + R)^{-1} d$$

are constructed using the gaussian structure functions in space including the data noise. These covariance matrices integrate different scales according to different area, like shelf or abyssal plain. The variances are deduced from the dataset. After calculating the profile's climatology, we have produced analyzed fields in temperature and salinity on 261 standard levels between 0 and 4000m, for each month. We have deduced the seasonal and annual climatology from the monthly climatology by a simple mean. The grid spacing is 1/5°.

Multi-scale influence

The particularity of our project is that we have respected different scales. Indeed near the coast, predominant effects are local effects like plume or upwelling, and on the contrary on the abyssal plain the variability is modified to large scale circulation. To respect these physical properties we modified the optimal analysis by changing the value of the radius of influence in the gaussian structure functions. To mix this both scales we have summed two covariance matrices one with a low scale and one with a large scale (Autret and Gaillard, 2004).

Results

Climatologies

This project generated different climatologies (www.ifremer.fr/climatologie-gascogne). First we have the monthly climatology profiles, used in the optimal estimation to compute the monthly and the interannual climatology. With the monthly climatology, we obtain different kinds of information like seasonal and annual climatology, and monthly vertical sections. From the monthly climatology we can compute the monthly density and the monthly geostophical stream.

Monthly profile's climatology

Optimal estimation computes temperature and salinity anomalies. These anomalies are calculated from a reference defined within the set of data. We have a reference for each month, which is a profile of temperature or salinity corresponding to the mean by depth of all the data of the month.

Monthly climatology

The climatology is defined on 261 levels from 0 m to 4000 m in temperature and salinity in the bay of Biscay (Figures 2 and 3). With each map, we supply the corresponding error field map, which give information on the reliability of the map. This map field confiance is linked to the density and the spatial repartition of the data.

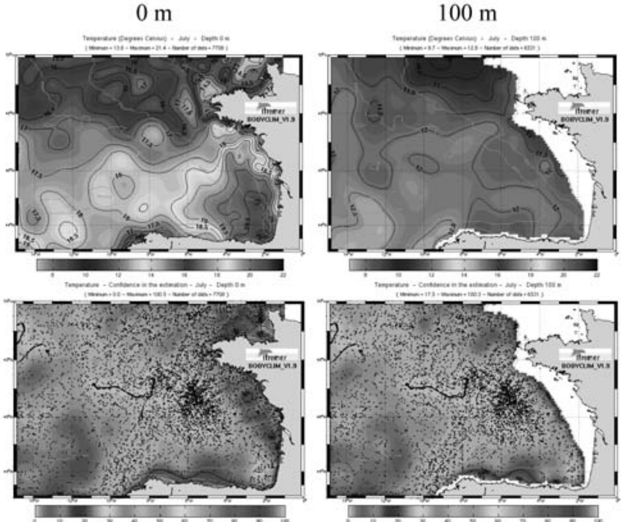


Figure 2. Maps of temperature (top panels) and maps of the confidence (percentage) in the corresponding estimation (bottom panels), for July for depths 0 and 100m.

Seasonal and annual climatology

From the monthly climatology, we have deduced two other climatologies, the seasonal and the annual. Due to the monthly distribution of data, we have preferred to average the monthly information rather than to compute a seasonal or annual optimal estimation. Indeed in this case, the estimation will be biased by the month which has the most data, so the result of an optimal analysis will correspond more to the month with the most the data.

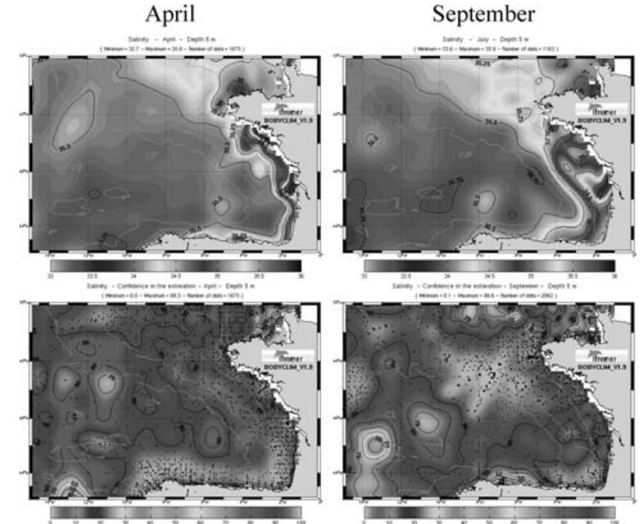
Interannual climatology

A new type of information which is presented by our study is the inter annual climatology. We wanted to show the annual changes in temperature and salinity over 50 years. For a fixed month, for every year, we calculated the maps of temperature of salinity by depth, by using a temporal window of 6 years around the year, which we made slide over 50 years. Construction of this climatology is currently underway.

Conclusions

The database is impressive and a high quality of climatology analysis has been obtained. The multi-scale influence gives some good results. Indeed we have succeeded in representing different scales on the same map. The diversity of information (monthly, seasonal, annual, interannual www.ifremer.fr/climatologie-gascogne) gives a new and complete spectrum of the temperature and salinity of the bay of Biscay.

Figure 3. Maps of salinity (top panels) and maps of the confidence in the corresponding estimation (bottom panels), for March for September



Acknowledgements

This work is supported by the project "Défi Golfe de Gascogne" and "Océanographie Côtière Opérationnelle" of the IFREMER. We express sincere gratitude to all of the data contributors. We thank the SHOM for having authorized us to use their data within the framework of this study. We thank the CORIOLIS project for supplying the matlab and fortran optimal analysis model.

References

Bretherton, F.P., Davis R.E., 1976 : A technique for objective analysis and design of oceanographic experiments applied to MODE-73. Depp-Sea Research 23: 559-582.

Autret E., Gaillard F., 2004 : Système opérationnel d'analyse des champs de température et de salinité mis en œuvre au centre de données CORIOLIS. Version 3.0

Observations of the Ushant tidal front during the FroMVar 2007 cruise.

A. Le Boyer[a], G. Cambon[a], N. Daniault[a], S. Herbette[a], L. Marié*[a,b]

Introduction

During the summer season, the hydrological structure of the shelf sea off western Brittany (Iroise Sea) is dominated by the influence of the Ushant tidal front, the interface along which tidally-mixed, nutrient-rich coastal waters encounter thermally-stratified open Celtic Sea waters. Despite the strong influence it bears on the physical (see for instance the satellite-derived SST map of Figure 1) as well as biological characteristics (Le Fèvre and Grall 1974) of the area, this feature has not received much attention since the SATIR-DYNATLANTE cruises of 1982 (Le Corre and Mariette 1985, Mariette and Le Cann 1985). The aim of the FroMVar project is to study its structure, dynamics and variability through a series of focused cruises, conducted on an annual basis. The two legs of the first FroMVar cruise took place aboard R/V Côtes de la Manche from september 13th 2007 to september 15th 2007 (spring tides) and from september 19th 2007 to september 22nd 2007 (neap tides). In this contribution, we will first present current data collected in the frontal region, then describe the observed thermal structure of the Front. Directions for future work will finally be presented.

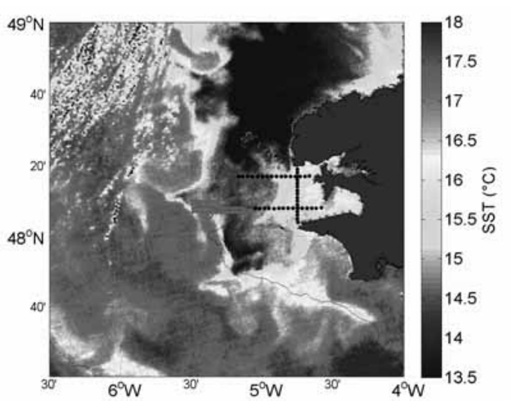


Figure 1. MODIS SST for september 13th 2007, 22PM. The red star in the middle marks the mooring location. Red dots mark CTD stations occupied during the first leg and black dots mark CTD stations occupied during the second leg. The thin black curve is the 100 m isobath. Data retrieved from the OceanColor Web site (see Feldman *et al.*)

Current profiles

SHOM, the french navy hydrography and oceanography service, maintains in the Iroise Sea area a radar-based surface current measurements system (WERA system). The surface currents in the area are thus very well documented.

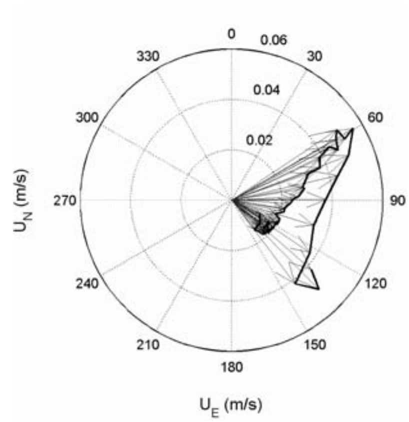


Figure 2. "Compass" plot of the currents at the mooring position, averaged over the whole deployment duration. Headings are relative to true north.

One of the main objectives of the FroMVar program, however, is to document the current structure of the Front in the water column. For that purpose, a 300 kHz RDI acoustic current profiler (denoted by a red star in Figure 1) has been deployed from june 6th to september 13th in the frontal region. Deployment depth was 120 m. The short deployment duration allowed very high vertical and temporal resolution data to be recorded (60 2m bins, sampling interval 10 seconds, no data averaging). The current data (not presented here) show the barotropic tidal currents to be strongly dominant (mean tidal ellipse major axis ~1.2 m/s, minor axis ~0.4 m/s). A baroclinic structure is however clearly apparent in the signal, which tends to indicate that the mooring was predominantly in the stratified area.

The thermocline position is clearly visible in the time-average of the current. In the deeper layer, the permanent currents are southeasterly, only weakly dependent of depth, and average to 1.4 cm/s heading 135° east of the true North direction. Rising in the water column to the thermocline level, we observe that the projection of the mean velocity in the 135° direction remains approximately constant, but that a strong northeasterly component appears. At the thermocline level, the currents average to 5.6 cm/s, heading to 60°. Rising to the surface, the permanent currents finally turn back to their deep orientation, averaging to roughly 5 cm/s, heading to 135°. These sub-surface currents estimates are consistent with other estimates obtained in the area from drifter trajectories or HF radar surface current measurements. Straightforward geostrophic calculations however seem to conclude to a predominantly southwest-northeast thermal front orientation, which contrasts with the clear north-south orientation obtained from satellite imagery. This indicates that other effects play an important role in setting the

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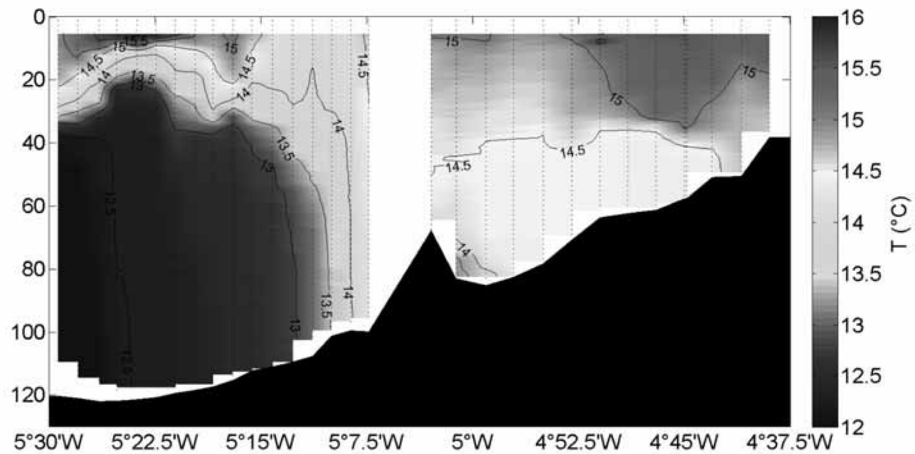

Figure 3. Temperature section across the frontal region along 48°08'N. Station positions are denoted by dotted lines. The western part of the section was occupied on September 14th (spring tides), and the eastern part on September 21st (neap tides).

permanent currents direction. An order 0 effect of bottom friction, for instance, would be to rotate to the right a predominantly north-south geostrophic flow pattern such as that expected.

Hydrological structure

Hydrological properties were surveyed during the two legs, using an SBE 25 CTD, fitted with a Chelsea AquaTracka Mark III fluorometer. While samples showed the CTD salinity offset to be reasonable (less than 0.01 psu before calibration) under thermally stabilized conditions (*i.e.* top or bottom stops in the profiles), the retrieval of salinity is rendered difficult by the very steep temperature gradient experienced by the CTD at the thermocline level (temperature variations as strong as 4°C in less than 20m have been encountered), which leads to very strong conductivity cell thermal mass effects. This problem is under study, in collaboration with SHOM researchers (see Mensah *et al.*). Salinity data will not be discussed further in this abstract.

Figure 3 shows the thermal structure observed along the 48°08N transect. The Front is clearly visible on the western side of the graph, where isotherms are seen to outcrop almost vertically both at the surface and the bottom. The thermocline is roughly at 30 m depth in the stratified region, but it is raised around 5°22.5'N by a cyclonic meander in the front, that is conspicuous in Figure 1 as well as in SST maps of previous and following days. Stratification patterns vary from nearly two-layer stratification (3.4°C temperature difference between top and bottom, thermocline thickness < 20 m) in the stratified region to almost completely homogeneous in the shoreward region (less than 0.4°C temperature difference between top and bottom). In the frontal zone, the temperature profile in the mixed waters between the top and bottom layer can possess different shapes, either connecting smoothly the two constant temperature values, or doing so in a series of steps, reminiscent of the "Philips effect" discussed by (Ruddick *et al.*, 1989). The eastern part of the section crosses another front, the "Inner Ushant Front", where stratified, hot waters contained in the shallow and less strongly stirred "Baie de Douarnenez" encounter the mixed waters. Quite steep vertical temperature gradients (0.5°C in less than 3 m depth) are for instance visible near 4°45'W. A small tongue of cold (<14°C) water is visible close to the end of the eastern part section. This water has a temperature very close to that measured nearby during the first leg, which might indicate it has moved, either due to long-period or tidal currents.

Conclusions, directions for future work.

In this abstract, we have described for want of space only a small fraction of the complete data set. Other components which are now being studied and put in perspective include lagrangian drifter data, HF radars data, chemistry data (nutrients and chlorophyl samples), numerical model outputs (MARS, ROMS) and atmospheric forcing analyses. By putting together all these elements, we hope a consistent dynamical picture of the present Ushant Thermal Front will soon be available.

Acknowledgements

It is a pleasure to thank here Stéphane Leizour and Xavier André for their help during the cruises, and Fabrice Ardhuin, Bernard Le Cann, Franck Dumas and Héloïse Muller for fruitful discussion during the cruise preparation and subsequent data analysis, and for sharing their as yet not published data sets.

The help of both crews of R/V Côtes de la Manche is gratefully acknowledged.

References

Feldman, G. C., C. R. McClain, Ocean Color Web, MODIS Reprocessing, NASA Goddard Space Flight Center. Eds. Kuring, N., Bailey, S. W. http://oceancolor.gsfc.nasa.gov/

Le Corre P., V. Mariette, 1982, Le front thermique d'Ouessant en août et septembre 1982, Campagne SATIR-DYNATLANT, *Campagnes Océanographiques Françaises, 1*, IFREMER, Brest (1985).

Le Fèvre J., J. R. Grall, On the relationship of *noctiluca* swarming off the western coast of Brittany with hydrological features and plankton characteristics of the environment, *J. exp. Mar. Biol. Ecol.*, 4: 287.

Mariette, V., B. Le Cann, 1985. Simulation of the formation of Ushant thermal front, *Cont. Shelf Res.,* 4: 637.

Mensah, V., M. Le Menn, Y. Morel, submitted to *J. Atm. Ocean. Technol.*

Ruddick, B. R., McDougall, T. J., Turner, J. S, The formation of layers in a uniformly stirred density gradient, 1989, *Deep Sea Res.,* 36: 597

Seis décadas de medición de la temperatura de superficie del agua de mar en el Aquarium de San Sebastián. Actualización de datos y revisión de tendencias y anomalías

Nerea Goikoetxea[a], Ángel Borja[a], Almudena Fontán[a] and Victoriano Valencia[a]

En el VI Simposio Internacional de Oceanografía del Golfo de Vizcaya, celebrado en 1998 en el Aquarium de la Sociedad Oceanográfica de Gipuzkoa en San Sebastián, se presentó una revisón de la serie de temperaturas del Aquarium para los 50 años del periodo entre 1947 y 1997 (Borja *et al*., 2000).

En dicho trabajo se presentaba la serie, se realizaban comparaciones con otros registros de temperatura y se discutían los principales factores que afectan a sus variaciones estacionales e interanuales. La temperatura del aire y la insolación, variables estrechamente relacionadas con los ciclos estacionales, aparecen como los factores que explican la mayor parte de la varianza de los registros. Otros factores como la tensión de vapor o la humedad relativa (relacionados con el calor latente de evaporación), los índices de afloramiento y de hundimiento (relacionados con el transporte de Ekman y la advección de aguas frías o calientes) o la turbulencia (relacionada con procesos de mexcla y reparto de calor en la columna de agua) aparecen como factores moduladores, con diferente incidencia estacional y significación estadística.

Por otra parte, se constata que, a pesar del caracter superficial y local de las mediciones las principales tendencias y anomalías registradas resultan acordes con las descitas en zonas más amplias. Este aspecto ha permitido utilizar esta serie como refencia en trabajos diversos en los que no se disponía de una ferecuencia equivalente en la toma de datos (Valencia *et al*., 2003), y en estudios de tendencias a largo término como los que se abordan en el Working Group on Oceanic Hydrography de ICES (por ejemplo, Hughes and Holliday, 2007).

En este sentido, la serie rebasa los 60 años de toma de datos y puede compararse con varios de los periodos tridecadales de referencia que considera la Organización Meteorológica Mundial. Particularmente interesante es el último periodo de referencia completado (1971-2000) para el que la serie es más consistenteen cuanto a método de medida y número de datos por año y, por tanto, puede ser retituida a una serie temporal de forma más estricta. Además también resulta especialmente interesante el estudio de las importantes anomalías registradas desde 2001 hasta el presente y de las tendencias que estos valores indican en el contexto actual de estudios sobre cambio climático.

La presente contribución se enfoca principalmente a estos aspectos.

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Methods/Data set

La medición de la temperatura se realiza diarimente en la bahía de San Sebastián a la 10 de la mañana. Se dispone de datos desde 1947 hasta la actualidad. Desde 1974 se recogen más de 300 medicionas anuales y en los últimos años se superan las 360 mediciones.

Results and Discussion

La Figura 1 muestra distintas tendencias en función del periodo de observación considerado y del periodo de referencia para el cálculo de las anomalías. Lo mismo puede decirse para los valores estacionales.

Se presentará un análisis más pormenorizado de estos aspectos con especial incidencia en los últimos años por comparación con las últimas tres décadas.

Acknowledgements

Agradecemos al Aquarium of San Sebastián (Sociedad Oceanográfica de Gipuzkoa) la disponibilidad de sus datos para este trabajo. N. Goikoetxea es beneficiaria de una beca de investigación en "*Oceanografía y Recursos Marinos*" de la Fundación Centros Tecnológicos, Iñaki Goenaga.

References

Borja, Á., J. Egaña, V. Valencia, J. Franco and R. Castro, 2000a. 1947-1997, Estudio y validación de una serie de datos diarios de temperatura del agua del mar en San Sebastián, procedente de su Aquarium. *Ozeanografika*, 3: 139-152.

Hughes, S.L. and N.P. Holliday (Eds). 2007. The Annual ICES Ocean Climate 2006. ICES Cooperative Research Report, No. 289. 55 pp.

Valencia, V., Borja, A., Fontán, A., Pérez, F.F., and Ríos, A.F., 2003. Temperature and salinity fluctuations in the Basque Coast (SE Bay of Biscay) from 1986 to 2000 related to the climatic factors. *ICES Marine Science Symposia*, 219: 340-342.

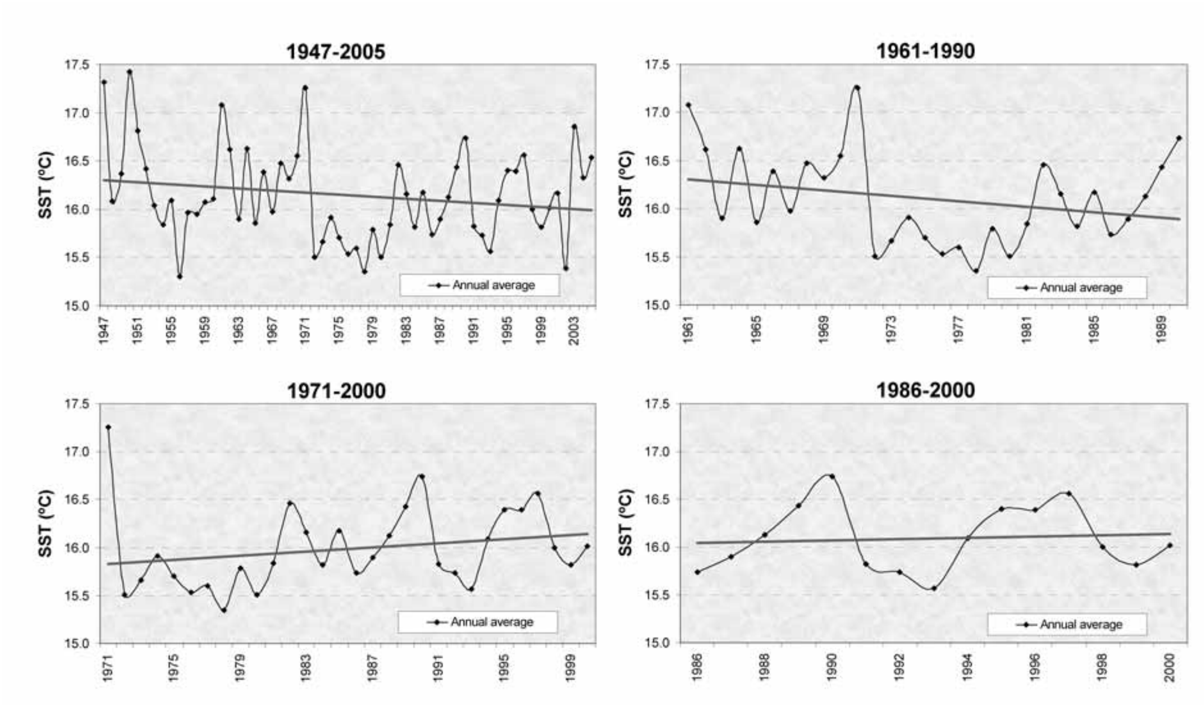

Figure 1. Tendencia de la temperatura en función del periodo de observación considerado y del periodo de referencia para el cálculo de las anomalías.

Spring and Summer Blooms of Phytoplankton (SeaWiFS/MODIS) along a Ferry line in the Bay of Biscay and W English Channel

Carlos García-Soto*

Introduction

FerryBox is a project of the European Union (2002-2004) that uses the ferries as Ships of Opportunity to carry out oceanographic research on the fields of plankton productivity; sediment transport and water masses. The present study, framed within the FerryBox objective 1, analysed with satellite data the occurrence of the major phytoplankton blooms along the route of the ferry *Pride of Bilbao* from Bilbao to Porstmouth. The ferry crosses the Bay of Biscay, the Celtic Shelf and the Western English Channel (Figure 1).

The relevance of a seasonal study is large. The spring phytoplankton bloom is one of the most extensive biological processes in the oceans and has significant ecological implications. Its timing can determine by match-mismatch effect the degree of survival of higher trophic levels such as fish larvae, and so control the recruitment success of important commercial fisheries at temperate and high latitudes (e.g. Cushing, 1990). The fixation of CO_2 by phytoplankton during spring also accounts for ~25% of the total CO_2 transferred annually from the atmosphere to the ocean in the NE Atlantic (e.g. Taylor, Watson & Robertson, 1992). During the summer large blooms of harmful dinoflagellates have also been described in the classic oceanographic literature (Pingree et al., 1977). along the Ferry route that is analysed here.

Methods

The study was carried out using Level 3 files of SeaWiFS chlorophyll concentration from NASA. The files have a spatial resolution of 9Km (0,088º of latitude and longitude) and a temporal resolution of 8 days (temporal average of daily observations). A total of 291 SeaWiFS files were used covering the period 2002-2004. The files were subsampled along the track of the Ferry (Pride of Bilbao) using a log file (lat and long positions) from the ferry and subsequently gridded against time in bins of 8days and 0.125º latitude. Higher resolution observations were also made using Level 3 data from the MODIS sensor onboard the Aqua satellite. The improvements made by the latest reprocessings of the SeaWiFS and MODIS data set can be found in http:/ /oceancolor.gsfc.nasa.gov/ REPROCESING. A comprehensive overview of SeaWiFS is given by McClain et al. (2004).

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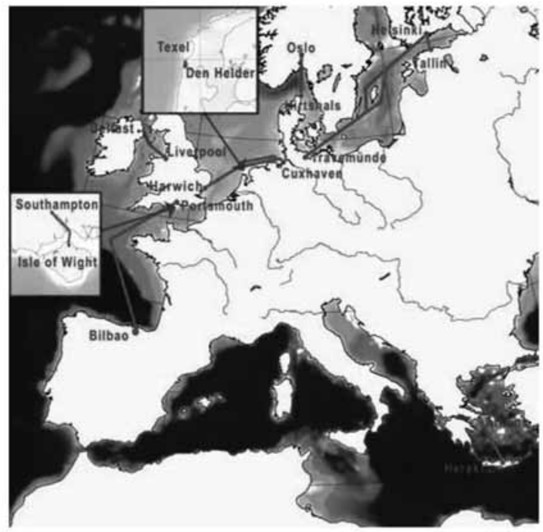

Figure 1 Ferry tracks in the FerryBox project.

Results and Discussion

Figure 1 shows a latitude-lime plot of SeaWiFS chlorophyll concentration along the track of the ferry *Pride of Bilbao* (Bilbao-Postmouth) during the first 3 years of duration of the FerryBox project (2002, 2003 and 2004). The spring phytoplankton bloom is observed to take place in the oceanic Bay of Biscay (up to ~46.5ºN) in March in the southern region, and at the end of April in the northern region. Interannual variability is observed in the intensity of this bloom with normal peak values (1-2 mg m^{-3}) more than doubled (4-5 mg m^{-3}) in 2003 (southern Bay of Biscay) and in 2004 (northern Bay of Biscay). A detail of the 2004 spring bloom is shown in Figure 2 that highlights the diferent timing and duration of the oceanic spring bloom with respect to that of the adjacent Celtic shelf and shelf-break regions. In the adjacent ocean, around ~46ºN, the major bloom development takes place on 29 April, very near Julian Day 120, as predicted before for this area under low wind anticyclonic conditions and very low stratification (García-Soto and Pingree, 1998).

Relevant blooms along the Ferry route (see Figure 1) also include very intense summer blooms in the Western Approaches and English Channel (~48º-50ºN). The SeaWiFS data of this region have been analysed during 6 full years (1998-2003) and show these exceptional blooms of phytoplankton taking place during summer 2000 (July-August), summer 2002 (July-August) and summer 2003 (June-July). Intense summer blooms of the dinoflagellate *Karenia mikimotoi* (known before as *Gyrodinium aureolum*) are known to develop in this region

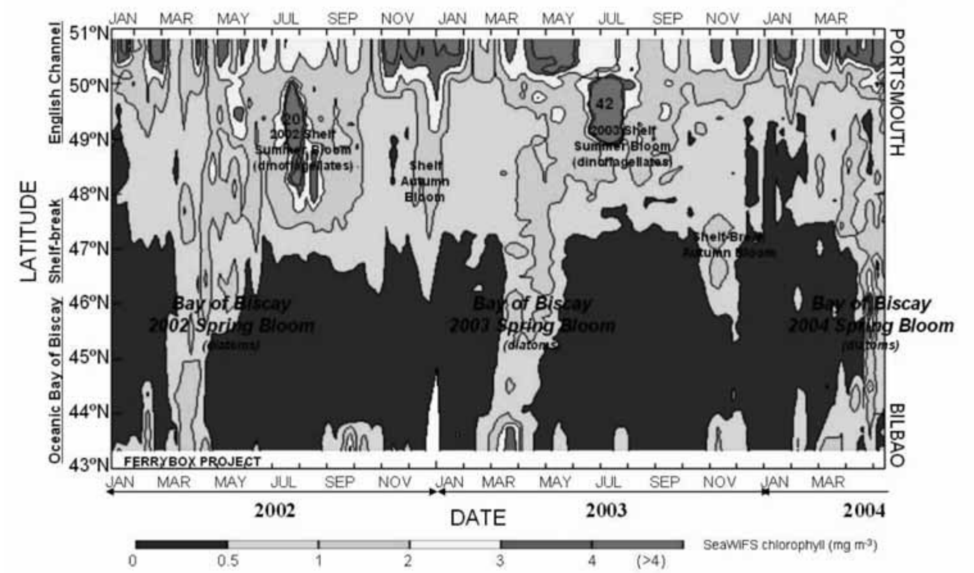

Figure 2 Latitude-Time distribution showing SeaWiFS chlorophyll concentration (mg m-3) along the track of the ferry *Pride of Bilbao* during the 2002, 2003 and 2004. The Figure shows the timing, duration and intensity of spring, summer and autumn blooms in the Bay of Biscay and W English Channel.

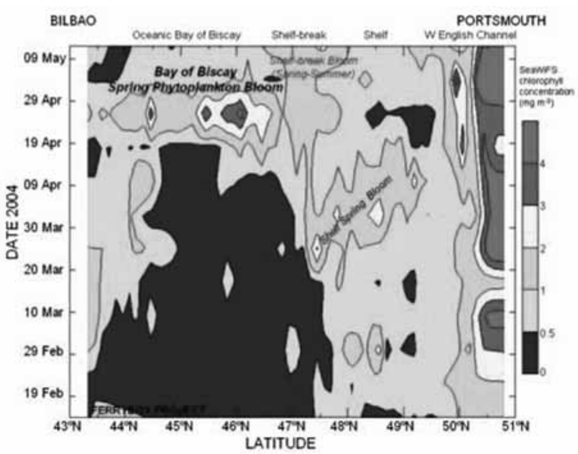

Figure 3 Detail of Figure 1 showing the occurrence of the spring phytoplankton bloom in the oceanic Bay of Biscay (around ~46ºN) near 1st May 2004 (Julian Day 120).

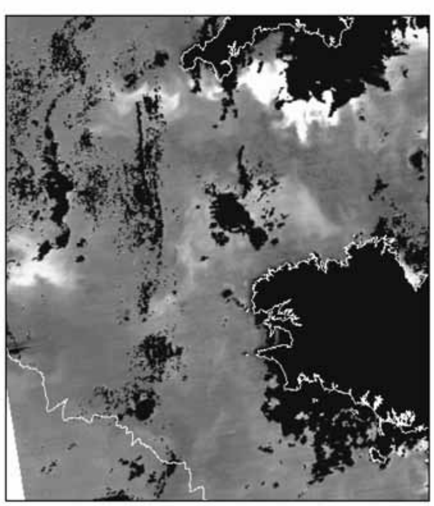

Figure 4 MODIS composite image showing a summer bloom of dinoflagellates in the W English Channel (21 July 2002).

(Pingree, 1977) and *in situ* studies of the 2003 bloom (Kelly-Guerrein et al., 2004) confirm the species. The maximum values of phytoplankton concentration (SeaWiFS) on these 3 exceptional years are 24, 20 and 42 mgChla m^{-3}. A composite image of MODIS-Aqua (443, 531 and 667nm) shows the surface structure and spectral signature of the the 2002 bloom.

Acknowledgements

This a a contribution of the European Project FerryBox.

References

Cushing, D.H., 1990. Plankton production and year-class strength in fish populations: An update of the match-mismatch hypothesis. *Advances in Marine Biology*, 26: 249-293.

García-Soto, C., R.D. Pingree, 1998. Late autumn distribution and seasonality of chlorophyll *a* at the shelf-break/slope region of the Armorican and Celtic shelf. *Journal of the Marine Biological Association of United Kingdom*, 78: 17-33.

Kelly-Guerrein, B.A., M.A. Qurban, D.J. Hydes, L. Fernand, I. Puillat A.M. Jégou, P. Lazure y C. Garcia-Soto, 2004. Understanding intense *Karenia mikimotoi* blooms in the western English Cannel from Ferrybox, ship survey, satellite, river and wind data. Ferrybox Open Conference 2004. Southampton (UK), 5-6 Octubre 2004.

McClain, C.R., G.C. Feldman, S.B. Hooker, 2004. An overview of the SeaWiFS project and strategies for producing a climate research quality global ocean bio-optical time series. *Deep Sea Research Part II*, 51: 5-42.

Pingree R.D., P.M. Holligan, R.N. Head, 1977. Survival of dinoflagellate blooms in the western English Channel. *Nature*, 265: 266-269.

Taylor, A.H., A.J. Watson, J.E. Robertson, 1992.. The influence of the Spring Phytoplankton Bloom on carbon dioxide and oxygen concentrations in the surface waters of the NE Atlantic. *Deep-Sea Research Part I*., 38: 137-152.

Real-time ecological modelling of nutrients and phytoplankton on the Bay of Biscay French shelf.

Alain Ménesguen,*[a] Jean-Michel Baey[b,c] and Marc Sourisseau[d]

Introduction

Following ocean monitoring and forecast, coastal operational oceanography is a growing domain, which aims at providing real-time assessment of several characteristics of the status of coastal waters and also short-term forecasts. Besides some scarce field measurements coming from buoys or ferryboxes, satellite remote sensing now provides repetitive and reliable surface maps of temperature, inorganic suspended matter and total chlorophyll content. This real-time observation of interesting oceanographic features (gyres, plumes, fronts, upwellings, blooms) can take advantage of 3D models run in an operational mode to explain the emergence and origin of some of these features. This communication presents a one year running experiment of providing on a web-site http://www.previmer.org/previsions/production_primaire/modele_eco_mars3d_gascogne the real-time spatial distribution of temperature, salinity, turbidity, 3 main nutrients and 3 types of phytoplankton over the French Atlantic coastal shelf. Actual on-line results are discussed as well as future improvements planned for 2008.

Methods

Area under study

The Bay of Biscay considered here extends from 7°30'W to the western French coast, and from 49°20'N to the northern Spanish coast. Model results are limited to the continental shelf, i.e. from the coast down to the -200m isobath.

Satellite data

NOAA AVHRR measurements of Sea Surface Temperature and MODIS colour measurements are collected by Ifremer's Nausicaa browser automat and processed in order to merge the 4 last days images with the current day, and hence partially fill the holes caused by cloud covering.

Model characteristics

The modelling component of the French PREVIMER project of Coastal Operational Oceanography is based on the MARS3D hydrodynamical code. The current application to the French Atlantic shelf is based on the model defined in Huret et al. (2007), using a regular grid with 5x5 km meshes and 10 sigma levels. Mechanical forcing is made by barotropic sea-level oscillation at the oceanic boundaries, and wind and atmospheric pressure at the sea surface; these are provided by the Aladin model of Météo-France with a 10 km and 3 h space-time resolution. Daily discharges as well as monthly river temperatures are provided by the Loire–Brittany and Adour–Garonne River Basin Agencies, for the 4 main rivers: Adour, Gironde, Loire, Vilaine. River daily concentrations for inorganic and organic dissolved nutrients are computed from empirical statistical relationships involving flow rate and time fitted to historical data (Guillaud and Bouriel, 2007). Suspended particulate matter is set to the maximum of ambient climatological monthly mean distribution derived from satellite data and the simulated suspended matter brought by the rivers. At the open boundaries, temperature and salinity are relaxed with a time lag of 13 days to the climatologies of Reynauld et al. (1998) for temperature and salinity, of Levitus for nutrients and chlorophyll.

Results

The model started in January 2003 with one spin-up year. This year was chosen because it appeared as average year in our monitoring data set. The run next switched directly from 2003 to 2007. The web site shows the daily computed maps from February 1st, 2007 until now. A pop-up window facility allows a first qualitative visual assessment of the fit between satellite measurements and simulations, for SST and total chlorophyll content of the sea surface layer. A detailed statistical analysis of one year long data series is in progress, which will give a more quantitative appraisal of the reliability of the operational model.

For SST, absolute differences between observed values and computed ones are mainly lower than 1.5 °C, except sometimes in the cold strongly mixed area of Ushant island (the model is too warm). The colding or warming initiation seems also to be delayed by the model. Fig. 1 gives an example of modelled vs. observed SST at the end of August.

For phytoplankton, goodness of fit between computed total chlorophyll and satellite-derived maps is irregular. Model tends to overestimate total chlorophyll content, but succeeds in exhibiting the good time- and space pattern of intense blooms in the plumes of Loire, Vilaine or Gironde rivers. The most interesting event during the rainy, bad summer 2007 was the intense blooms spreading in front of Loire and Vilaine estuaries. During July, for instance, local newspapers related appearance of numerous patches of "green tides", i.e. surface waters colored

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in intense, fluorescent green by the dinoflagellate *Lepidodinium chlorophorum* (previously *Gymnodinium chlorophorum*). On July, 21st for instance, the satellite image shows very high chlorophyll values near the Loire-Vilaine estuaries, and the model also gives this pattern (see Fig. 2). The added value from the model is the information that these plankton blooms are mainly composed of dinoflagellates in that area, which is in accordance with the field observations of *Lepidodinium chlorophorum* massive blooms (see Fig. 3).

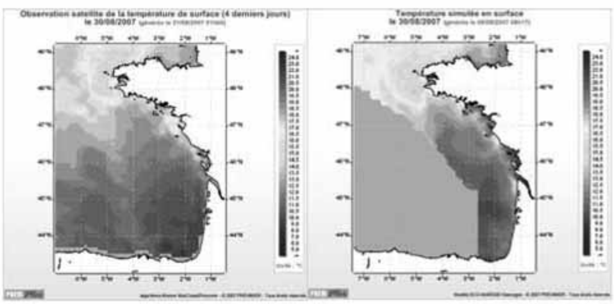

Figure 1. SST of the Bay of Biscay measured by satellite (left) and simulated by the MARS3D model (right) on August, 30th 2007

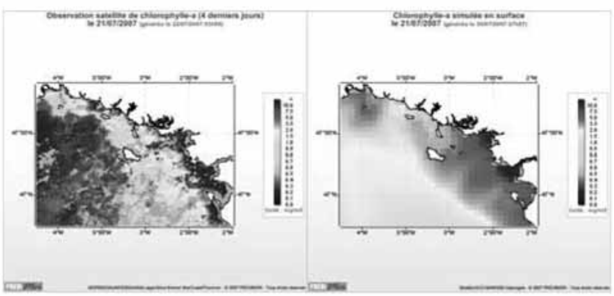

Figure 2. Chlorophyll content of the surface layer of the Loire-Vilaine estuaries area measured by satellite (left) and simulated by the ECO-MARS3D model (right) on July, 21th 2007

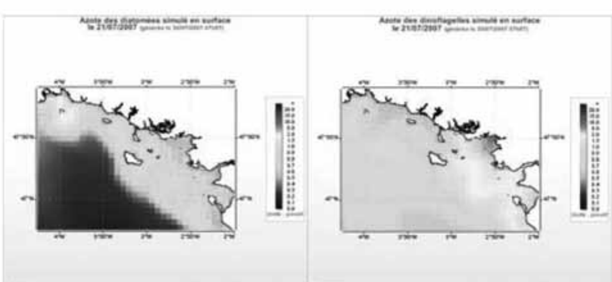

Figure 3. Diatom (left) and dinoflagellate (right) concentrations of the surface layer of the Loire-Vilaine estuaries area as simulated by the ECO-MARS3D model on July, 21th 2007. Units are µmol.L^{-1} of algal nitrogen.

Discussion

Two questions immediately arise about such operational ecological models. First, can we validate them enough by field measurements and give confidence intervals around predicted values? Second, what are the final products of the model which users really need? Apart from satellite maps of observed temperature and chlorophyll, field measurements are very scarce, and no field data is available for several state variables of such an ecological model! Some future needs will be discussed, as well as the interest of feeding this coastal model by boundary conditions provided by OGCM as Mercator. Besides classical state variables yet available on the web site, additional diagnostic variables will be proposed, in order to enhance the didactic impact of such a web site; for instance, tracking the origin of nitrogen in algal compartments as explained in Ménesguen et al.(2006) will provide some causative explanation to the sudden massive blooms of diatoms or dinoflagellates, and help pointing the rivers in which the nitrogen loading has to be lowered in priority.

Conclusions

This first attempt at running an ecological model of the phytoplankton on the French Atlantic shelf has proved realistic enough to be applied on the two other French shelves: the English Channel (planned in 2008) and the Western Mediterranean Sea (planned in 2009). For the Bay of Biscay, a new 4x4 km grid will be used in 2008, which covers the whole area, i.e. including the shelf slope and the abyssal plain.

Apart from the immediate interest of such information, this operational tool will provide over the years a growing bank of daily simulated situations, which will be used to build a statistical description of the "mean" nutrient and phytoplanktonic annual cycle in these coastal areas, as well as define what can be designated as being "extreme" events.

Acknowledgements

We are indebted to Francis Gohin and Jean-François Piollé (Ifremer/Brest) for providing processed satellite pictures, to Guillaume Galibert (Atlantide-ALTRAN Ouest) for monitoring the daily computing process, and to Fabrice Lecornu, Jean-François Le Roux and Jacques Legrand (Ifremer/Brest) for management of the PREVIMER project (www.previmer.org). This work has been funded partially by the Region Bretagne.

References

Guillaud, J.-F., L. Bouriel, 2007. Relationships between nitrate concentration and river flow, and temporal trends of nitrate in 25 rivers of Brittany (France). *Revue des Sciences de l'Eau,* 20(2) : 213-226.

Huret, M., F. Gohin, D. Demas, M. Lunven, V. Garçon, 2007. Use of SeaWiFS data for light availability and parameter estimation of a phytoplankton production model of the Bay of Biscay. *Journal of Marine Systems*, 65(1-4): 509-531.

Ménesguen, A., P. Cugier, I. Leblond, 2006. A new numerical technique for tracking chemical species in a multi-source, coastal ecosystem, applied to nitrogen causing *Ulva* blooms in the Bay of Brest (France). *Limnoogy and. Oceanography*, 51, 591-601. (http://aslo.org/lo/toc/vol_51/issue_1_part_2/0591.pdf)

Reynaud, T., P. Legrand, H. Mercier, B. Barnier, 1998. A new analysis of hydrographic data in the Atlantic and its application to an inverse modelling study, *Int. WOCE Newsl.32:*29–31.

Nitrogen uptake by size-fractionated plankton in the North Biscay Bay during spring

Jean-François Maguer, Stéphane L'helguen, Matthieu Waeles, Pascal Morin, Ricardo Riso, Julien Caradec

Introduction

The North Biscay Bay is characterized by its broad continental shelf and a very high freshwater discharge from Loire and Vilaine Rivers. This offshore spreading of freshwater induces strong vertical haline stratification and contributes in great part to the nutrient enrichment over most of the continental shelf. These inputs can greatly affect the ecosystem structure; in particular, they allow the development of the late winter phytoplankton blooms in the central part of the shelf and in the proximal Vilaine plume (Morin *et al*., 1991; Lampert *et al*., 2002, Guillaud *et al*., 2006). An important aspect of these freshwater inputs is a large excess of dissolved inorganic nitrogen (DIN), mainly as nitrate, with regard to phosphate and silicate, which introduces a strong imbalance in the nutrient ratios in adjacent coastal waters. These nutrient ratio alterations can impact the phytoplankton community, i.e the species composition and/or size-structure levels (Smayda, 1990 ; Riegman *et al*., 1993, Yin *et al*., 2001).

The phytoplankton response to NID enrichment by the Loire and Vilaine Rivers over the continental shelf was studied during spring(Cruise GASPROD, April 2002). Nitrate and ammonium uptake rates were measured for two planktonic size fractions (non-fractionated and <10 µm) over the continental shelf, from the Loire mouth to the oceanic waters. The results were discussed in relation with nutrient distribution and phytoplankton size structure.

Results and discussion

Nutrient concentrations decreased from the Loire freshwater discharge to the oceanic waters (Figure 1a) with N/P ratios always greater than the Redfield ratio (16:1). Nitrate was the major DIN compounds at both stations, with concentrations (0.9 – 29.5 µmol L^{-1}) always greater than those of ammonium (0.1 – 0.8 µmol L^{-1}). In the proximal plumes and in the central area of the shelf, DIN and silicate (data no shown) never reached limiting concentrations within the productive layer (Maguer *et al*., 2000 ; Sarthou *et al*., 2005). On the other hand, possible limitation by phosphate, already suggested (Lunven *et al*., 2005), can begin to take place in the central area as shown by the phosphate depletion detected within the euphotic layer (Figure 1b). In the offshore area, nutrient concentrations, nitrate in particular, were weaker than those typically found in this area in winter (Morin *et al*., 1991), suggesting the onset of the spring bloom. It is worth noting that N/P ratios were balanced in this zone.

The phytoplankton biomass was generally low across the shelf, with Chl *a* concentration ranging from 0.2 to 2.9 µg L^{-1} (Figure 2a) The highest biomass was observed in the proximal Loire and Vilaine plumes and was dominated by the large phytoplankton (>10µm) with their importance remaining more or less the same at both stations (mean ± S.D : 69 ± 17% of total) (Figure 2b). This biomass was mainly associated to diatoms species as suggested by the high fuco/chla ratio measured in this area. In the central area and in the offshore waters, chl a concentrations were less than 1.5 µg L^{-1}. The >10 µm size accounted between 2 and 70% of Chl *a* (mean ± S.D. = 44 ± 33%) in the offshore waters, and only for 19 ± 20% in the central area.

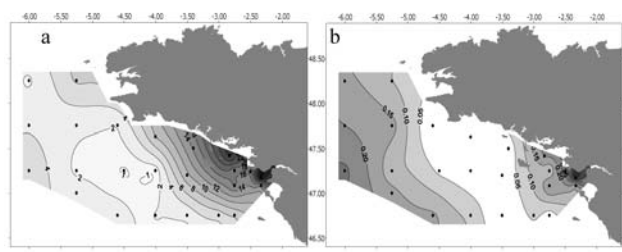

Figure 1. a) Nitrate and b)phosphate concentrations (µmol L^{-1}) in surface water of the North Biscay Bay in April 2002.

Nitrogen uptake rates (Figure 3a) varied from 0.17 to 1.91 mmol L^{-1} d^{-1}, with the highest values observed in the proximal Loire and Vilaine plumes and in the offshore waters and the lowest in the central area of the shelf. The major part of nitrogen uptake was mediated by the >10 µm size fraction of plankton in the proximal plumes and in the offshore waters (up to 83 and 77% of N uptake, respectively), whereas in the central part of the shelf, more than 75% of N were taken up by the < 10 µm size fraction (Figure 3b).

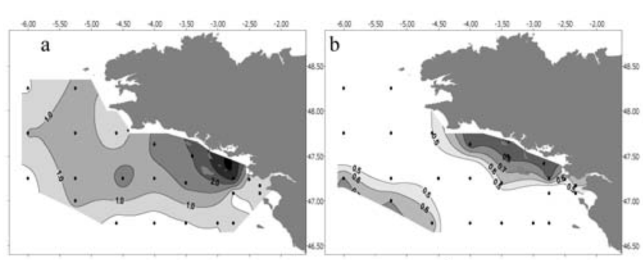

Figure 2. a) Chlorophyll a concentration (µg L^{-1}) and b) percent of chlorophyll a in >10 µm size fraction of the North Biscay Bay in April 2002

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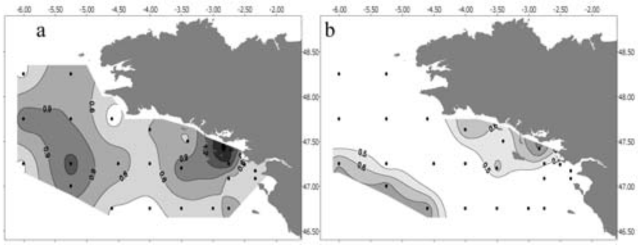

Figure 3. a) N total uptake (in mmol $L^{-1}d^{-1}$) and b) percent of N uptake by >10 µm size fraction of the North Biscay Bay in April 2002.

Most of N used by < 10 µm size fraction was in the form of ammonium (mean ± S.D. = 66 ± 22%) (Figure 4b) even though this compound represented only ~8% (range <1 to 30%) of ambient nitrogen. The large phytoplankton (>10 µm) taken up nitrate preferentially (Figure 4a) in the proximal plumes (mean ± S.D.: 75 ± 16%) where nitrate was abundant and in the offshore waters (mean ± S.D.: 81 ± 9%). In the central area, the > 10 µm size fraction showed a significant preference for ammonium (mean ± S.D.: 65 ± 25%).

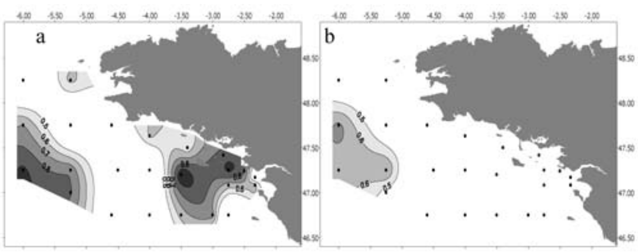

Figure 4. F-ratio (Nitrate uptake / N total uptake) in a) > 10 and b) < 10 µm size fraction of plankton of the North Biscay Bay in April 2002.

Conclusions

This study show that dissolved inorganic nitrogen inputs from the Loire and Vilaine rivers allows the phytoplankton development to continue in the near shore of the North Biscay Bay after the late winter blooms. DIN inputs, mainly as nitrate, are used by the large phytoplankton cells which can be rapidly sinked from the surface layer to the benthic compartment. This have led to the conclusion that a part of DIN inputs is trapped in the proximal plumes and thus do not reach the shelf central area.

Acknowledgements

This work was supported by the French Programme National d'Environnement Côtier

References

Guillaud, J-F. Aminot, A. Delmas, D. Gohin, F. Lunven, M. Herbalnd, A. Labry, C. 2006. Trends of riverine nutrient inputs for thirty years in the northern Bay of Biscay, and schemes of phytoplankton responses. X International Symposium on Oceanography of the Bay of Biscay, April 2006, Vigo, Galicia, Spain. In "*Oceanography of the Bay of Biscay"* (Alvarez, I., DeCastro, M., Gomez-Gesteira, M., Lorenzo, M.N., Prégo, R. Eds), 11-14

Lampert, L. Queguiner, B. Labasque, T. Pichon, A. Lebreton, N. 2002. Spatial variability of phytoplankton composition and biomass on the eastern continental shelf of the Bay of Biscay (North-east Atlantic) Evidence for a bloom of Emiliana Huxleyi (Prymnesiophyceae) in spring 1998. *Continental shelf Research* 22, 1225-1247.

Lunven, M. et al. 2005. Nutrient and phytoplankton distribution in the Loire River plume (Bay of Biscay, France) resolved by a new Fine Scale Sampler. *Estuarine Coastal and Shelf Science*, 65, 94-208.

Maguer, J.F. L'Helguen, S. Le Corre, P. 2000. Nitrogen uptake by phytoplankton in a shallow waters tidal front. Estuarine Coastal Shelf Science, 51, 349-357

Morin, P. Le Corre, P. Marty, Y. L'Helguen, S. 1991. Spring evolution of nutrients and phytoplankton on the Armorican shelf (North West European Shelf). *Oceanologica Acta*, 14, 263-279.

Riegman, R. Kuipers, B.R. Noordeloos, A.A.M. Witte, H.J. 1993. Size differential control of phytoplankton and the structure of plankton communities. *Netherlands Journal of Sea Research*. 255-265.

Sarthou, G. Klass, R.T. Blain, S. Treguer, P. 2005. Growth physiology and fate of diatoms in the ocean : a review. *Journal of Sea Research*. 53, 25-42;

Smayda, T.J. 1990. Novel and nuisance phytoplankton blooms in the sea. Evidence for a global epidemic. In "*Toxic Marine Phytoplankton Blooms*", (Graneli, E. Sundstrbm, B. Edler, B. Anderson, D.M. Eds.) Elsevier, N.Y. 29-44.

Yin, K. Qian, P.-Y. Wu,M.C.S. Chen, J.C. Huang, L. Song, X. Jian, W. 2001. Shift from P to N limitation of phytoplankton biomass across the Pearl River estuarine plume during summer. *Marine Ecology Progress Series*. 221, 17–28.

Characterisation of hydrodynamical conditions on the Aquitan shelf prior to *Dinophysis* events in the Arcachon Basin

Francois Batifoulier[a,B], Pascal Lazure, Daniele Maurer, Patrick Gentien, Philippe Bonneton, Christine Dupuy, Elise Marquis

Introduction

The Arcachon Basin in the Bay of Biscay is subject to episodes of *Dinophysis*, toxic phytoplankton species. *Dinophysis* are one of the causes of shellfish toxicity that makes them unfit for human consumption. The exploitation of shellfish is, with tourism, the most important activity of the local economy; this explains the strong expectations from the Aquitaine Region to understand this problem. We focused our work on the most important episodes of *Dinophysis* observed in the Arcachon Basin. In this approach we had worked on realistic simulations (from the IFREMER-MARS 3D hydrodynamical code), satellite data (SST), weather data (METEO FRANCE) and *in situ* measurements (REPHY). In this work, besides the validation of the MARS-3D code, we define the hydrodynamical, hydrological and weather conditions preceding these episodes in order to determine where are from *Dinophysis* populations measured in the Basin.

Methods

In this study, we used data sets coming from three sources: *in situ* measurements, satellite data, MARS 3D realistic simulations.

▪ *In Situ* Measurements

REPHY network

The REPHY[1] is a French network operated by the twelve IFREMER coastal laboratories. This network is designed mainly to monitor toxic phytoplankton species. In the frame of this network, phytoplankton species are checked fortnightly at four locations of the Basin ("Bouée 7", «Teychan», «Comprian» and «Jacquets» [see Figure 1]).

This network provides information about the phytoplankton flora accompanying *Dinophysis* as well as temperature and salinity sub surface measurements.

At the same time, when the alert threshold of 500 cells/litre is overtaken tests on oysters and mussels are done to check the toxicity of the shellfishes.

In spite of the fact that these data are very local, they provide useful information on the sequence of events and their geographical distribution.

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[1] *www.ifremer.fr/envlit/surveillance/rephy.htm*
[2] *www.osi-saf.org/visiteurs/produits/nar_sst.php*
[3] *ww.eumetsat.int/Home/Main/Access_to_Data/Meteosat_Image_Services/SP_1123237865326?l=en*
[4] *www.eumetsat.int/groups/cps/documents/document/pdf_conf_p45_s3_05_donlon_v.pdf*

Fish stocks assessment field trips

Several stock assessment field trips in the Biscay Bay allowed to build a large data base of CTD (Conductivity Temperature Depth) profiles. In 2005, measurements of phytoplankton have also been done during the PELGAS campaign on the Biscay Bay shelf at the same time that the 2005 *Dinophysis* event.

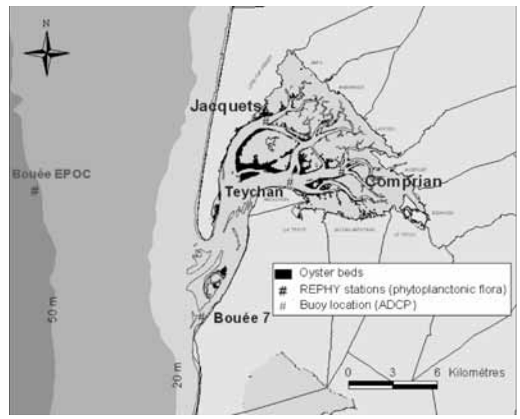


Figure 1 Implantations of the measurements sites

ADCP data

In 2002, an ADCP (Dupuis *et al*., 2004) has been set in front of the Arcachon Basin in the open sea at 54 meters deep [see "Bouée EPOC" Figure 1]. Currents in the water column have been recorded hourly for 3 months every two meters.

▪ Satellite Data

Satellites provide a larger view of surface temperature and chlorophyll but are usable only when there is no cloud cover. NAR[2] (Near Atlantic Region, zone GASC) and SEVIRI[3] (Spinning Enhanced Visible and InfraRed Imager) are OSI SAF[4] (Ocean and Sea Ice Satellite Application Facility) products. They provide sea surface temperature (SST) data. NAR SST comes from NOA-18 polar-orbiting satellite (previously NOAA-17 and NOAA-16). The archive is available since 2001 at a 2km spatial resolution; they are produced four times a day. SEVIRI SST comes from METEOSAT geostationary satellites (METEOSAT 8 to 11). The archive is available since 2002; the hourly images have a spatial resolution of 5.56km (0.05°).

▪ MARS 3D

MARS 3D (Lazure and Dumas, 2007) is a Bloomberg & Mellor-like model in sigma coordinates. A wider barotropic model extending from Portugal to Iceland is used to provide boundary conditions for the three-dimensional model. Tidal constituents along the open boundary of the large model are extracted from the

Schwiderski atlas. Surface wind stress and pressure are provided by the ARPEGE model from METEO FRANCE. The 3D model is forced by the free surface and has a resolution of 4km. Loire, Gironde and Adour river runoffs are prescribed in their own estuaries and taken from daily measurements.

Since current data are scarce over the Aquitan shelf, the model has been very useful to this study.

Results

Dynophysis events caracteristics

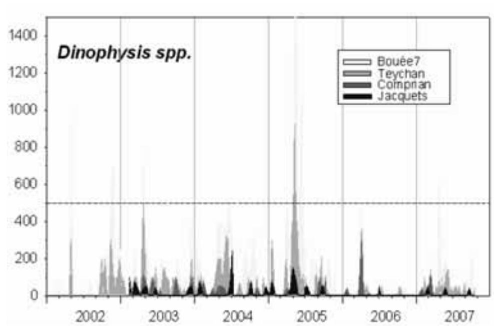
This study is focused on ten *Dinophysis* events from 2001 to 2005. Out of these ten events, 80% are in spring and 20% in early winter. They last from two weeks to one month with *Dinophysis* concentration from 400 cells/litre to 1900 cells/litre.

Dynophysis come from Aquitan shelf

Monitoring results (see Figure 1) show that the concentration of *Dinophysis* is more important in the entrance of the Arcachon Basin («Bouée 7») than in the inner part of the Bay where it declines («Teychan», «Comprian» and «Jacquets»).

«Bouée 7» where is measured the strongest concentration, shows about twelve events over 500 *Dinophysis* cells/litre and two over 1500 cells/litre since 1995.

Figure 2. Evolution of the abundance of *Dinophysis* in the 4 stations



followed in the frame work of the REPHY in the Basin of Arcachon

From this observation, *Dinophysis* is thought to be advected in the Arcachon Basin from the open shelf. This study is therefore focused on the Aquitan shelf dynamic with a particular attention during the *Dinophysis* events.

Meteorological conditions

Winds prior *Dinophysis* events are rather N-S than E-O directed. The prevailing winds are for 50% northward and 50 % southward with some low wind events.

Discussion

Dinophysis ecology is relatively unknown. However, a stratification of the water column is required. This stratification can be induced either by temperature or salinity. The climatology of the Bay of Biscay (Vandermeirsh *et al*, this issue) shows that thermal stratification over the Aquitan shelf occurs from early may to November. Most of the events occur during this period. Nevertheless, some events have been observed in November 2002 and mid-March 2001 when the water column is as a rule thermally homogeneous. During these events, the stratification is likely to be induced by river plumes. Actually, a week before these events, strong runoff from Adour river (up to 1600m^3/s) have been recorded meanwhile the wind blew from the South. It is then inferred that the *Dinophysis* population has grown within Adour river plume.

Moreover, most of the events are linked to Northern or Southern wind rather than Western or Eastern wind. As shown by Pingree and Le Cann (1989), the induced circulation is stronger when the wind is directed along the coast than perpendicularly. This raises the question of a local growth of *Dinophysis* which could be linked to retention structures as shown by Xie *et al.* (2006), or an advection from the North or the South. At the two boundaries of the Aquitan shelf, *Dinophysis* observations have been reported in the literature. In the Basque country, *Dinophysis* have been observed, generally at low concentration (Borja *et al*.,2004 and Seoane *et al*., 2005) and in front of the Gironde estuary, some high *Dinophysis* concentrations have been measured (Delmas *et al.*, 1992).
Hence, model results and the data previously introduced in the chapter Method will be used to assess the circulation on the shelf prior to *Dinophysis* events and evaluate the residence time off the Arcachon Basin. It is expected that this analysis will give clues to understand whether the *Dinophysis* grows in front of Arcachon Basin or is advected from a remote source.

Acknowledgements

The authors would like to thank IFREMER staff at Arcachon and the personnel of the REPHY program without whom this study would not have been possible.

References

Lazure, P., F. Dumas, 2007, An external–internal mode coupling for a 3D hydrodynamical model for applications at regional scale (MARS). *Advances in Water Resources*.

Xie, H., P. Lazure, P. Gentien, 2007, Small scale retentive structures and Dinophysis, *Journal of Marine Systems,* Volume 64, Issues 1-4, January 2007, Pages 173-188

Delmas, D., A. Herbland, S.Y. Maestrini, 1992, Environmental conditions which lead to increase in cell density of the toxic dinoflagellates Dinophysis spp. In nutrient-rich and nutrient-poor waters of the French Altantic coast, *Marine Ecology Progress series,* Vol.89:53-61,1992.

Seoane, S., A. Laza, E. Orive, 2005, Monitoring phytoplankton assemblages in estuarine waters: The application of pigment analysis and microscopy to size-fractionated samples, *Estuarine, Costal and Shelf Science* 67 (2006) 343-354.

Borja, Á., Franco, J., Valencia, V., Bald, J., Muxika, I., Belzunce, M. J., Solaun, O., 2004. Implementation of the European water framework directive from the Basque country (northern Spain): a methodological approach, *Marine Pollution Bulletin* (Vol. 48) (No. 3/4) 209-218

Pingree, R., B. Le Cann, 1989, Celtic and armorican slope and shelf residual currents. Progress in Oceanography, 23 :303–338.

Dupuis, H., G. Goasguen, L. Michel, B. Michard, P. Bretel, 2004. Inter-comparaisons de mesures de vagues au large du Cap Ferret. *VIIIèmes Journées Nationales Génie Civil* – Génie Côtier, Compiègne, 7-9.

Vertical distribution of living planktic foraminifera in the Northern part of the Plateau des Landes (Bay of Biscay)

Sophie Retailleau*[a], Hélène Howa[a,b], Neven Lončarić, N.[a,b], Fabien Lombard[c], Laurent Labeyrie[c]

Introduction

This work is the basic part of the French national project FORCLIM "Temperature and Salinity of the North Atlantic by geochemical and isotopic analyses of foraminiferal shells" (Howa *et al.,* 2007). The objective of the project is to further improve oceanographic proxies ($\delta^{18}O$, $\delta^{13}C$ and trace element content from planktic foraminiferal shells) which allow quantification of hydrological changes during recent periods of rapid climate change. In this context, our study aims to increase resolution of paleo-estimates by calibration using in-situ collected living fauna. We will try to better understand planktic foraminifera ecology, taking into account their vertical and lateral distribution, and population seasonality. Ecological studies are frequent in open ocean (e.g. Ottens, 1992; Lončarić *et al.*, 2007) but studies which distinguish living from dead specimens are scarce (e.g. Watkins *et al.*, 1998; Schiebel *et al.*, 2000, and 2002). Previous investigations in the Bay of Biscay were performed on taphonomical assemblages collected by long cores (Caralp, 1968; Pujol, 1980) and on sea surface plankton tows considering total foraminiferal population without distinction on species level (Albaina and Irigoien, 2007). Here, using a method that allows good discrimination between live and dead organisms, we compare the foraminiferal vertical distribution between two seasons: a warm period and a spring.

Methods

In order to investigate the vertical distribution of planktic foraminifera in an open bay, plankton tows were collected at station WH, located at 2000m depth, on the northern border of the Plateau des Landes (Bay of Biscay, 44°32'N; 2°45'W). During two R/V *Côte de la Manche* cruises, the upper 700m of the water column was sampled at 9 depth intervals (0-20; 20-40; 40-60; 60-80; 80-100; 100-200; 200-300; 300-500; 500-700m). Samples were colored with Rose Bengal (1mg/l) in order to differenciate living foraminifera from dead ones (following Walton, 1952) and stoked in alcohol 95%. Simultaneously, the hydrology was recorded by CTD device, equipped with an additional oxygen and fluorescence sensor. In the laboratory, samples were sieved into size classes of 100-150µm and >150µm. Dyed planktic foraminiferal tests were determined and counted on a species level, following the taxonomy of Hemleben *et al.* (1989).

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Two different seasonal situations of the hydrography and fauna were investigated : an exceptional warm period (22[nd] June 2006) and a spring situation (15[th] April 2007).

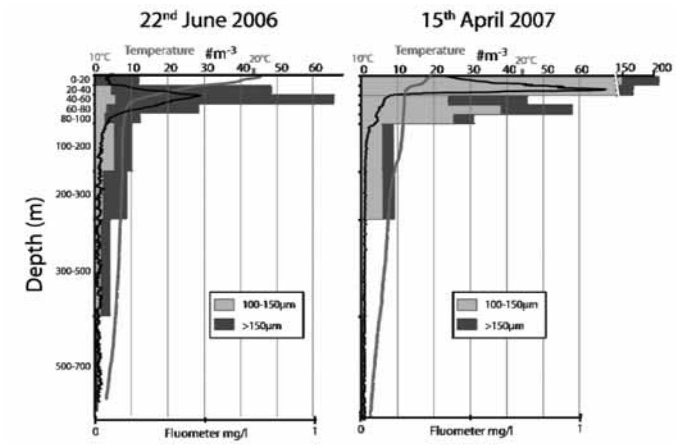

Figure 1. Vertical distribution of planktic foraminifera (in specimen by cubic meter) at station WH, in June 2006 and April 2007, with profiles of temperature (in °C, grey line) and chlorophyll-*a* (in mg/l, black line).

Results

In the Bay of Biscay, summer warming of 2006 was the most important since the last years with an average SST of 21°C, i.e. 1.5°C above the seasonal average (Drévillon *et al.*, 2006). In June 2006, SST was about 21°C, allowing the development of a strong thermocline between surface and 60m depth. Chlorophyll-*a* maximum zone extended between 20 and 80m with a moderate concentration peak of 0.5mg/l. Living foraminifera were found from sea surface to 700m depth with 85% of the population in the upper 100m of the water column. The highest concentration of 65sp/m^3 coincided with the chlorophyll-*a* peak (Retailleau *et al.*, 2007).

Hydrology pattern during Spring 2007 showed usual characteristics (IFREMER Atlas : http://www.ifremer.fr/climatologie-gascogne/index.php) with a SST around 14°C, a weak thermocline between 16 and 23m and a thin mixed layer developed close to the surface. A high chlorophyll-*a* maximum, with concentration of more than 1mg/l, was recorded at 35m depth. Living foraminifera showed a shallower vertical distribution extending 300m, with 96% of the population in the upper 100m. The maximum of 204sp/m^3 occurred near the sea surface.

At this site, 17 taxa of living planktic foraminifera are recognized. The more abundant species, *Globigerina bulloides*, *Neogloquadrina pachyderma* dextral and *Globigerinella* *quinqueloba*, are all present during both sampling periods, with spring concentrations exceeding summer ones for two or more times. Other species, as *Globigerinita glutinata* and *Globigerinella calida* have high abundance only in spring period. For all mentioned species, the vertical distribution follows the chlorophyll-*a* profile.

Orbulina universa occurs with extremely high abundance only during warm period, just above the chlorophyll-*a* maximum, but is rare in spring samples.

The two deep-dwelling species, *Globorotalia inflata,* living at the base of the maximum chlorophyll-*a* zone (60-100m)*,* and *Globorotalia scitula,* living between 100 and 500m, are present in both April and June samples, yet *G. inflata* is more abundant during spring and *G. scitula* during summer.

Discussion

Assemblages of living planktic foraminifera at the station WH are in concordance with characteristic assemblages observed in the deep North Atlantic (Ottens, 1992; Schiebel *et al.*, 1995; Schiebel *et al.,* 2000). Specimen concentrations in spring are close to those measured by Schiebel *et al.* (1995) in the North Atlantic Ocean during the same season, and they are three times higher than during warm period. This could be triggered by an elevated chlorophyll-*a* concentration few days before the April cruise as observed by the SeaWiFS images (http://seawifs.gsfc.nasa.gov/SEAWIFS). Significant contribution of fine fraction specimens in total assemblages during spring together with enhanced concentrations may suggest that the observed population was sampled after a period of intense foraminiferal reproduction. Our data argue for the possibility of a direct effect of spring phytoplankton bloom (Lampert, 2001) on planktic foraminifera population.

Conclusions

Our study is the first document concerning living planktic foraminifera and their vertical distribution in the Bay of Biscay. More than 85% of the living population is restricted to the upper 100m of the water column. Species show variability in the habitat depth and their maximum abundance position differs in accordance with thermocline and chlorophyll-*a*. Almost all species are strongly linked to high chlorophyll-*a* concentration and strong temperature gradient. Deep-dwelling species live either at the base (*G. inflata*) or far below the chlorophyll-*a* zone (*G. scitula*).

Where almost all species are present in both studied seasons, some seem to be related to the warm surface water (*O. universa*), or specific temporaly food supply (*G. glutinata*). This preliminary conclusions will be strengthened by additional sampling sets from three next oceanographic cruises planed in the Bay of Biscay in 2008.

Acknowledgements

Crews of the R/V "Côte de la Manche" (CNRS-INSU) and engineers of Technical Department INSU are gratefully acknowledged for their cooperation. We are grateful to Ralf Schiebel for his participation during the first cruise and verification of the taxonomy.

This study is financially supported by the ANR (Agence Nationale de la Recherche – French Ministry of Research) and by the Regional Council of Pays de la Loire.

References

Albaina, A. and X. Irigoien, 2007. Fine scale zooplankton distribution in the Bay of Biscay in spring 2004. *Journal of plankton research*, 29 (10): 851-870.

Caralp, M., 1968. Variations climatiques pléistocène dans le Golfe de Gascogne d'après les foraminifères planctoniques. *Bulletin de l'Institut de Géologie du Bassin d'Aquitaine*, 5 : 87-110.

Drévillon, M., V. Landes, E. Rémy, 2006. Ca chauffe dans le Golfe de Gascogne et le Golfe du Lion en juillet 2006. Bulletin commenté Mercator Ocean n°14. http://www.mercator.eu.org/html/produits/

Hemleben, Ch., M. Spindler and O.R. Anderson, 1989. Modern Planktonic Foraminifera. Springer Verlag, Berlin, 363 pp.

Howa, H., P. Anschutz, F. Eynaud, F.J. Jorissen, L. Labeyrie, F. Lombard, N. Lončarić, B. Malaizé, E. Michel, A. Mouret, S.L.N. Retailleau and S. Schmidt, 2007. French national project FORCLIM : development of a proxy for the palaeohydrology in the North 0Atlantic. The Micropalaeontological Society's Foraminifera and nanofossil groups joint spring meeting 2007, Angers (France). Meeting handbook and abstracts.

Lampert, L., 2001. Dynamique saisonnière et variabilité pigmentaire des populations phytoplanctoniques dans l'Atlantique Nord (Golfe de Gascogne), Université de Bretagne Occidentale, PhD thesis, 294pp.

Lončarić, N., van Iperen, J., Kroon D. and Brummer, G.-J.A., 2007, Seasonal export and sediment preservation of diatomaceous, foraminiferal and organic matter mass fluxes in a trophic gradient across the SE Atlantic, Progress in Oceanography, 73, pp. 27–59.

Ottens, J.J., 1992. April and August Northeast Atlantic surface water masses reflected in planktic foraminifera. *Netherlands Journal of Sea Research*, 28 (4): 261-283.

Pujol, C., 1980. Les foraminifères planctoniques de l'Atlantiques Nord au Quaternaire. Ecologie-Stratigraphie-Environnement. Mémoires de l'Institut de Géologie du Bassin d'Aquitaine 10 :254p. Université de Bordeaux.

Retailleau, S., H. Howa, N. Lončarić, R. Schiebel and S. Terrien, 2007. Distribution of live planktonic foraminifera in the Bay of Biscay during a warm summer. The Micropalaeontological Society's Foraminifera and nanofossil groups joint spring meeting 2007, Angers (France). Meeting handbook and abstracts.

Schiebel, R. and Hemleben, 2000. Interannual variability of planktic foraminiferal populations and test flux in the eastern North Atlantic Ocean (JGOFS). *Deep-Sea Research II*, 47: 1809-1852.

Schiebel, R., B. Hiller and C. Hemleben, 1995. Impacts of storms on recent planktic foraminiferal test production and CaCO3 flux in the North Atlantic at 47°N, 20°W (JGOFS). *Marine Micropaleontology*, 26: 115-129.

Walton, W.R., 1952. Techniques for recognition of living foraminifera. *Contribution from the Cushman Foundation for Foraminiferal Research*, 3: 56-60.

Watkins, J.M., A.C. Mix, J. Wilson, 1998. Living planktic foraminifera in the central tropical Pacific Ocean: articulating the equatorial 'cold tongue' during la Niña, 1992. *Marine Micropaleontology*, 33:157-174.

Temporal pattern of surface ichthyoplankton in southern bay of Biscay (W. Atlantic)

Jean d'Elbée*[a] , Iker Castège[b], Frank D'Amico[c] , Georges Hémery[d], Yann Lalanne[c], Claude Mouchès[c] and Françoise Pautrizel[e]

Our study aims at collecting data on the whole surface ichthyoplankton assemblage in the Bay of Biscay on a long-term basis (> 10 years). Sampling strategy is based on monthly collection and designed to strengthen the temporal dimension of long-term pattern. It is part of a larger programme research on the zooplanktonic, seabirds and sea mammals communities of the Southern Bay of Biscay (d'Elbée & Prouzet, 2001 ;Castège et al., 2004; Hémery et al. 2007).

From September 2000 to December 2006, we collected on a monthly basis 57 surface plankton samples from a unique station located in the south Bay of Biscay (43°37N ; 1°43W - France) near the deep canyon of Capbreton (Figure 1). In this paper, we present results from the ichthyoplanktonic assemblage only.

Figure 1. Location of the sampling station (dark square) in the south Bay of Biscay.

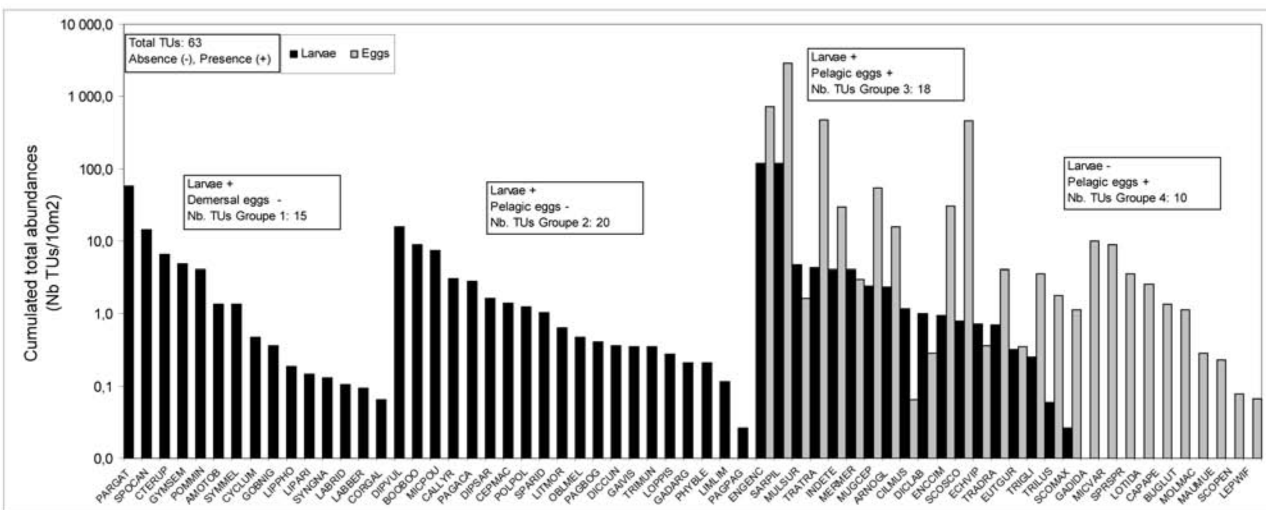

Figure 2. Cumulated abundances of the 63 TUs sorted by decreasing order in the 4 fonctional groups and according to the presence (quoted +) or absence (quoted -) of at least one or two developmental stages : egg (grey bar) or larval (black bar).

Among the 63 species censused, 35 were present at larval stage only whilst 10 were represented by their eggs only. Those taxa (N= 18) being represented by both stages (egg + larvae) have the highest abundance (Figure 2). This presence in the surface plankton assemblage of species at either or both stage is interpreted in the context of the bathymetric distribution of species and the chosen sampling strategy.

Maximum in ichthyoplanktonic abundance and diversity occur in February-March for eggs and May-June for larvae. This 3-month time lag between those two stages is to be related to the egg hatching and larvae recruitment to the pelagic environment (Figure 3). Mean egg abundance (82.4± 29.8 eggs/10 m²) was 10-fold higher than larvae abundance (7.1± 1.8 larvae /10 m²).

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Despite pronounced monthly variations, no statistical significant decrease in either egg or larvae abundance was noticed during this 6-years study period. Compared to previous published studies, our work shows that the peak in ichthyoplanktonic diversity occurs two months before; furthermore laying period spread over the whole year being sustained even during autumn and winter. Using ordination we aim at describing annual sequence of taxa appearance at the study site : Gadiforms, Ammodytidae and Pleuronectiforms are present during winter whilst many Sparidae, Blennidae, Labridae and Gobiidae form the summer group. Only three species occurred all across the year : European anchovy *Engraulis encrasicolus*, European pilchard *Sardina pilchardus* and Atlantic horse mackerel *Trachurus trachurus*.

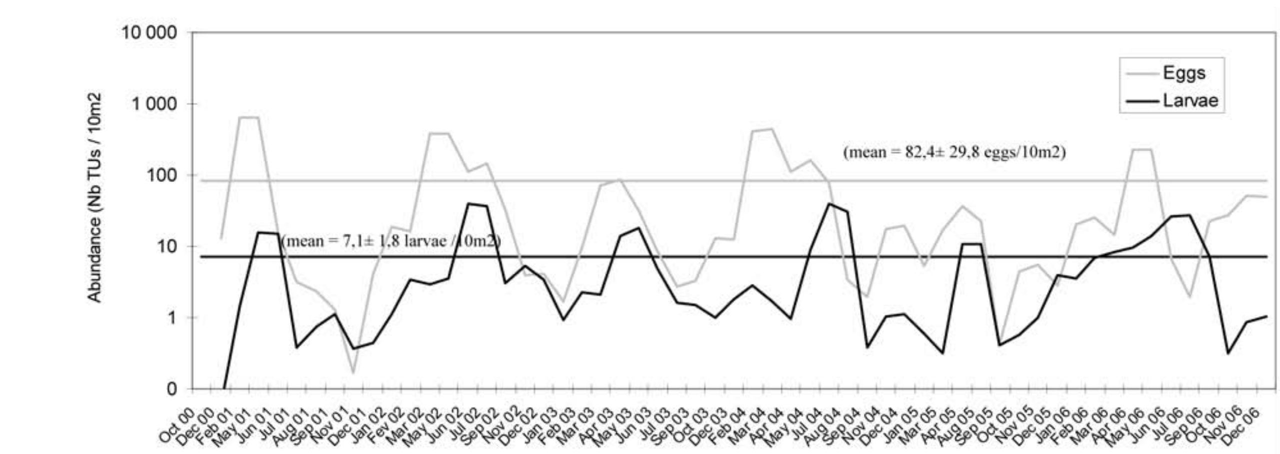

Figure 3 : Variation of moving averages (width of windows = 2) of monthly total ichthyoplanktonic abundance as revealed by egg stage (grey bars) and larval stage (black bars) during the course of the study (2000-2006). (NB: logarithmic scale)

Key words : Ichthyoplankton, bay of Biscay, temporal monitoring, biological diversity.

Acknowledgements

This study was part of the regional research programme ERMMA « Environnement et Ressources des Milieux Marins Aquitains » under the coordination of Muséum National d'Histoire Naturelle (Paris) and funded in part by the Conseil Général des Landes, the SGAR Aquitaine and the Conseil Régional d'Aquitaine.

References

Castège I., Hémery G., Roux N., d'Elbée J., Lalanne Y., d'Amico F. and Mouchès C., 2004. Changes in abundance and at-sea distribution of seabirds in the Bay of Biscay prior to, and following the «Erika» oil spill. *Aquat. Living Resour*. 17, 361-367.

Elbée (d') J. and Prouzet P., 2001. *Océanographie du golfe de Gascogne*. VIIe Colloq. Int., Biarritz, 4-6 avril 2000. Ed. Ifremer, Actes Colloq., 31, 369p. Monographie

Hémery G., D'Amico F., Castège I., Dupont B., Elbée (d') J., Lalanne Y. and Mouchès C. (2007). Detecting The Impact Of Oceano-Climatic Changes On Marine Ecosystems Using A Multivariate Index: The Case Of The Bay Of Biscay (North Atlantic-European Ocean). *Global Change Biology*, OnlineAccepted Articles, Accepted article online: 20-Oct-2007. doi: 10.1111/j.1365-2486.2007.01471.x

The RNA/DNA optimal value: a complement to the RNA/DNA starvation value to determine the overall status of fish larvae populations

Díaz E,*[a] Txurruka JM[b] and Villate F[c]

Introduction

Pelagic fishes have high fecundity and high mortality during early life stages. For that reason, the annual recruitment shows a high variability that has an impact in the overall stock abundance. One of the factors influencing larval mortality and therefore recruitment is larvae condition. The study of larval condition can be undertaken at morphological (Gwak et al.; 1999; Islam et al.; 2006), histological (Theilacker, 1986; Theilacker & Watanabe, 1989; Gwak et al., 1999) or biochemical levels. In relation to the last level, the recent improvement in methods for nucleic acid quantification has made easier their use as indicators of the physiological state of individuals (for reviews see Ferron & Legget, 1994; Bergeron, 1997; Buckley et al., 2006). The most commonly used indicator is the RNA/DNA ratio (R/D), which is based upon the fact that the amount of DNA per cell is constant in somatic tissues of a given species, whilst the amount of RNA per cell is directly and closely related to the protein synthesis capability of the cell. Therefore, R/D ratio may be taken as an indicator of the metabolic intensity of a larva and it has been proven to be an useful marker of nutritional condition and growth rate in fish larvae (Buckley, 1984; Clemmesen, 1994; Chícharo et al., 1998a; Catalan et al. 2006).

Different calibration experiments have been made to determine fish larvae "R/D starving value" by subjecting the larvae to starvation periods both in the laboratory (Clemmesen, 1994) and in the field (Chícharo, 1997). However, the "R/D starving value" is not suitable to determine the overall well being of the population, and other R/D values should be determined with this aim. In this sense, as survival probability increases with size, faster growing larvae will have a lower death probability, and therefore, laying aside pathological situations, and when food is not limintig, R/D index will increase durign growth. However, our hypothesis is that this R/D value can not increase indifenetely, and should reach a ceiling determined by cell biochemistry. In that sense, Pepin et al., (1999) stated that R/D and growth rate are indicators of survival probability and, as population gets older, their values contract towards high values.In this study we try to find this ceiling and we analyse its potential use to determine the overall status of the population.

To find this R/D value three different pelagic species have been used in the present study: *Engraulis encrasicolus, Sardina pilchardus* and *Trachurus trachurus*. To avoid the environmental effect all the larvae form the present study were caught in the same month: June 2000.

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Methods

Study area

The study was carried out in three stations (D1, D2 and D3) in the inner Bay of Biscay, on the Basque continental shelf area off San Sebastian, at 1° 55´W and 43° 20-34´N (Fig. 1).

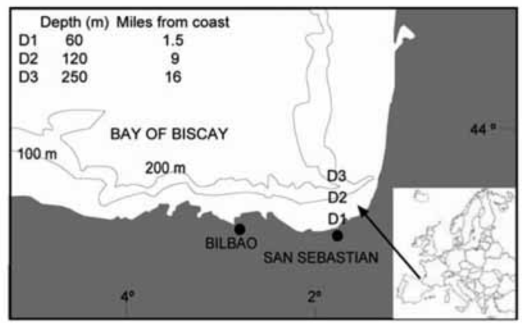

Figure 1. Location of the sampling points in the Bay of Biscay.

Sampling

To obtain the larvae, oblique tows (using a 40 cm diameter bongo fitted with a 335 µm mesh net) were carried out. After sampling, the larvae were removed immediately from the plankton samples, using pipettes. The larvae were transferred to cryovials filled with filtered sea water, so as to facilitate the later extraction of larvae; afterwards, they were frozen in liquid nitrogen and stored at -80 ºC in the laboratory.

Laboratory analysis

Larvae were rinsed with distilled water to eliminate salt and, subsequently, they were freeze-dried and weighed in a Sartorius M3P microbalance to determine Dry Weight (DW). Sub-samples of the larvae were ashed at 450 ºC, for 4 hours, to determine their mineral matter and, in this way, to calculate the OM content of the larvae. The nucleic acids were quantified following the protocol proposed by the PARS project (2000) after several intercalibration trials (Belchier et al., 2004). The mean standard curves slopes ratio of DNA/RNA was 2.65 ± 0.025.

Results & Discussion

The function that best described the relationship between the R/D index of a larva and its total OM content (Fig. 2) was asymptotic and it took the shape of a rectangular hyperbola. The relation became asymptotic when the index reached 4.7 in the case of *Trachurus trachurus,* 3.4 in that of *Engraulis encrasicolus*, and 4.3 in *Sardina pilchardus*. This asymptotic relation confirms our hypothesis that the R/D values should reach a ceiling durign larval growth. Therefore, it could be concluded that these values correspond to the maximum R/D value that could be reached in the environmental circumstances happening at that time, thus they would correspond to the "actual R/D optimal values" for these species in June 2001. A previous study stated that the R/D index appears to reach a species independent minimum value necessary for survival (Clemmesen, 1994). As in the present study the confidance intervals for the R/D asymptotic value of the three species are within the same range we could conclude that the R/D optimal values are also species independent.

In other studies that included more data from different months, and therefore different environmental circumstances, the asymptotic R/D values were 3.5 in *Engraulis encrasicolus* (Díaz et al., in press) and 3.6 in *Sardina pilchardus* (Díaz et al., manuscript in preparation), demostrating that even if they move within the same range, environmental circumstances could have effect in the index. Thus, it would neccesary, by means of controlled laboratory experiments, to determine the values at which the relationship of R/D with OM becomes asymptotic in these three species. Different combinations of temperatures and levels of preys, the two main factors affecting the index (Buckley, 1984; Ferron & Legget, 1994; Esteves et al., 2000; Caldarone 2005), will lead to different asymptotic R/D values. As the experiment will approach the optimal combination of food and temperature, the R/D values will tend to increase and will asymptotize in a "high" value limited by cell biochemistry. This asymptotic R/D value would be the "absolutely optimal" value that would permit the, only theoretically possible, non-limited larval growth and, therefore, would optimise larval survival probability or fitness. The "actual" R/D values found in a given larval population, when compared with the above mentioned "starving" R/D values and using this "absolutely optimal" R/D values as complementary information, could be used to determine the overall status of the population. This approach would allow the determination of the overall well being of the population, and not only its nutritional status, as the R/D starvation values do.

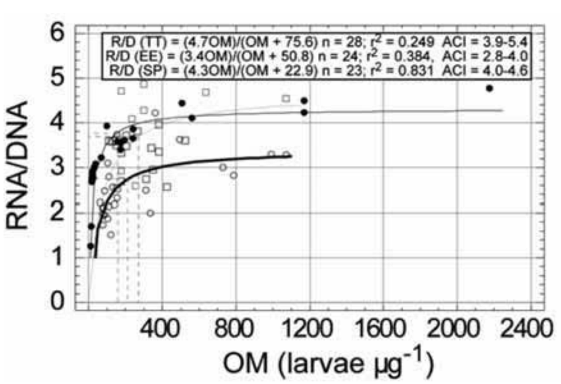

Figure 2. □: *Trachurus trachurus,* o: *Engraulis encrasicolus,* and ●: *Sardina pilchardus* Relationship of the RNA/DNA index with the OM content of larvae. Key: ACI: Asympotic 95% Confidance Interval.

Conclussions

The calculation of the "absolutely optimal" R/D values" for different species in the laboratory as a complement to the starvation values, will help in the determination of the overall well being of a larval population in the field, and therefore, to better understand the recruitment processes.

Acknowledgements

E. Díaz was supported by a grant from the Department of Education, Universities and Research of the Basque Government and the study by the Spanish Ministry of Science and Technology (MAR1999-0328-C03-02).

References

Belchier, M., Clemmesen, C., Cortés, D., Doan, L., Folkvord, T., García, A., Geffen, A., Hoie, H., Johannessen, A., Mokness, E., de Pontual H., Ramírez, T., Schnack, D., B. Sveinsbo, 2004. Recruitment studies: manual on precision and accuracy of tools. ICES Tech Mar Environm Sci 33:35 pp

Bergeron, J.P., 1997. Nucleic acids in ichthyoplankton ecology: a review, with emphasis on recent advances for new perspectives. J Fish Biol 51:284-302

Buckley, L.J. 1984. RNA-DNA ratio: an index of larval fish growth in the sea. Mar Biol 80:2291-298

Buckley, L.J., Caldarone, E.M., Lough, R.G., J.M. St Onge-Burns, 2006. Ontogenetic and seasonal trends in recent growth rates of Atlantic cod and haddock larvae on Georges Bank: effects of photoperiod and temperature. Mar Ecol Prog Ser 325:205-226

Caldarone, E.M. 2005. Estimating growth in haddock larvae *Melanogrammus aeglefinus* from RNA:DNA ratios and water temperature. Mar Ecol Prog Ser 293:241-252

Catalán, I.A., Olivar, M.P., Palomera, I., E. Berdalet, 2006. Link between environmental anomalies, growth and condition of pilchard *Sardina pilchardus* larvae in the northwestern Mediterranean. Mar Ecol Prog Ser 307:219-231

Chícharo, M.A. 1997. Starvation in field caught *Sardina pilchardus* larvae off southern Portugal. Sci Mar 61:507-516

Chícharo, M.A., Chícharo, L., Valdés, L., López-Jamar, E., P. Ré, 1998a. Estimation of starvation and diel variation of the RNA/DNA ratios in fiel-caught *Sardina pilchardus* larvae off the north of Spain. Mar Ecol Prog Ser 164:273-283

Clemmesen, C. 1994. The effect of food availability, age or size on the R/D ratio of individually measured herring larvae: laboratory calibration. Mar Biol 118:377-382

Díaz E., Txurruka, J.M., F. Villate Modeling the biochemical composition and determining the condition in anchovy larvae (*Engraulis encrasicolus*) during growth. In press.

Esteves, E., Pina, T., Chícharo, M.A., P. Andrade, 2000. The distribution of estuarine fish larvae: nutritional

Gwak, W.-S., Seikai, T., M. Tanaka, 1999. Evaluation of starvation status of laboratory reared Japanese flounder *Paralichthys olivaceous* larvae and juveniles based on morphological and histological characteristics. Fish Sci 65:339-346

Islam, M.S., Hibino, M., Nakayama, K., M. Tanaka, 2006. Condition of larval and early juvenile Japanese temperate bass *Lateolabrax japonicus* related to spatial distribution and feeding in the Chikugo estuarine nursery ground in the Ariake Bay, Japan. J Sea Res 55:141-155

PARS 2000. Manual of tools for recruitment studies. FAIR-CT96-1371. Precision and Accuracy of Tools in Recruitment Studies

Pepin, P., Evans, G.T., T.H. Shears, 1999. Patterns of RNA/DNA ratios in larval fish and their relationship to survival in the field. ICES J Mar Sci 56: 697–706

Theilacker, G.H. 1986. Starvation-induced mortality of young sea-caught jack mackerel *Trachurus symmetricus*, determined with histological and morphological methods. Fish Bull US 84:1-17

Theilacker, G.H., Y. Watanabe, 1989. Midgut cell height defines nutritional status of laboratory raised larval northern anchovy *Engraulis mordax*. Fish Bull US 87:457-469

Presence of potential domoic acid-producing species of the genus *Pseudo-nitzschia* (Bacllariophyceae) in the Nervion River estuary

Emma Orive, Aitor Laza-Martinez, Sergio Seoane and Aitor Alonso

Introduction

The Nervion River estuary (Northern Spain) has experienced in the last decade a marked increase in water quality after the implementation of a wastewater treatment program which has permit to recover even the inside beaches for bathing and other recreational uses (Garcia-Barcina et al., 2006). This is one of the largest estuaries in the northern coast of Spain (Cantabrian Sea) where, in addition to self break fronts and eddies of slope waters, river plumes constitute a preferably area for the Bay of Biscay anchovy (Motos et al. 1996), one of the main marine resources of the region. Several reports have shown the incidence of the anchovies and other planktivorous fishes as vectors of domoic acid (DA), the amnesic shellfish poisoning (ASP) produced by several *Pseudo-nitzschia* species known to be widely distributed (Hasle, 2002). The contamination with DA of planktivorous fishes can lead to neurotoxic affections or even massive deaths of their predators, which include fishes, marine birds and mammals (Lefebvre et al 2002; Busse et al., 2006). Since 2000, estuarine monitoring for phytoplankton species composition and abundance is being carried out through the entire salinity gradient of the Nervion River estuary. These surveys show that *Pseudonitzschia* spp. appear recurrently in moderate to high concentrations in the outer estuary. In this study, we report on the abundance and distribution of *Pseudo-nitzschia* along the Nervion River estuary including a detailed ultrastructural description of the nine identified species.

Methods

For cell enumeration, subsurface samples were collected monthly from March 2000 to September 2006 at eight stations located along the longitudinal axis of the estuary. In addition to bottle samples, tow nets were obtained at station 1. For species identification two sampling strategies were followed. On the one hand, the net samples taken in the outer estuary in which *Pseudo-nitzschia* were observed to be dominant were acid cleaned and the frustules studied at the transmission electron microscope (TEM). On the other hand, clonal cultures were obtained by isolating specimens from field samples taken on 11 occasions from November 2006 to September 2007. Stock cultures were maintained at a temperature of 17 ºC, a salinity of 30-35 psu in f/2, and a light intensity of 60 μE m^{-2} s^{-1}.

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Results

Pseudonitzschia species distributed preferable for the outer estuary where reached maximum densities of about 3.10^5 cells l^{-1} at station 1 coinciding with salinity values highest than 32. Only in one occasion *Pseudo-nitzschia* abundance was higher in the middle estuary (station 4) where salinity dropped to 17.2. Most peak values were observed in spring. By means of TEM, nine species of *Pseudo-nitzschia*, all of them potentially toxic, were identified from net samples and 30 isolates of estuarine waters. Four of the species corresponded to the seriata complex (*P. australis, P. fraudulenta, P. pungens* and *P. subpacifica*) and five of them (*P. delicatissima, P. caciantha, P. galaxiae, P. multistriata* and *P. pseudodelicatissima*) to the delicatissima complex.

References

Busse, L.B., Venrick, E.L., Antrobus, R., Miller, P.E., Vigilant, V., Silver, M.W., Mengelt, C., Mydlarz, L., Prezelin, B.B., 2006. Domoic acid in phytoplankton and fish in San Diego, CA, USA. *Harmful Algae*, 5: 91-101.

García-Barcina, J.M., J.A. Gonzalez-Oreja, A. De la Sota, 2006. Assessing improvement of the Bilbao estuary water quality in response to pollution abatement measures. *Water Research*, 40: 951-960.

Hasle, G.R., 2002. Are most of the domoic acid-producing species of the diatom genus Pseudonitzschia cosmopolites? *Harmful Algae*, 1: 137-146.

Lefebvre, K.A., S. Bargu, T. Kieckhefer, M.W. Silver, 2002. From sanddabs to blue whales: the pervasiveness of domoic acid. *Toxicon*, 40: 971-977.

Motos, L., A. Uriarte, V. Valencia, 1996. The spawning environment of the Bay of Biscay anchovy (*Engraulis encrasicolus* L). *Scientia Marina,* 60: 117-140.

The effects of a winter upwelling on biogeochemical and planktonic components in an area close to the Galician Upwelling Core: The Sound of Corcubión (NW Spain)

Manuel Varela,*[a] Antonio Bode[a] Ricardo Prego[b] and Carlos García Soto[c]

Introduction

Coastal upwelling systems have been largely studied because of its biological importance. Upwelling re-fertilize superficial levels of water increasing the biological productivity of the coastal zones in the main world upwelling systems (Di Lorenzo, 2003; Nixon and Thomas, 2001). The northernmost limit of the North Atlantic Upwelling System is the NW Iberian upwelling zone. The Galician Coast is fertilized during spring- summer by upwelling events of nutrient-rich Eastern North Atlantic Central Water mass (ENACW, Fraga, 1981; Fiuza *et al.*, 1998) favoured by north winds flowing along the coast (Blanton *et al.*, 1984). During autumn and winter, continental runoff is the dominant nutrient supply (Dale *et al.*, 2004). Spring-summer upwelling is a typical feature in the Galician Coast, and has been detailed described in the Galician Coast (Alvarez-Salgado et al., 1993). However the persistence of NE winds blowing at shelf during the wet season can also produce coastal upwelling events which importance have only recently been characterized from a hydrographic point of view (Alvarez *et al.*, 2003). On the contrary, the biogeochemical and phytoplankton patterns related to these out of season upwelling events is still poorly known (Prego *et al.,* 2007). In this study we investigate the consequences of a winter upwelling on biogeochemical and phytoplankton patterns in the Sound of Corcubion, an area close to the Galician upwelling core located near Cape Finisterre.

Methods

Cruise PresFis (Prestige-Finisterre)-0205 was carried out on 19th of February 2005 during winter in the area of Corcubion Sound and continental shelf close to Cape Finisterre. A total of 17 stations (Fig.1) were sampled. For each station a CTD 25 SeaBird cast was carried out to obtain vertical profiles of temperature and salinity. In 7 stations water was sampled using General Oceanic Niskin bottles of 5 L incorporated to a General Oceanic Rossete. Samples were obtained for the study of, nutrients salts, oxygen, chlorophyll and phytoplankton Station G in front of cape Finisterre was sampled as reference. Dissolved oxygen was fixed and analyzed within 24 h using the Winkler method (Aminot, 1983). Nutrient samples were frozen and kept at -20ºC until processing and were measured using a Technicon AAIII autoanalyzer following the Hansen and Grasshoff (1983) methods. Samples for the determination of chlorophyll *a* were filtered through glass fiber filters Whatman GF/F, and chlorophyll was extracted in 90% acetone (Unesco, 1994) and its concentration determined by spectrofluorimetry (Neveux and Panouse, 1987). Phytoplankton samples were were preserved with Lugol´s solution and counted following the technique described by Utermöhl.

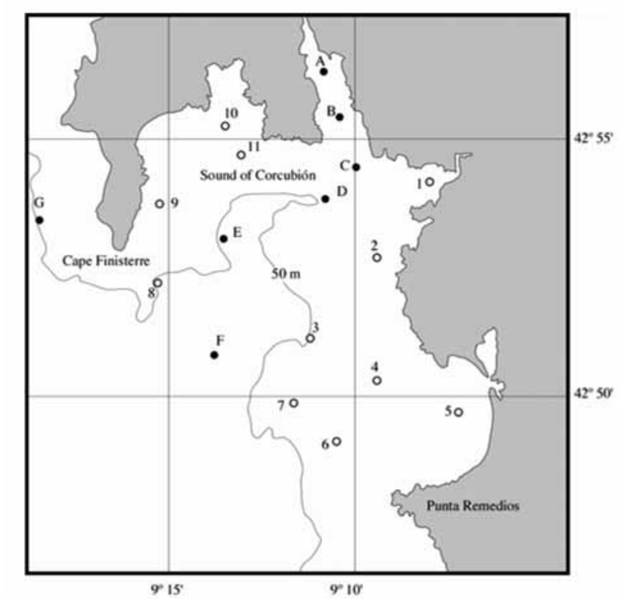

Figure 1. Sampling stations.
• Hydrography ◦ Hydrography, chemistry and biology

Results and Discussion

Before sampling, the area was affected by strong NE winds, favouring upwelling conditions. Upwelling indexes were highly positive. Salinity is a better track for upwelling than temperature as in winter water temperature is low. Salinity showed unusual high values for this season and indicated an intrusion of upwelling water affecting up to the inner par of the Sound. This water showed characteristics of Iberia Poleward Current (IPC), as the levels on nitrates (around 5 μM) are lower than the usual measured for the summer upwelling of ENACW (Varela *et al.,* 2005, Prego et *al.,* 2007). Continental water was only important in the very surface of the inner sound, as a consequence of long period of dry weather prior sampling. The combination of nutrient supply and the increased solar radiation associated to NE winds allowed for a phytoplankton bloom, dominated by the chain forming diatom *Lauderia annulata* , with abundances

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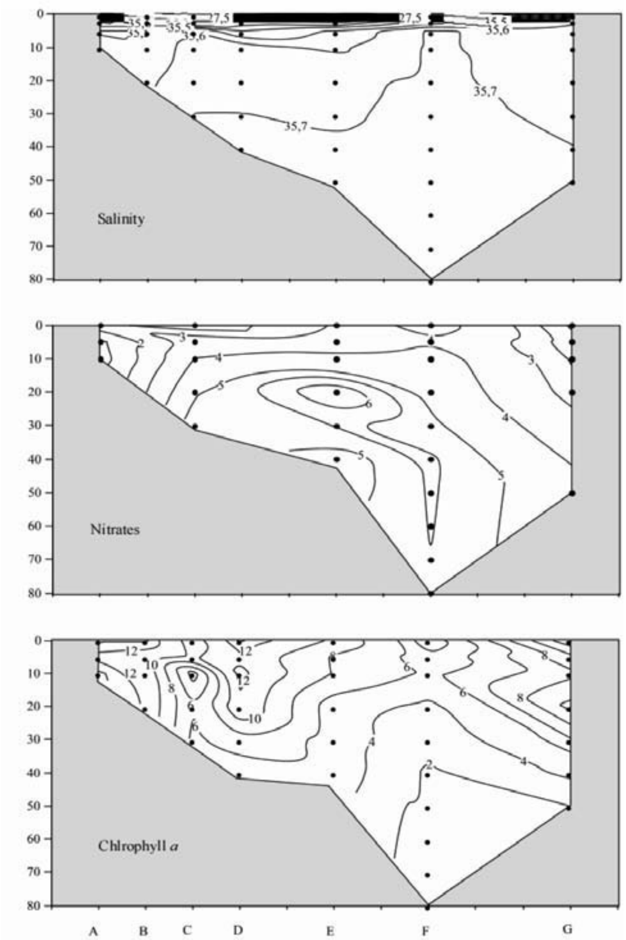

Figure 1. Profil of selected variables along the axis of the sound

500 cells mL^{-1} . Phytoplankton biomass was high except for the outer area (st F). Due to strong NE winds, blowing in the direction of the Sound axis, we might expect a strong export of phytoplankton biomass to the outer area. However the accumulation of chlorophyll occurs in the inner and middle part, suggests the existence of some physical mechanisms favouring accumulation as eddies of the development of an upwelling front. The study shows the existence of an unusual upwelling during winter in the NW Iberian Peninsula and the important effect on phytoplankton. This phenomenon is not common although it has been reported for the Pontevedra Ria in 1998 (Prego *et al*., 2007). Satellite data showed important winter blooms in winter in the period 1997-2007. Revision of historical data might relate of these blooms with upwelling events in this season. IPCC (Anonymous, 2007) and other studies (Moreno et *al.,* 2005) predict a decreases in the summer upwelling intensity for the NW Iberian Peninsula, associated to temperate and sunny winters. In this case the blooms occurring in winter could balance in some extent the decrease in productivity related to weaker summer upwelling events.

Acknowledgements

We thanks the crew of R/V Lura for the their assistance during sampling. This study has been supported by the Spanish CICYT Project "Reconocimiento Oceanográfico en la época de floración primaveral en la zona de Cabo Finisterre (Galicia, Costa de La Muerte)" in relation to the Prestige oil spill.

References

Álvarez, I., deCastro, M., Prego, R. and Gómez–Gesteira, M., 2003. Hydrographic Characterization of a Winter-Upwelling Event in the Ria of Pontevedra (NW Spain). Estuarine, Coastal and Shelf Science 56, 869-876.

Alvarez-Salgado, X.A., Rosón, G., Pérez, F.F. and Pazos, Y., 1993. Hydrographic Variability off the Rias Baixas (NW Spain) during the upwelling season. Journal of Geophysical Research 98, 14447-14455.

Aminot, A., 1983. Dosage de l'oxygène dissous. In: Aminot, A., Chaussepied, M. (Eds.), Manuel des Analyses Chimiques en Milieu Marin. CNEXO, Brest, pp. 75–92.

Anonymous (2007) Climate Change 2007. The Physical Science Basis. Working Group I Contribution to the Fourth Assessment Report of the IPCC. Cambridge University Press: 989 pp

Blanton, J.O., Atkinson, L.P., Castillejo F. and Montero, A.L., 1984. Coastal upwelling of the Rias Bajas, Galicia, northwest Spain, I; Hydrographic studies, Rapp. P. V. Reun. Cons. Int. Explor. Mer. 183, 179–190.

Dale, A., Prego, R., Millward, G. and Gómez-Gesteira, M., 2004. Transient oceanic and tidal contributions to water exchanges and residence times in a coastal upwelling system in the NE Atlantic: the Pontevedra Ria, Galicia. Marine Pollution Bulletin 49, 235-248.

Di Lorenzo, E., 2003. Seasonal dynamics of the surface circulation in the Southern California Current System. Deep-Sea Reserch II 50, 2371-2388.

Fiuza, A.F.G., Hamann, M. ,Ambar, I., Díaz del Río, G., González, N. and Cabanas, J. M., 1998. Water masses and their circulation off western Iberia during May 1993. Deep-Sea Research Part I 45, 1127–1160.

Fraga, F., 1981. Upwelling off the Galician Coast, Northwest Spain. In: Richards F. A. (Ed.), Coastal upwelling. Washington, DC: American Geophysical Union. pp. 176–182.

Hansen, H.P. and Grasshoff, K., 1983. Automated chemical analysis. In: Grasshoff, K., Ehrhardt M. and Kremling K. (Eds.), Methods of Seawater Analysis. 2nd ed. Verlag Chemie, Weinheim, pp. 368–376.

Moreno JM et al (2005) Evaluación Preliminar de los impactos en España por efectos del Cambio Climático. Ministerio de Medio Ambiente. Madrid 822 pp

Neveux, J. & Panouse, M. (1987) Spectrofluorometric determination of chlorophylls and pheophytins. Archiv fur Hydrobiologie, **109**, 567-581.

Nixon, S. and Thomas, A., 2001. Research Note. On the size of the Peru upwelling ecosystem. Deep-Sea Research I 48, 2521–2528.

Prego, R., Guzmán-Zuñiga, D., Varela, M., Gomez-Gesteira, M. and deCastro, M. 2007 Consequences of winter upwelling events on biogeochemical and phytoplankton patterns in a western Galician Ria (NW Iberian Peninsula) Estuarine, Coastal and Shelf Science, 73: 409-422.

Unesco. (1994) Protocols for the Joint Global Ocean Flux Study (JGOFS) core measurements. *Manuals and Guides*, **29**, 1-70.

Varela, M., Prego, R., Pazos, Y., and Moroño, A., 2005. Influence of upwelling and river runoff interaction on phytoplankton assemblages in a Middle Galician Ria and Comparison with northern and southern rias (NW Iberian Peninsula) Estuarine, Coastal and Shelf Science 64, 721-737.

Growth rates and pigment patterns of haptophytes isolated from estuarine waters

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Introduction

The relative importance of haptophyte algae in the marine environment has been underestimated due to the difficulty to identify most of their species with the microscope, the usual technique for counting phytoplankton cells (Thomsen et al., 1994). Together with other small cells, haptophyte algae have been included generally in the group of small flagellates. The use of high performance liquid chromatography (HPLC) to analyze the pigment content of the phytoplankton assemblages has revealed, based on the presence of Hex-fuco, that these algae are of paramount importance in different marine areas (Obayashi et al., 2001; Carreto et al., 2003; Rodriguez et al., 2003; Llewellyn et al., 2005; Seoane et al., 2005). In addition to the relative importance of the haptophytes in mixed phytoplankton assemblages, several species of this group are known by its ability to form blooms in coastal as well as in open marine waters (Dahl et al., 1998; Moestrup and Thomsen, 2003; Seoane et al., 2005). It was the aim of this study to know: (i) the capacity of several species of haptophytes isolated from the Nervion River estuary to growth with optimal conditions of predation and nutrients and with the irradiance, temperature and salinity typical of the outer and middle estuary in later spring and summer, (ii) whether these species could be identified as haptophytes when using Hex-fuco or the more specific Chls *c* as markers.

Methods

Twelve haptophytes were isolated by pippeting or serial dilution from samples taken at four sites located in the outer extreme (Abra of Bilbao) of the Nervion River estuary. Unialgal, non-axenic cultures were grown at a temperature of 18 ± 2 ºC and a salinity of 30 psu in filter-sterilized (0.22 µm Millipore) natural water from the own estuary enriched with f/2 medium (Guillard and Ryther 1962). Cultures were exposed to a 12 L: 12 D cycle and acclimated to the experimental conditions for at least 5 days.

Triplicate samples were grown under light intensities of 60, 110 and 350 µmol photons m^{-2} s^{-1} in borosilicate tubes containing 10 ml culture medium. Growth rates were measured directly in the culture tubes by reading the in vivo Chl *a* fluorescence with a Turner Designs 10-100R fluorometer.

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Volumes of 10 ml of exponentially growing unialgal cultures were vacuum filtered onto Whatman GF/F glass fiber filters. Pigments were assessed by HPLC following the method of Zapata et al. (2000).

Results

For all species, growth rates increased significantly with increasing irradiance ($p< 0.001$), showing all of them grow rates greater than 0.5 divisions d^{-1}. Certain species such as *Chrysochromulina* sp. "eyelash", *Chrysochromulina simplex*, *Isochrysis galbana* and *Imantonia rotunda* experienced a gradual increase from the lesser to the greater irradiance whereas others such as *Chrysochromulina pringsheimii*, *Emiliania huxleyi*, *Pavlova gyrans* and *Pleurochrysis roscoffensis* experienced a sharp increase between 110 and 350 µmol photons m^{-2} s^{-1}. At the lesser intensity, the minimum growth rate (0.54 divisions d^{-1}) was exhibited by *Pavlova gyrans* and the maximum (1.20 divisions d^{-1}) by *Pleurochrysis roscoffensis*. At the greater intensity, the greatest growth rate (2.23 divisions d^{-1}) was also exhibited by *Pleurochrysis roscoffensis* while the lesser rate (0.94 divisions d^{-1}) was observed in *Chrysochromulina throndsenii*.

All species contained MgDVP and Chl c_2 and most species, except *Isochrysis galbana*, *Pleurochrysis roscoffensis* and *Pavlova gyrans* contained Chl c_3. The Chl c_2 MGDG (18:4/14:0) was present in almost all species. Other chlorophylls, such as MV Chl c_3, Chl c_1 and some Chl c_2 were detected in only a few species. Fucoxanthin, diadinoxanthin and β,β- carotene were the only carotenoids shared by all the species. The fucoxanthin derivatives But-fuco, 4-keto-Fuco, 4-keto-Hex-fuco and Hex-fuco appeared in different way. 4-keto-Hex-fuco and Hex-fuco were present in almost all species, whereas But-fuco and 4-keto-Fuco were more specific.

Acknowledgements

This research was funded by the University of the Basque Country (project 9/UPV00118.310-15339/2003) and by a postdoctoral contract to S.S.

References

Carreto, J.I., Montoya, N.G., Benavides, H.R., Guerrero, R., Carignan, M.O., 2003. Characterization of spring phytoplankton communities in the Rio de La Plata maritime front using pigment signatures and cell microscopy. Marine Biology, 1 43: 1013-1027.

Dahl, E., Edvarsen, B., Eikrem, W., 1998. *Chrysochromulina* blooms in the Skagerrak after 1988. In: Reguera, B., Blanco, J., Fernandez, M.L., Wyatt, T. (Eds.), Harmful algae. Xunta de Galicia and

Intergovernmental Oceanographic Commission of UNESCO, pp. 104-105.

Guillard, R.R.L., Ryther, J.H., 1962. Studies of marine planktonic diatoms. I. Cyclotella nana Hutedt and Detonula confervacea Cleve. Can. J. Microbiol. 8, 229-239.

Llewellyn, C.A., Fishwick, J.R., Blackford, J.C., 2005. Phytoplankton community assemblage in the English Channel: a comparison using chlorophyll a derived from HPLC-CHEMTAX and carbon derived from microscopy cell counts. J. Plankton Res. 27, 103-119.

Moestrup, Ø., Thomsen, H.A., 2003. Taxonomy of toxic haptophytes (Prymnesiophytes). In: Hallegraeff, G.M., Anderson, D.M., Cembella, A.D. (Eds.), Manual of harmful marine microalgae. IOC Manual and Guides UNESCO, Paris, pp. 433-463.

Obayashi, Y., Tanoue, E., Suzuki, K., Handa, N., Nojiri, Y.,Wong, C.S., 2001. Spatial and temporal variabilities of phytoplankton community structure in the northern North Pacific as determined by phytoplankton pigments. Deep Sea Res. I 48, 439-469.

Rodríguez, F., Pazos, Y., Maneiro,J., Zapata, M., 2003. Temporal variation in phytoplankton assemblages and pigment composition at a fixed station of the Ría of Pontevedra (NW Spain). Estuar. Coast. Shelf Sci. 58, 499-515.

Seoane, S., Laza, A., Urrutxurtu, I., Orive, E., 2005. Phytoplankton assemblages and their dominant pigments in the Nervion River estuary. Hydrobiologia 549, 1-13.

Thomsen, H.A., Buck, K.R., Chavez F.P. 1994. Haptophytes as components of marine phytoplankton. In: Green, J.C., Leadbeater, B.S.C. (Eds.), The Haptophyte algae. Clarendon Press, Oxford, pp. 187-208.

Zapata, M., Rodríguez, F., Garrido, J.L., 2000. Separation of chlorophylls and carotenoids from marine phytoplankton: a new HPLC method using a reversed phase C-8 column and pyridine-containing mobile phases. Mar. Ecol. Prog. Ser. 195, 29-45.

Nutrient behaviour in tidal estuaries of the Arcachon lagoon

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Introduction

The Arcachon lagoon represents a unique and fragile ecosystem of the littoral of the Bay of Biscay. It is a mesotidal lagoon, covering 156 km².

Lagoon's waters have a long residence time estimated to 27 to 39 days (IFREMER, 2006), which induces a high influence of any changes in water quality. Eutrophication has been observed and partially attributed to increase of nitrogen loadings supply by the development of intensive farming (IFREMER, 1994).

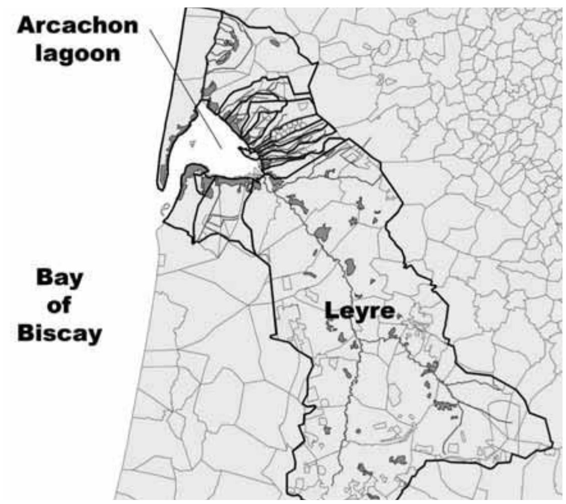

Figure 1. Catchment of Arcachon lagoon.

The lagoon is supplied with freshwater by an anthropized catchment of 3000 km² : intensive farming, housing, cultivated forest. The leyre river contibutes to 80% of the freshwater inputs and it is the major continental source of nutrient. In 2007, the annual flux of dissolved inorganic nitrogen (DIN) was 590 tons (with 560 tons in nitrate form), and 3.8 tons for dissolved inorganic phosphorus (DIP) for the Leyre river, and 630 tons of DIN and 4.2 tons of DIP for the entire catchement. In the Leyre river, the annual average concentrations were 95 µmol/L of NO3, 4.2 of NH4 and 0.3 of DIP.

The average DIN in Arcachon bay is respectively 4.8 µmol/L of NO3 and 2.3 µmol/L of NH4 and 0.2 µmol/L of DIP (SOMLIT).

The nutrient budget from watershed is well known, but we don't know what amount of these nutrients are really available in Arcachon lagoon, and what kind of proccesses occur in the estuaries that connect rivers and the lagoon. It is a key step to a better comprehension of nutrient biogeochemical dynamics in this coastal environment.

Methods

We have studied two estuaries : the Leyre estuary because of its impact on the lagoon ; the Ponteil estuary, which is the connection between two small streams, the Ponteil river, which is a signifiant source of dissolved ammonia, and the Milieu river, enriched in nitrate. Samples were collected along the salinity gradient at each season in 2007. Dissolved content was collected by in situ filtration with 0.2 µm filters. Particles were collected by filtration on GFF filters (for POC and PON) and AC filters (for POP). DIN and DIP were analysed by colorimetric standardised methods (Aminot and Chaussepied, 1983). DON and DOP were analysed after persulfate digestion as described by Valderrama (Valderrama, 1981).

Results and discussion

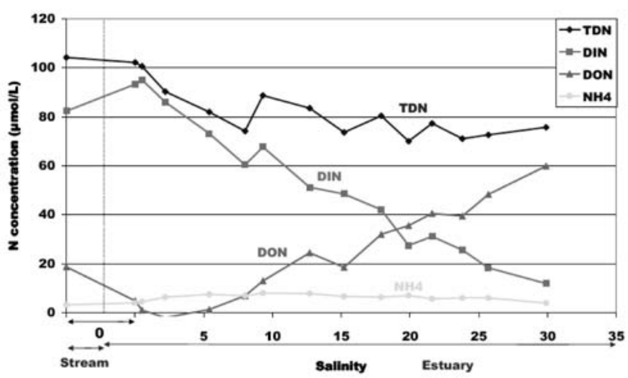

Figure 2. Dissolved nitrogen in the Leyre estuary.

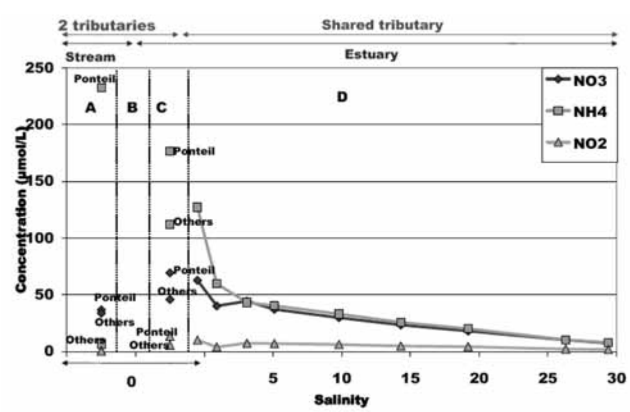

Figure 3. DIN in the Ponteil estuary

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DIN vs. salinity curve (fig. 2) is typical of a conservative mixing inside the estuary as frequently observed in other systems (Middelburg and Nieuwenhuize, 2001). We observed a supply of DIN between the river end member and the mouth of the estuary. This enrichment is interpreted as the result of continental DON mineralization, because the continental DON pool disappears and the DIN increase with the same magnitude.

We observe in the Ponteil estuary (fig .3) that the high concentration of ammonia of the Ponteil river decreases in the mouth of the estuary contrary to nitrate concentration, which increases. Nitrogen behaviour observed in the Leyre and the Ponteil estuaries suggests an efficient nitrification capacity although ammonia decrease might be due to biologic assimilation (e.g. Middelburg and Nieuwenhuize, 2000a; Middelburg and Nieuwenhuize, 2000b). Similar trend was observed in highly turbid and polluted estuaries like the Scheldt (Middelburg and Nieuwenhuize, 2001).

Although continental waters are a source of DIN, we observe that lagoon water is an enriched endmember of DON (fig. 2). DON concentration is three times higher than DIN. We will try to better characterize this N fraction in the future.

DIP is diluted in the salinity gradient (fig. 4), such as DIN. We don't observe a source of DIP around salinity 5 to 10 as it was observed in turbid estuaries like the Scheldt or the Gironde (Deborde et al., 2007; Van Der Zee et al., 2007). Indeed, the source of DIP in turbid estuaries is due to particulate phosphorus desorption and organic matter mineralization within the turbidity maximum. The catchment of the Arcachon lagoon supplies few suspended particle matter, and the geometry and hydrology of the small estuaries do not support the formation of a turbidity maximum zone.

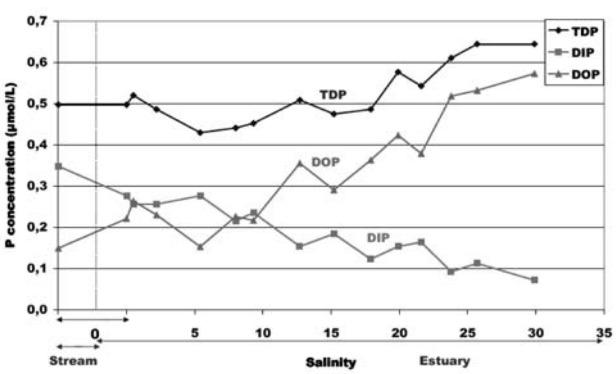

Figure 4. Dissolved phosphorus in the Leyre estuary

Like DON, the lagoon waters are a large reservoir of DOP, which is five times more concentrated than DIP. We have to determine the DOP quality and reactivity to understand its role in biogeochemical cycles.

Acknowledgements

This work is supported by the Région Aquitaine, the PNEC-Chantier Littoral Atlantique, and the ANR Protidal.

References

Aminot, A. and Chaussepied, M., 1983. Manuel des analyses chimiques en milieu marin. CNEXO, Brest.

Deborde, J. et al., 2007. The dynamics of phosphorus in turbid estuarine systems: Example of the Gironde estuary (France). Limnology and Oceanography, 52(2): 862-872.

IFREMER, 1994. Etude de la prolifération des algues vertes dans le bassin d'Arcachon.

IFREMER, 2006. Caractérisation des composantes hydrodynamiques d'une lagune mésotidale : le Bassin d'Arcachon.

Middelburg, J.J. and Nieuwenhuize, J., 2000a. Nitrogen uptake by heterotrophic bacteria and phytoplankton in the nitrate-rich Thames estuary. Marine Ecology Progress Series, 203: 13-21.

Middelburg, J.J. and Nieuwenhuize, J., 2000b. Uptake of dissolved inorganic nitrogen in turbid, tidal estuaries. Marine Ecology Progress Series, 192: 79-88.

Middelburg, J.J. and Nieuwenhuize, J., 2001. Nitrogen Isotope Tracing of Dissolved Inorganic Nitrogen Behaviour in Tidal Estuaries. Estuarine, Coastal and Shelf Science, 53(3): 385-391.

Valderrama, J.C., 1981. The simultaneous analysis of total nitrogen and total phosphorus in natural waters. Marine Chemistry, 10(2): 109-122.

Van Der Zee, C., Roevros, N. and Chou, L., 2007. Phosphorus speciation, transformation and retention in the Scheldt estuary (Belgium/The Netherlands) from the freshwater tidal limits to the North Sea. Marine Chemistry, 106(1-2 SPEC. ISS.): 76-91.

Nano- and microplankton size-structure during late summer in the Southern Bay of Biscay

Eva Álvarez,*[a] Ángel López-Urrutia[a] and Enrique Nogueira[a]

Introduction

The structure of the planktonic community, characterised by its species composition, size-spectra or trophic relationships among its components, is one of the main determinants of ecosystem functioning and dynamics (Tilman, 1999). The analysis of structural aspects can focus on an unique trophic level or on the whole community. In this later case, it is necesasary to apply an aggregation criterion to simplify the complexity of the planktonic community.

Organism size is a criterion that permits the simplification of a food web, and a reference variable in physiology and ecology. Thus, it can be used as a scaling factor and aggregation criterion to produce a macroscopic description of the pelagic community through the description of particle size distributions or biomass size spectra (Rodríguez, 1994).

Automatic methods based on image analysis are capable of rapidly counting and measuring a large number of particles, althought sacrifiying some taxonomic information. The Flow Cytometer and Microscope (FlowCAM) provides images and size-distributions for natural marine samples (Sieracki, 1998) with not significantly different results when compared with traditional microscopy-based methods (See et al., 2005).

Theorethical (Platt and Denman, 1978) and experimental (Blanco, 1994) results suggest that there is a simple relation between the numerical abundance and the size of planktonic organisms in the ocean. The observed size-abundance spectrum of plankton in a given water column is the result of a combination of diverse processes at the individual or community level and the physical enviroment ocurring at particular spatial and temporal scales (Rodriguez, 1994).

The study of the whole community on the basis of size-spectra allows to make inferences about ecosystem energetics, which are related to energy transfer eficiency between trophic levels and the amount of biomass that can be sustained by the lower trophic levels.

Methods

Sample collection

Two cruises were carried out aboard the RV Francisco de Paula Navarro in the central Cantabrian Sea during 2007: PERPLAN 1 (16 to 28 August) and PERPLAN 2 (20 October to 2 November). The two cruises consisted of intensive sampling of five stations situated off the Gijón coast (Fig 1). Here we summarize the data obtained at station 2 (43º 40.0723 N, 5º 34.8633 W, 110 m depth).

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Sampling was carried out with a rossette sampler fitted with a CTD. Seawater samples were collected from Niskin bottles at fixed depths of 0, 20, 40 and 75 meters and at chlorophyll maximum depth (DCM). For the analysis of the nano- and microplankton using FlowCAM, 1 l of water was colected and handled with care avoiding bubbles and turbulence. The sample was pre-filtered through a 200 µm mesh-size, and stored in the dark and refrigerated with running seawater until subsequent analysis in the laboratory.

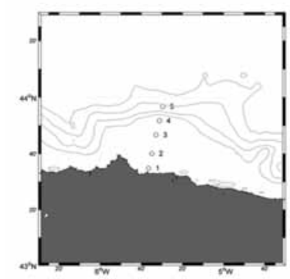

Figure 1. Map of the study area, showing the sampling stations.

Sample analysis

The size-structure of nano-and microplankton (5-120 µm) was determined using the FlowCAM with a 10x objetive and a 100 µm flow chamber. For each sample, two subsamples were processed. First, and after carefully rotating the bottle, 10 mL were poured into the sample inlet and analyzed in Autoimage Mode with the detection threshold set at 5 µm in equivalent spherical diameter (EDS). Then, 500 mL were concentrated down to 10mL by reverse filtration (Throndsen, 1978) with a 15 µm net. This subsample was analyzed in Scatter Triggered Mode with the detection threshold set at 15 µm in EDS. The instrument was cleaned with distilled water between each two analysis and with a 2% bleach solution at the end of the day (maximum 10 samples).

Sampled volume was calculated for each subsample considering the dimensions of the raw photos taken by the instrument. For each sub-sample, the FlowCAM analysis produces a spreedsheat with various particle characteristics, among them, ESD and volume. Volumes were converted to biomass using the equation provided by Montagnes (1994).

Data processing

Normalized abundance size spectra (NASS, Blanco et al, 1994) were used to examine the distribution of plankton abundance among different size classes for each subsample. For the unconcentrated subsample only those size classes with statistically reliable counts (>10 counts per size class) were considered. For the concentrated sample the lower size for reliable counts was set at 25 µm to account for the retention efficiency of the 15 µm mesh . A total of seven size clases for each subsample were considered. The parameters of the regression model fitted to the NASS were obtained combining both subsamples.

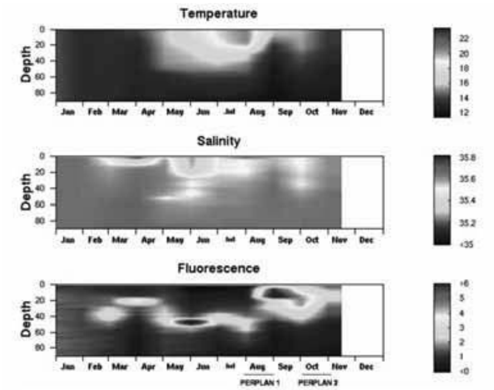

Figure 2 Temperature, salinity and fluorescence profiles in station 2 during 2007 collected by RADIALES project.

Results and discussion

Perplan 1 was carried out when the water column was estratified. Fluorescence showed the higher values at the sub-surface, near 40 m depth. Perplan 2 was carried out when stratification had been broken due to the seasonal cooling, and fluorescence was maximum at the surface (Fig 2).

Double logaritmic scale plots of the NASS for all data from August cruise had a slope of -2.09 (R^2=0.98), whereas the NASS with the data from the October cruise had a lower slope of -2.37 (R^2=0.97) (Fig 3a), due to the lower abundance of organisms within large size-classes.

In August, size-classes larger than 1.6E4 µm^3 in volume were located around the DCM (mean 41.5m); while the smaller size classes did not follow a clear pattern. In October, the size-classes larger than 6.5E4 µm^3 were more abundant near the DCM (mean 16m), whereas smaller size classes concentrated mostly close to the surface (Fig 3b).

The abundance of organisms in the larger size-classes was higher in August, consisting mainly of chain-forming diatoms (*Guinardia* sp., *Chaetoceros* sp., *Thalassiosira* sp.). In October, diatoms were less abundant while ciliates (*Laboea* sp., *Mesodinium rubrum*), dinoflagelates (*Ceratium* sp., *Dinophysis* sp.) and crustacean nauplii become dominant (Fig 3c). The identification of organisms in the smallest size-classes was not possible with the settings used for FlowCAM.

Acknowledgements

We are indebted to all participants in Perplan cruises, to the Ecology Department of Oviedo University and to J.A. Sostres for their technical support. This work was funded by Plan Nacional project PERPLAN (Ref: CTM2006-04854) and by a predoctoral grant *Severo Ochoa* from Principado de Asturias.

References

Blanco, J.M., F. Echevarría, C.M. García, 1994. Dealing with size-spectra: Some conceptual and mathematical problems. *Scientia Marina*, 58(1-2):17-29.

Montagnes, D.J.S., J.A. Berges, 1994. Estimating carbon, nitrogen, protein and chlorophyll a from volume in marine phytoplankton. *Limnology and Oceanography*, 39(5):1044-1060.

Platt, T., K. Denman, 1978. The structure of pelagic marine ecosystems. Rapports et Proces-verbaux des Reunions. *Conseil International pour l'Exploration de la Mer*, 173: 60-65.

Rodríguez, J., 1994. Some comments on the size-based structural analysis of the pelagic ecosystem. *Scientia Marina,* 58(1-2):1-10.

See, J.H., L. Campbell, T.L. Richardson, J.L. Pinckney, R. Shen, 2005. Combining new technologies for determination of phytoplankton community structure in the northern Gulf of Mexico. *Journal of Phycology*, 41:305-310.

Sieracki, C.K., M.E. Sieracki, C.S. Yentsch, 1998. An imaging-in-flow system for automated analysis of marine microplankton. *Marine Ecology Progress Series*, 168:285-296.

Throndsen, J., 1978. Preservation and storage, pages 66-74 in Sournia, ed. Phytoplankton Manual. Paris, UNESCO.

Tilman, D., 1999. The ecological consequences of changes in biodiversity: a search for general principles. *Ecology*, 80(5):1455-1474.

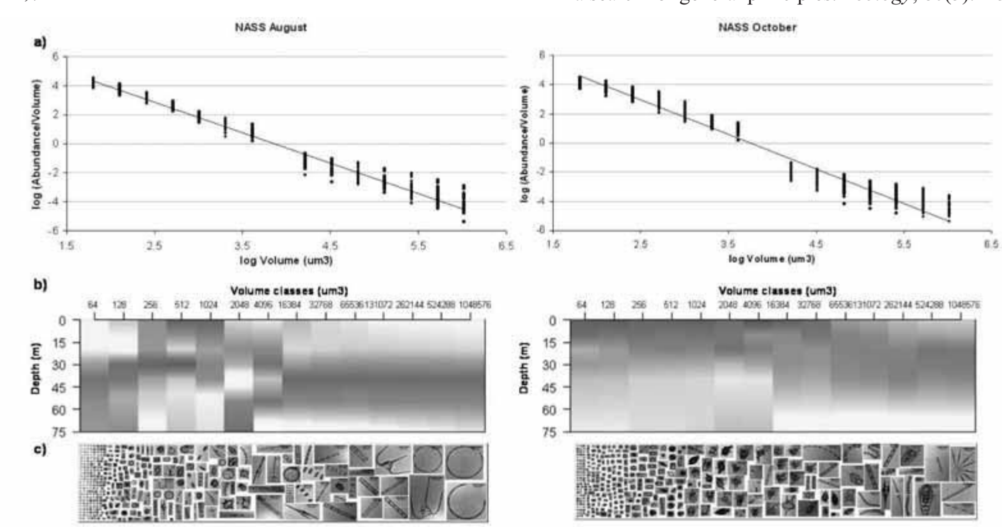

Figure 3 Normalized Abundance Size Spectra (NASS) for August and October 2007: a) NASS in double scale logarithmic showing the fitted regression model, b) variation of normalized abundance for each size class with depth (normalized abundance for each size class was standardized to zero mean and unit variance) and c) example photos taken by the FlowCAM.

A method based on chlorophyll-a concentration for the assessment of phytoplankton status in coastal and transitional waters

Marta Revilla*[a], Ángel Borja, Juan Bald, Javier Franco, Victoriano Valencia

Introduction

Phytoplankton is one of the elements recommended by the European Water Framework Directive (WFD) to be included into the assessment of the ecological status (OJEC, 2000). However, some difficulties arise when dealing with phytoplankton-based metrics in estuaries, due to the high temporal and spatial variability of the hydrographical conditions, which can overlap the anthropogenic influence on the phytoplankton communities. In this way, the WFD Intercalibration exercises among Member States conducted during the last two years in the North East Atlantic ecoregion have not faced yet the assessment of the phytoplankton element in transitional waters (estuaries), but only in coastal waters (http://circa.europa.eu/Public/irc/jrc/jrc_eewai/library). This contribution present a metric based on biomass (chlorophyll "a" concentration) for assessing the phytoplankton status in coastal and transitional waters, which has been applied in the Basque Country (Northern Spain) and fulfils the requirements of the WFD.

Methods

The data set (1995-2006) was obtained from the Basque Monitoring Network (Borja *et al.,* 2004). Chlorophyll "a" (Chl-a) was measured, at surface, by CTD in 19 coastal stations and by bottle samples in 32 estuarine stations. The CTD was regularly calibrated with the same method employed for the analysis of bottle samples (filtration through Whatman GF/C filters, pigment extraction in acetone and spectrofotometry). The stations were visited quarterly (usually, in February, May, August and November). The 90th percentile of Chl-a (µg L^{-1}) was calculated with all the seasonal data, over 6-year periods, at each station.

The sampling stations were assigned to one of three different water types, on the basis of its salinity (Table 1), following the methodology developed by Bald (2005) and Bald *et al.* (2005) for the physico-chemical status assessment in this study area.

According to the WFD, the value of the metric at the reference condition and the boundaries between classes in the Ecological Quality Ratio must be established for each water type. These values were decided by expert judgement and historical data (Chl-a in an off-shore station considered to be in "high" status due to its distance from pollution sources (for details, see Borja *et al.,* 2004, 2007), and they are showed in Tables 1 and 2.

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Table 1. The different water types proposed in the Basque Country for the phytoplankton element, with the values of the biomass metric at the reference condition and class boundaries. Metric: 90th Percentile Chl-a (µg L^{-1}). CW: Coastal Waters; TW: Transitional Waters. The values agreed during the WFD Intercalibration exercises are shadowed.

Water type	Salinity	Reference condition	High/ Good	Good/ Moderate	Moderate/ Poor	Poor/ Bad
CW	> 34.5	2.33	3.5	7.0	10.5	14.0
TW-Euhaline	32.0 - 34.5	2.67	4.0	8.0	12.0	16.0
TW	2.7 – 32.0	5.33	8.0	12.0	16.0	32.0

Table 2. The values of the Ecological Quality Ratio at the class boundaries in each water type. Metric: 90th Percentile Chl-a (µg L^{-1}). CW: Coastal Waters; TW: Transitional Waters. The values agreed during the WFD Intercalibration exercises are shadowed.

Water type	High/ Good	Good/ Moderate	Moderate/ Poor	Poor/ Bad
CW	0.667	0.333	0.222	0.167
TW-Euhaline	0.667	0.333	0.222	0.167
TW	0.667	0.444	0.333	0.167

Results and Discussion

The metric has been applied to several locations in the Basque Country that represent CW, TW and TW-Euhaline types. The results of the more recent assessment based upon Chl-a (the 2001-2006 year-period) indicated that all the coastal locations were at "high" status (data not shown). Although most of the TW were also classified at "high" status, the phytoplankton biomass metric showed more variation among the estuarine locations. The worse status was found in the upper reaches of the Oka estuary, where the Chl-a metric indicated "poor" ecological quality (Figure 1). This estuary receives high nutrient inputs (mainly ammonia and phosphate) at its head due to the discharge of urban wastewater. Recurrent phytoplankton blooms in spring and summer, and high rates of organic matter degradation have been previously described at this location, where oxygen saturation frequently drops below 40% at the bottom column (Orive *et al.,* 2004).

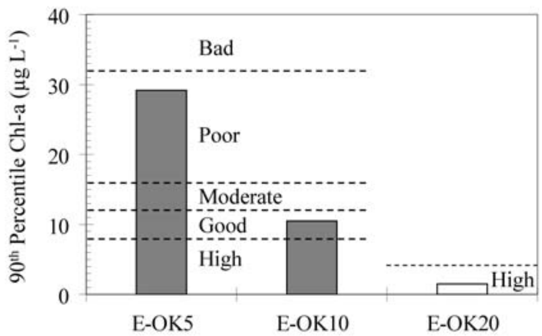

Figure 1. The value of the phytoplankton biomass metric in the Oka estuary. E-OK5, E-OK10 and E-OK20 are stations located in the upper, middle and lower reaches, respectively. The phytoplankton status estimated by this metric is indicated.

The temporal variability of the phytoplankton biomass metric has also been studied. Data on Chl-a from 1995 to present allow the calculation of the 90th percentile for 6-year mobile periods in some sampling stations. The results concerning the Nervión estuary are shown in Figure 2. This estuary historically has supported a high industrial and population pressure (Borja *et al.,* 2006). However, since 2000, the concentrations of ammonia and phosphate have been greatly reduced due to the improvement of the wastewater treatment system. This reduction in nutrient inputs could explain the trend observed in the estuary towards a better phytoplankton status (Figure 2).

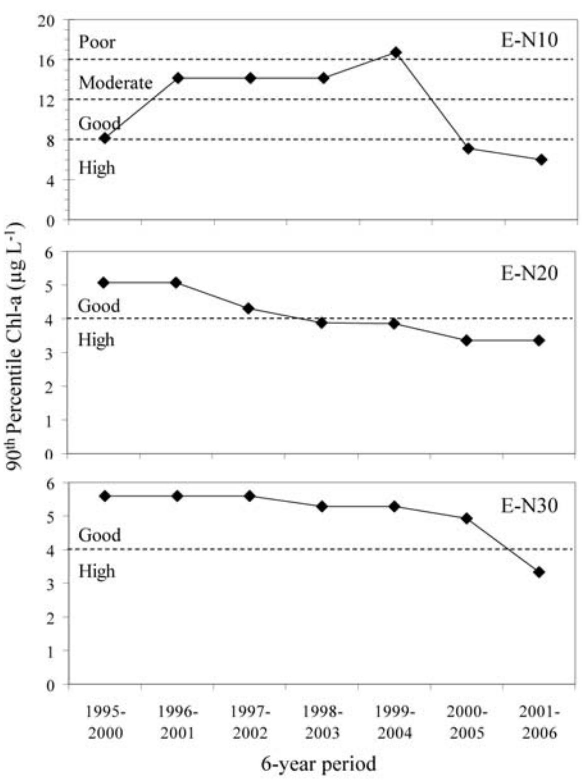

Figure 2. Evolution of the phytoplankton biomass metric since 1995 in three sites along the Nervión estuary. E-N10: upper estuary; E-N20 and E-N30: lower estuary. The phytoplankton status is indicated.

Conclusions

The phytoplankton status has been assessed in the Basque Country (N Spain), not only in coastal waters, but also in estuaries by using a tool based on phytoplankton biomass (Chl-a). This methodology fulfils the basic requirements of the WFD and it responds to changes in human pressures (both spatially and temporally).

Acknowledgements

This study was supported by the Departamento de Medio Ambiente and Ordenación del Territorio of the Basque Government, the project Plan Nacional (CTM2006-09583) funded by the European Regional Development Fund (FEDER) and the Spanish Ministry of Education and Science (MEC), and a contract of M. Revilla by the MEC programme Torres Quevedo (PTQ04-3-0595).

References

Bald, J., 2005. Propuesta para la evaluación del estado físico-químico de las aguas costeras y de transición del País Vasco. PhD thesis, University of Navarra, unpublished.

Bald, J., A. Borja, I. Muxika, J. Franco, V. Valencia, 2005. Assessing reference conditions and physico-chemical status according to the European Water Framework Directive: A case-study from the Basque Country (Northern Spain). Marine Pollution Bulletin, 50: 1508-1522.

Borja, A., J. Franco, V. Valencia, J. Bald, I. Muxika, M. J. Belzunce, O. Solaun, 2004. Implementation of the European Water Framework Directive from the Basque Country (northern Spain): a methodological approach. Marine Pollution Bulletin, 48: 209-218.

Borja, A., I. Galparsoro, O. Solaun, I. Muxika, E.M. Tello, A. Uriarte and V. Valencia, 2006. The European Water Framework Directive and the DPSIR, a methodological approach on assessing the risk of failing to achieve the good ecological status. Estuarine, Coastal and Shelf Science, 66: 84-96.

Borja, A., J. Bald, M.J. Belzunce, J. Franco, J.M. Garmendia, I. Muxika, M. Revilla, G. Rodríguez, O.Solaun, I. Tueros, A. Uriarte, V. Valencia, I. Adarraga, F. Aguirrezabalaga, I. Cruz, A. Laza, M.A. Marquiegui, J. Martínez, E. Orive, J.Mª Ruiz, S. Seoane, J.C. Sola, A. Manzanos, 2007. Red de seguimiento del estado ecológico de las aguas de transición y costeras de la Comunidad Autónoma del País Vasco. Informe de AZTI-Tecnalia para la Dirección de Aguas del Departamento de Medio Ambiente y Ordenación del Territorio, Gobierno Vasco. 14 Tomos, 591 pp.

OJEC (Official Journal of the European Communities), 2000. Directive 2000/60/EC of the European Parliament and of the Council. L327/1 - L327/72.

Orive E, Franco J, Madariaga I & Revilla M 2004 Bacterioplankton and Phytoplankton. In: A. Borja & M. Collins (Ed). Oceanography and Marine Environment of the Basque Country. Elsevier Oceanography Series 70. Amsterdam.

Size-fractionated phytoplankton biomass, primary production and respiration in the Nervión-Ibaizabal estuary

Ainhize Butron, *[a] Arantza Iriarte[a] and Iosu Madariaga[b]

Introduction

In most estuaries, phytoplankton productivity is a major source of organic matter, especially in those receiving an important bulk of nutrients from the basin, as in the Nervión-Ibaizabal. The European Water Framework Directive (2000/60/EC) establishes the requirement to describe phytoplanktonic blooms and their assemblages in order to establish the ecological status of estuaries. For that reason the study of the spatial and temporal patterns of size-fractionated chlorophyll *a* biomass and primary production is essential. Respiration is the major consumption process of photosynthetically fixed carbon in the water column. Knowledge of respiration rates is vital for the quantification of energy and carbon flux within marine food webs. However, in estuaries along the Cantabrian coast concomitant measurements of primary production and respiration along spatial and temporal gradients have only been done in the estuary of Urdaibai (Orive *et al.*, 2004).

The main objectives of the present work were to determine the seasonal pattern of the size-structure of the phytoplankton community and of primary production and respiration along the longitudinal axis of the Nervión-Ibaizabal estuary. Environmental factors influencing them were also investigated.

Methods

Surface and bottom water samples were taken monthly from April 2003 to September 2004 at 6 stations along the longitudinal axis of the Nervión-Ibaizabal estuary (Figure 1). Secchi disk depths were measured at each station. Nutrient concentrations were measured following Parsons *et al.* (1984). Samples for chlorophyll *a* and primary production analysis were size fractionated (<8 and >8 µm) by filtration using polycarbonate filters. Chlorophyll *a* was extracted with 90% acetone and measured spectrophotometrically (Parsons *et al.*, 1984). Primary productivity was measured using the standard ^{14}C method (Steemann-Nielsen, 1952) as described in Parsons *et al.* (1984). Plankton community respiration was estimated measuring changes in dissolved oxygen during incubations in the dark. Dissolved oxygen was measured with the Winkler titration technique (Granéli & Granéli, 1991). Primary production and respiration rate mesurements were only performed for surface samples.

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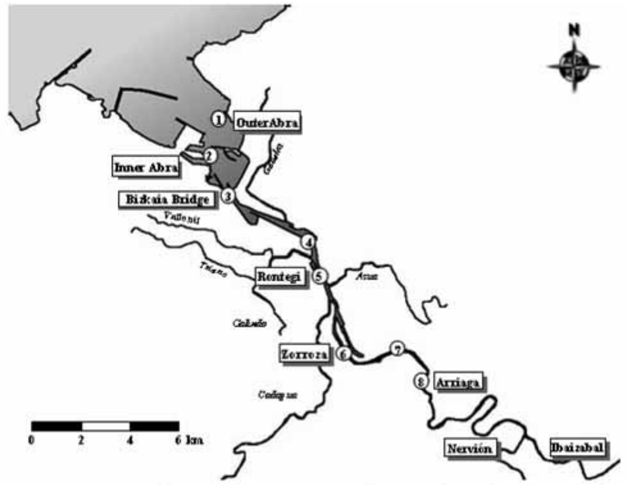

Figure 1. Map of study area and sampling stations in the Nervión-Ibaizabal estuary.

Results

The Nervión-Ibaizabal estuary nowadays has a medium turbidity level. Light attenuation coefficient (k) in the inner and mid-estuary varied between 0.5 and 1.5 m^{-1}. In the Abra bay it varied between 0.5-0.8 m^{-1}. Mean water column irradiance values in spring are usually ~125 µE m^{-2} s^{-1}. Similar values have been reported in other estuaries as the threshold needed for the onset of the spring bloom (Hitchcock & Smayda, 1977; Colijn, 1982; Iriarte & Purdie, 2004).

At the intermediate and inner stations (stations 3 to 8) concentrations of ammonium, phosphate and silicate in the estuary were high enough not to limit phytoplanktonic growth during the entire annual cycle. In summer months at stations 1 and 2 silicate concentrations and, sometimes, phosphate concentrations could be limiting (sensu Fisher *et al.*, 1992). The most important source of phosphate and ammonium in the estuary were the inputs of the WWTP of Galindo.

Phytoplankton biomass measured as chlorophyll *a* concentration varied between 0.4 and 55.7 µg L^{-1}, being always higher in surface than at the bottom. In both cases, chlorophyll *a* concentration increased longitudinally from the outer to the inner estuary. At the intermediate and inner estuary (stations 3 to 8) chlorophyll *a* biomass peaked in summer, both in surface and bottom samples. In the outer Abra bay, the seasonal pattern varied between the two years under study, with peak values in summer in 2003 and peaks in late spring (May) in the drier and warmer 2004.

Primary production rates ranged from 0.001 and 3.163 g C m^{-3} d^{-1}. Primary production followed the same seasonal and longitudinal patterns as chlorophyll *a*.

High nutrient concentrations in the intermediate and inner parts of the estuary allowed phytoplanktonic biomass to reach significantly higher values in those areas than in the Abra bay.

In the nutrient-replete waters of the intermediate and inner estuary higher temperature, irradiance and residence time during summer would explain the increase in photosynthetic activity. In the lower nutrient area of the Abra bay, river flow may have been an important factor explaining the year-to-year variations in the seasonal pattern of chlorophyll *a* concentration, being drier springs responsible for a shift from summer to spring chlorophyll *a* peaks.

In general, phytoplankton biomass and primary production were dominated (53-80%) by the largest size-fraction (>8 µm), but in summer 2003 and during winter months at the outer and intermediate sampling stations the small fraction increased its importance. This could reflect the relevance of small phytoplankton during lower nutrient conditions, when small flagellates (cryptophytes, haptophytes) are probably better adapted. In the nutrient replete inner sampling stations the >8 µm fraction (mainly diatoms) dominated during the annual cycle.

Plankton community respiration rates varied between 0.004 and 0.101 g O_2 m^{-3} h^{-1}. Maximum values of surface community respiration rates were measured during the spring bloom in the Abra bay (station 2) and in summer months at the intermediate and inner estuary (stations 5 and 8). These maximum values coincided with chlorophyll *a* biomass and primary production maxima. The correlation of respiration rates with temperature was positive and significant.

Acknowledgements

The University of the Basque Country has funded A.B. with a PhD grant.

References

Colijn, F. 1982. Light absorption in the waters of the Ems-Dollard estuary and its consequences for the growth of phytoplankton and microphytobenthos. *Neth. J. Sea Res.*, 15 (2): 196-216.

Fisher, T.R., Peele, E.R., Ammerman, J.W., Harding, L.W.Jr. 1992. Nutrient limitation of phytoplankton in Chesapeake Bay. *Mar. Ecol. Prog. Ser.*, 82: 51-63.

Granéli, W., Granéli, E. 1991. Automatic potentiometric determination of dissolved oxygen. *Mar. Biol.*, 108: 341-348.

Hitchcock, G.L., Smayda, T.J. 1977. The importance of light in the initiation of the 1972-1973 winter-spring diatom bloom in Narragansett Bay. *Limnol. Oceanogr.*, 22: 126-131.

Iriarte, A., Purdie, D.A. 2004. Factors controlling the timing of major spring bloom events in a UK south coast estuary. *Est. Coast. Shelf Sci.*, 61: 679-690.

Orive, E., Madariaga, I., Revilla, M., Franco, J. 2004. Bakterioplankton and phytoplankton communities. In: Borja, A. and Collins, M. (Eds.) *Oceanography and Marine Environment of the Basque Country*, Elsevier Oceanography Series, 70: 367-393.

Parsons, T.R., Maita, Y., Lalli, C.M. 1984. *A manual of chemical and biological methods for seawater analysis*. Pergamon Press, Oxford. 171 pp.

Steemann-Nielsen, E. 1952. The use of radio-active carbon (^{14}C) for measuring organic production in the sea. *J. Cons. Perm. Int. Explor. Mer.*, 18: 117-140.

The spatial distribution of plankton within the Bay of Biscay during spring on the French continental shelf of the Bay of Biscay: relation to the hydrologic environment

Christine Dupuy[1], Elise Marquis[2], Hans J. Hartmann [1], Claude Courties[3]

Abstract

The study concerns the distribution in spring in the south of the Bay of Biscay of the planktonic communities and its factors influencing. The distribution of the plankton and in particular the microzooplankton (more than 60% of biomass of heterotrophic organisms) on the continental shelf is very contrasted, linked to hydrologic strongly contrasted structures and the structure of primary production, influenced in part by the Gironde plume and could induce areas more or less appropriate to the nutrition of the small pelagic fishes and its larvae.

Introduction

The previous studies concerning the plankton dynamics on the French continental shelf of the Bay of Biscay allowed establishing a functioning of the planktonic food web in the spring. After the winter phytoplankton blooms exhausted phosphorus (Labry et al. 2001), the dominance of the small autotrophic cells appeared (Herbland et al. 1998) and would induce directly the development of the microzooplankton with the establishment of a microbial food web (Marquis et al. 2006). The distribution in spring in the south of the Bay of Biscay of the planktonic communities and its factors influencing was studied. Several stations (figure 1) were sampled in May-June 2003-2004-2005 in subsurface and the maximum of chlorophyll.

Methods

Sampling was realized during the PELGAS cruises in May-June 2003, 2004 and 2005. The hydrologic characteristics (CTD and fluorescence) and the sampling of the planktonic communities on two depths (Niskin bottles) was systematically realized on a series of stations similar each year in the South part of the Bay of Biscay (figure 1). Sampling permit to the measure the chlorophyll *a* and nutrients concentrations as well as to the abundance and composition of bacteria, picophytoplankton, nanoflagellates, diatoms, dinoflagellates, ciliates and metazoan microplankton. Mesozooplancton was sampled every station by a WP2 net (mesh of 200 µm).

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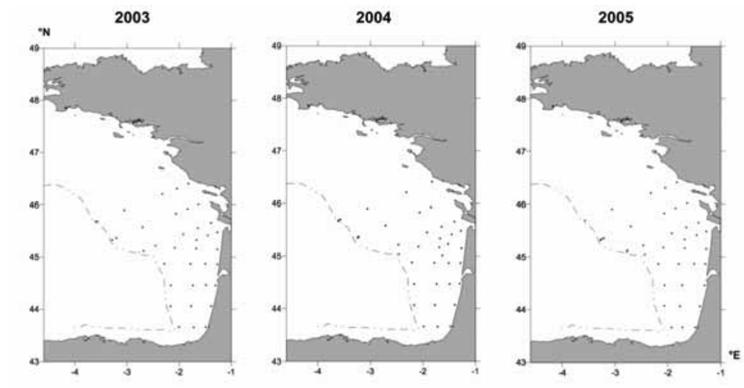

Figure 1. The study site locations

Results and discussion

The highest concentrations of chlorophyll *a* were found to the coast (majority of diatoms) and in particular in the zone of influence of Gironde plume (figure 2).

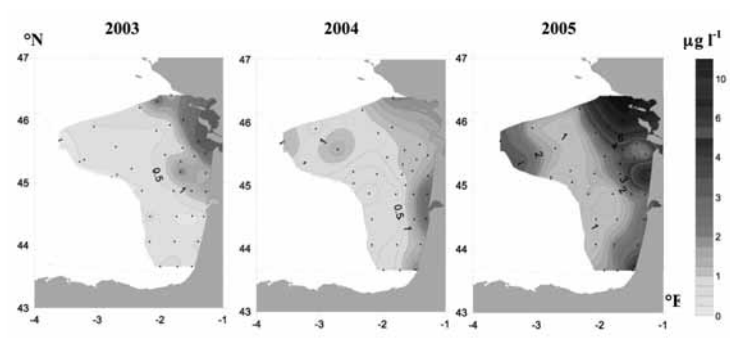

Figure 2. Spatial distribution of chlorophyll a (µg chl/L) between subsurface and maximum of chlorophyll in May-June 2003, 2004 and 2005.

The distribution of the microzooplankon was done according to 3 geographic zones according to a gradient with a higher biomass near the coast (figure 3). The principal heterotrophic planktonic organisms were the microzooplankton representing more than 60% of the heterotrophic biomass in spring. The environmental parameter, more influencing the distribution of the planktonic organisms, was the Gironde plume and therefore the proximity to the coast every spring. The specific composition and the contribution of the different communities (i.e. heterotrophic dinoflagellates, ciliates and micrometazoa) of defined every zone varied each year, corresponded to the spring succession of development of each community. Despite differences of taxonomic composition, the lines (biomass and hydrologic characteristic) of the 3 geographic zones, described from the microzooplankton, apparead each year (figure 3).

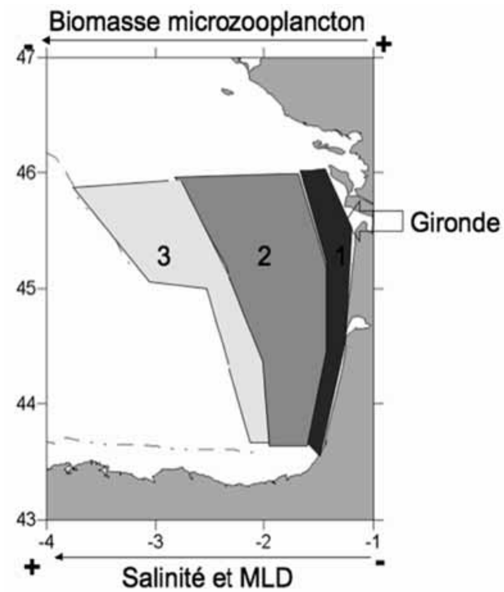

Figure 3 Spatial distribution of microzooplankton in May-June 2003, 2004 and 2005.

The contrasted hydrology of the continental shelf corresponded well to this distribution and to the typology proposed by Planque et al (2004) according to the spring hydrologic characteristics of the Bay of Biscay (figure 4). The zone "offshore" corresponds to the zone 7 of Planque et al (2004), the zone "continental shelf" to the zone 6 and the zone "Coast" to the zones 4 and 5 (figures 3 and 4). This characteristic can be exploited in order to describe the environment of the small pelagic fishes and to specify the relations between the fish distribution with the planktonic communities and especially microzooplankton (Petitgas et al. 2002, Planque et al. 2006).

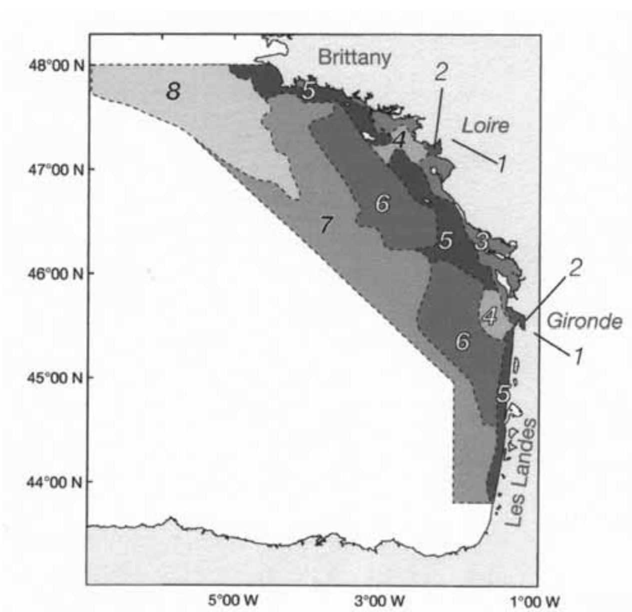

Figure 4 Spatial distribution of 8 hydrologic zones in the Bay of Biscay in Spring (Planque et al. 2004).

Acknowledgments

This work was supported by the the French "Programme National Environnement Côtier"- Atlantic working site and IFREMER.

References

HERBLAND A, DELMAS D, LABORDE P, SAUTOUR B, ARTIGAS F (1998) Phytoplankton spring bloom of the Gironde plume waters in the Bay of Biscay: early phosphorus limitation and food-web consequences. Oceanologica Acta 21: 279-291

LABRY C., HERBLAND A., DELMAS D., LABORDE P., LAZURE P., FROIDEFOND J.M., JEGOU A.M., SAUTOUR B. (2001) Initiation of winter phytoplankton blooms within the Gironde plume waters in the Bay of Biscay. *Marine Ecology Progress Series* 212, 117-130.

PETIGAS P, HERBLAND A, DELMAS D, BOURRIAU P, BERGERON J-P, KOUETA N, FROIDEFOND J-M, MASSE J, SANTOS M, BEILLOIS P (2002) Functional entities in Biscay pelagic ecosystem and their relation with the distribution of fish. ICES CM2002/ O:04, 18 pp

PLANQUE B, LAZURE P, JEGOU A-M (2004) Detecting hydrological ladscapes over the Bay of Biscay continental shelf in spring. Climate Research 28: 41-52

PLANQUE B, LAZURE P, JEGOU A-M (2006) Typology of hydrological structures modelled and observed over the Bay of Biscay shelf. Scientia Marina 70: 43-50

Accumulation of northern krill (*Meganyctiphanes norvegica*) in a convergence zone at the Cap Breton Canyon (southern Bay of Biscay).

Enrique Nogueira[*a], Joan Miquel Batle[b], Jesús Cabal[a], Gonzalo González-Nuevo[a], Rafael Revilla[a], Eva Álvarez[a], Juan Bueno[a]

Introduction

Physical-biological interactions generate spatial patterns in the distribution of plankton. In the last decade, it has being emphasized the importance of mesoscale physical structures in the distribution and production of plankton (Ressler and Jochens, 2003). Some authors have shown that organisms at the higher-trophic levels, including cephalopods, cetaceans and sea-birds also respond to these mesoscale features that control the availability of their prey (Davis et al. 2002).

Northern krill (Meganyctiphanes norvegica) plays a pivotal role in the transfer of energy from the lower to the higher trophic levels of the food-web (Warren et al. 2004). During an oceanography-fisheries cruise conducted in the Bay of Biscay in autumn, a thin and large layer (ca. 15 m height on average, 1 nautical mile length) of northern krill was acoustically detected, and confirmed by a fishing haul, at the sub-surface layer (between 15-30 m depth) over the shelf-edge at the cap Breton Canyon. The position of this layer is concurrent with a converge zone associated to anticyclone eddy activity in this area. As far as we know, this is the first time that such a large layer of northern krill is reported in the Bay of Biscay.

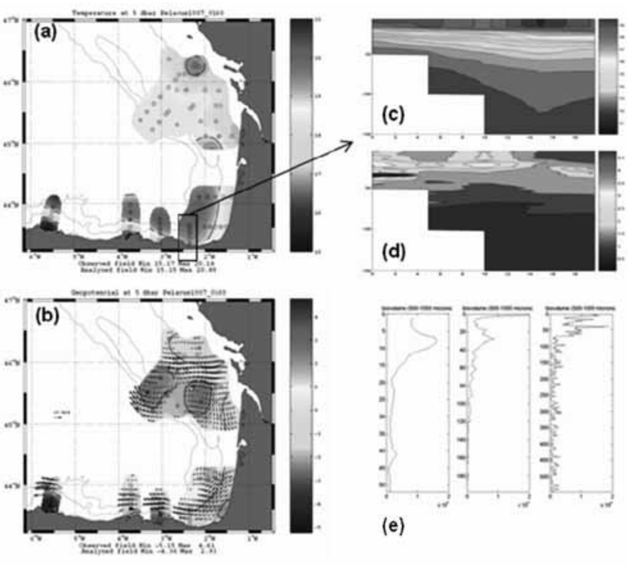

Figure 1. Oceanographic conditions in the Bay of Biscay between 19/09 and 04/10 of 2007 (a-b), and across the shelf at 2º 21' longitude on day 21 (c-d). **(a)** Temperature at 5 dbar (ºC); **(b)** geopotential at 5 dbar (cm); **(c)** temperature and **(d)** fluorescence (arbitrary units) along the transect; **(e)** biovolume (μm^3) of particles in the 0.5-1 mm equivalent spherical diameter (ESD) size-class at stations 1, 3 and 5 of the transect.

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Methods

The PELACUS-1007 cruise was carried out on board RV Thalassa in the Bay of Biscay from September 19th to October 13th of 2007, to evaluate the spatial distribution and abundance of the pelagic community, from plankton to small pelagic fishes, and to study its relationship with the oceanographic conditions. Information on abundance and distribution of marine mammals and birds was also acquired. During day-time, under-way measurements of acoustic backscatter at 18, 38, 70, 120 and 200 kHz (SIMRAD ER60 scientific echo-sounder), opportunistic fishing hauls for identification of echo-traces, surface oceanographic conditions (temperature, salinity and fluorescence) and observations of top predators were carried out. At night, a profiler package was lowered at prescribed oceanographic stations from the surface down to a maximum 500 m depth. The profiler package consist of a rosette with twelve 5 l Niskin bottles for water sampling, a SBE 911 CTD (conductivity-temperature-depth), a Wet Lab Eco-AFL fluorometer, a SBE 43 oxygen probe, a Wet Lab transmisometer for measuring the amount of suspended particulate matter and a laser optical plankton counter (LOPC from BOT) for counting and sizing plankton between 90 and 20•103 μm size range. Meteorological information was acquired continuously during the cruise. Additional satellite-derived information (sea surface temperature, color and altimetry) was also gathered at different stages.

Results and Discussion

The general oceanographic conditions during the cruise revealed the occurrence of coastal upwelling in the Cantabrian Sea (Fig. 1a), anti-cyclonic eddy activity in the inner part of the Bay (Fig. 1b) and river plumes, and associated fronts and meanders, in the French shelf. In a coastal-offshore transect off 2º 21' longitude, the tilt down of isotherms at the shelf edge were indicative of the presence of a converge area (Fig. 1c). Maximum fluorescence values were observed at the subsurface along the transect, but diminished notably at the outer stations (Fig. 1d). Contrastingly, zooplankton biovolumen in the 0.5-1 mm equivalent spherical diameter size-range was higher offshore than at the coast (Fig. 1e).

Over the shelf edge of this transect, high acoustic backscattering was detected for the all the operation frequencies at a sub-surface layer located between 20-30 m depth, and with dimensions of 15 m height on average and 1 nautical mile length (Fig. 2a). A fishing haul with a pelagic net (2 cm mesh-size at the cod-end) confirmed that the layer corresponded to almost pure northern krill (Meganyctiphanes norvegica) of 21.4 mm average (16.7-26.2 mm range) standard length (from the posterior edge of the eye to the tip of the telson) (Fig. 2b).

The aspect of the layer changed from the sunset to night (Fig. 3). It become more disperse and the center of gravity of the ascend up to 15 m depth. The occurrence of the layer was concurrent with a drop of sub-surface chlorophyll (fluorescence) and with the presence of marine mammals in the area (José Cedeira and Salvador García, pers. com.).

Acknowledgements

The authors whish to thank all the crew of the RV Thalassa for their continuous assistance during the cruise. EN thanks also all the participants in the cruise. The cruise was carried out within the frame of the IEO structural project ECOPEL (Ecology of small pelagic fishes).

References

Davis, R.W., J.G. Ortega-Díaz, C.A. Ribic, W.E. Evans, D.C. Biggs, P.H. Ressler, R.B. Cady, E.J Harris, R.R. Leben, K.D. Mullin, B Würsig. 2002. Cetacean habitat in the northern Gulf of Mexico. Deep-Sea Research I, 49: 121-142.

Ressler, P.H., A.E. Jochens. 2003. Hydrography and acoustic evidence for enhanced plankton stocks in a small cyclone in the northeastern Gulf of Mexico. Continental Shelf Research, 23: 41-61.

Warren J.D., S.A. Demer, D.E. McGehee, R. Di Mento, J.F. Borsani. 2004. Zooplankton in the Ligurian Sea: Part II. Exploration of their physical and biological forcing functions during summer 2000. Journal of Plankton research, 26 (12): 1419-1427.

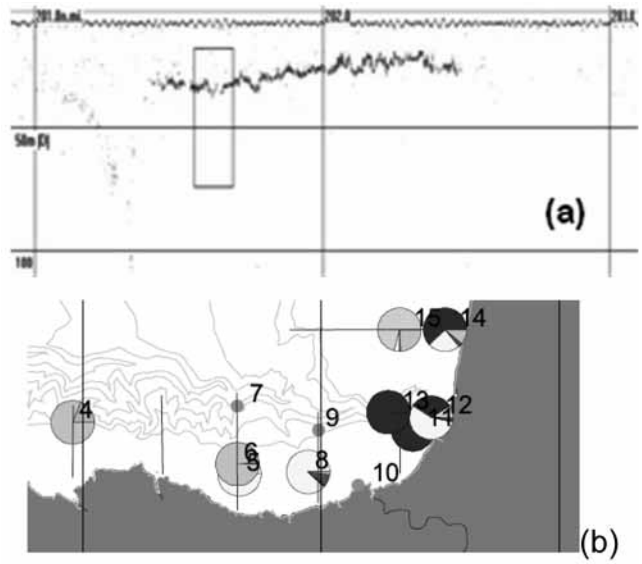

Figure 2. **(a)** Echogram at 38 kHz corresponding to M. Norvegica; and **(b)** location of the identification fishing haul (number 7).

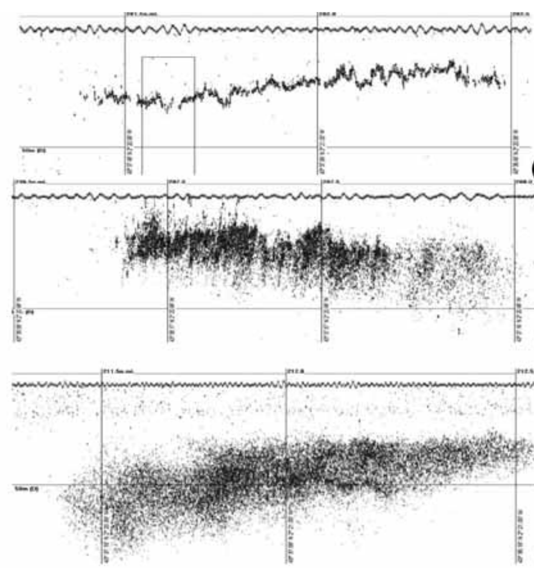

Figure 3. Three different echograms acquired at 38 kHz for the same patch of M. norvegica, (a) at dusk (19 GMT), (b) at night (21 GMT) and (c) during the fishing haul (22 GMT). Vessel speed 10 knots for echograms (a) and (b) an 4 knots for (c).

Environmental forcing and ichthyoplankton composition and distribution off the NW and N Iberian Peninsula coast, in spring

José María Rodríguez, Gonzalo Gonzalez-Nuevo, César Gonzalez-Pola and Jesús Cabal

Introduction

Environmental physical processes are of major importance for the horizontal distribution of icthyoplankton abundance and for the horizontal structure of larval fish assemblages. The location and spawning strategy of adult fishes, the vertical distribution of fish larvae and their migratory behaviour are also involved in the horizontal distribution of fish larvae. Nevertheless, in plankton communities, biological-physical interactions are more important in determining patterns of horizontal distribution than purely biological forcing mechanisms (Mackas et al. 1985).

The oceanography off the Portuguese and Spanish coasts is highly influenced by seasonal factors. During winter, the shelf slope circulation is dominated by the Iberian Poleward Current (IPC). In spring-summer, dominant northerly winds produce coastal upwelling and equatorward flow. The IPC generates convergence zones over the shelf-break and mesocale eddies (Fernandez et al. 1993; Relvas et al. 2007). All these structures are important for the horizontal distribution of fish larvae, working as retention and/or poleward/equatorward transport mechanisms.

The aim of this study is to examine the relationship between selected environmental variables and ichthyoplankton off the NW and N Iberian Peninsula coasts, in spring.

Methods

Sampling procedures

The study area, sampled during the cruise Pelacus 0405, included the shelves and upper slope (coast-500 m isobath) of two geographic regions: the Atlantic region, from river Duero to Estaca de Bares cape, and the Cantabrian region (Fig. 1).

Hydrographic conditions were measured at every sampling station with a CTD SeaBird 25. Spiciness was analysed following the method proposed by (Gonzalez-Nuevo and Nogueira 2005).

Mesozooplankton and ichthyoplankton were sampled at three stations in every transect (Fig. 1) with a triple WP2 net.

Data analysis

The hydrographic data revealed the presence of two hydrographic regions (see “Results”), which coincided with the Atlantic and Cantabrian geographic regions. Within each region, the horizontal structure of its assemblage was analysed using hierarchical agglomerative clustering and the non-metric multidimensional scaling (MDS).

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The relationship between the larval fish assemblage and environmental variables was analysed with Canonical Correspondence Analysis (CCA), using CANOCO 4.5. Only species caught in more than three samples were inclued in the analysis. The explanatory variables were sea surface temperature (SST), sea surface salinity (SSS), Chlorophyll *a* concentration, mesozooplankton biomass and station depths.

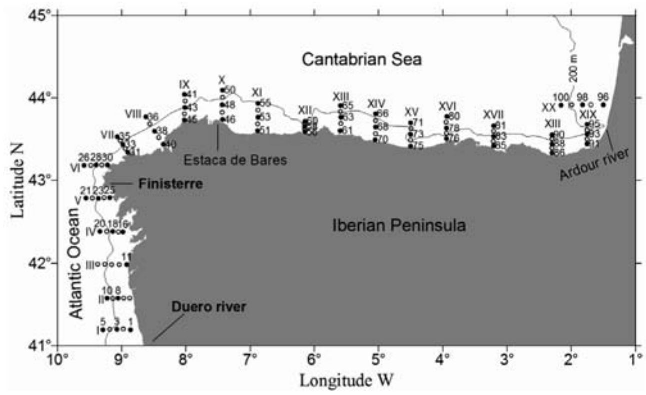

Figure 1. Study area and station map. (○) stations sampled for hydrography, (•) stations sampled for zooplankton and ichthyoplankton

Results

Hydrography

The spiciness analysis revealed the presence of an apparent frontal structure, located around Estaca de Bares cape (7.2 ºW), which separated two hydrographic regions. The Atlantic region showed significantly warmer (>13.0) and saltier (>36.66) surface waters than the Cantabrian region (t-test, df = 55, $p < 0.0001$, in both cases). In the Cantabrian region, SST significantly decreased and salinity, on the contrary, significantly increased offshore (Kruskalll Wallis test, $W < 0.02$). The spiciness analysis and cross-shelf vertical profiles of salinity revealed the presence of a salinity front located around the shelf break, which increased its intensity from west to east. This front was not found in the Atlantic region.

Ichthyoplankton composition, abundance and distribution

In all, 51 species of fish larvae, belonging to 26 families, were identified. *Sardina pilchardus* (58.7% of the total catches) dominated the larval fish assemblage.

Fish egg abundance was significantly lower (t-test, df = 55, $p < 0.02$) in the Atlantic than in the Cantabrian region. In both regions, abundance decreased offshore. Larval abundance was also lower in the Atlantic than in the Cantabrian region, decreasing offshore in both regions, but significantly (KW, p <

0.001) in the Cantabrian region only.

Results of the the Spearman's rank correlation indicated that fish egg and larval abundance were negatively correlated with SSS and depth and positively correlated with mesozooplankton biomass. Also, larval abundance was positively correlated with SST.

Larval fish assemblages

Larval diversity was significantly higher in the Atlantic than in the Cantabrian region (t-test, df = 55, $p < 0.01$). This indicated differences in the larval fish assemblage structure between both regions (Legendre and Legendre 1998).

In the Atlantic region, the classification (cluster) and the ordination (MDS) analysis grouped together, apart from three outliers, all the sampling stations. In the Cantabrian region, the classification and the ordination techniques produced two larval assemblages: a neritic and an outer assemblage.

The Monte Carlo permutation test showed that only three environmental variables (depth, SST and mesozooplankton biomass) were significant ($p < 0.05$) in explaining species distribution. Depth was highly and positively correlated with axis 1 while temperature was the environmental variable that showed the highest correlation with axis 2. Larvae of oceanic mesopelagic species were clustered on the right side of the ordination biplot while all the other species (neritic fish larvae) were clustered on the left side of the biplot.

Discussion

Hydrography

The Pelacus 2005 cruise was carried out at the beginning of the transition from typical winter downwelling conditions to summer upwelling ones (Fraga 1981), a period characterised by strong hydrographic variability (Torres and Barton 2007). The IPC would have been the main responsible for the presence of the shelf slope front found in the eastern Cantabrian region (Fernandez et al. 1993). The absence of the shelf break front along the Atlantic and westernmost Cantabrian regions could have been related with the offshore displacement of the IPC under upwelling favourable conditions (Torres and Barton 2007) recorded a few days after the beginning of the cruise.

S. pilchardus widely dominated the ichthyoplankton population. This is not surprising because this is the most abundant fish species along the west and north shelves of the Iberian Peninsula, and the cruise was carried out at the time of the spawning peak of this species in the region.

Whether fish spawning patterns may be interpreted as an adaptive strategies to certain environmental factors to optimise larval survival (Roy et al. 1989), the more intense spawning recorded in the Cantabrian Sea suggests that environmental conditions in this region were more suitable for eggs and larval survival than in the Atlantic region. Results of the correlation analysis indicated that spawning was more intense in shallow, coastal waters with lower salinities, because of river runoff, and with higher mesozooplankton biomass. Rivers runoff are much more important in the Catabrian Sea. They transport nutrients into the sea and produce a strong haline stratification that, in the absence of thermal stratification, gives stability to the water column, favours biological production (Borja et al., 1996), increases food concentration and makes it available to fish larvae (Lasker, 1984). Moreover, the shelf break front may contribute to larval survival, working as a retention mechanism for neritic spawners (Fernandez et al. 1993; Gonzalez-Quiros et al. 2004)

Larval assemblages

The Atlantic region, as revealed by multivariate analysis, was inhabited by a homogenous larval fish assemblage. The upwelling event, which occurred at the beginning of the cruise, could have been responsible for this homogeneity.

In the Cantabrian region, the shelf slope front, located in the central and eastern zones, seems to have been the responsible for the structuring of the larval fish community into two assemblages.

The CCA analysis revealed that depth, a cross-shelf gradient, was the main environmental gradient in explaining larval fish distribution. Larval fish species, associated with depth waters, were clustered on the right side of the plot, while larval species associated with shallow waters, were clustered on the left side of the plot.

Acknowledgements

This work was supported by the EU project SARDIN and by the Instituto Español de Oceanografía project PELACUS.

References

Borja, A., A. Uriarte, V. Valencia, L. Motos, A. Uriarte, 1996, Relationships between anchovy (*Engraulis encrasicolus* L.) recruitment and the environment in the Bay of Biscay. Scientia Marina, 60 (Supl. 2): 179-192.

Fernandez, E., J. Cabal, J.L. Acuña, A. Bode, A. Botas, C. Garcia-Soto, 1993. Plankton distribution across a solpe current-induced front in the southern Bay of Biscay. Journal of Plankton Research ,15: 619-641

Fraga, F. 1981. Upwelling off the Galician coast. northwest, Spain. In: Richard, F. (Ed.) Coastal Upwelling. Am. Geophys. Union. Washington, pp 176-182.

Gonzalez-Nuevo, G., E. Nogueira, 2005. Intrusions of warm and salty waters onto the NW and N Iberian shelf in early spring and its relationship to climate variability. Journal of Atmospheric and Ocean Science, 10: 361-375

Gonzalez-Quiros, R., A. Pascual, D. Gomis, R. Anadon, 2004. Influence of mesoscale physical forcing on trophic pathways and fish larvae retention in the central Cantabrian Sea. Fisheries Oceanography, 13: 351-364.

Lasker, R. 1984. The role of stable ocean in larval fish survival and subsequent recruitment. In: Lasker R (ed) Marine fish larvae. Morphology, ecology and relation to fisheries. Washington Sea Grant Program, Washington, pp 79-87

Legendre, P., L. Legendre, 1998. Numerical ecology. Elsevier, Amsterdan.

Mackas, D.L., K.L.,Denman, M.R., Abbot, 1985. Plankton patchines: Biology in the physical vernacular. Bulletin of Marine Science, 37: 652-674.

Relvas, P., E.D., Barton, J., Dubert, P.B., Oliveira, A., Peliz, J.C.B., da Silva, A.M.P., Santos, 2007. Physical oceanography of the western Iberia ecosystem: Latest views and challenges. Progress in Oceanography, 74: 149-173

Roy, C., P., Cury, A., Fontana, H., Belvèze, 1989. Stratégies spatio-temporelles de la reproduction des clupéidés des zones d'upwelling d'Afrique de l'Ouest. Aquatic Living Resources, 2: 21-29

Torres, R., E.D., Barton (2007) Onset of the Iberian upwelling along the Galician coast. Continental Shelf Research, 27 1759-1778.

Modelling phytoplankton dynamics in a mesotidal estuary

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Introduction

The negative impact that cultural eutrophication has on natural aquatic systems has made it one of the main concerns of the most recent framework for environmental legislation on aquatic environments' protection. The processes that may lead to eutrophication and determine its impact on the systems are of particular relevance. In this context, the question of whether an estuarine system is nutrient- or light limited is of paramount importance in predictive studies (Baird *et al.*, 2001). Physical characteristics of the estuary such as the residence time and turbidity control the availability of nutrients and light in the system (Monbet, 1992). Ultimately, if a particular system is light limited, then nutrient enrichment will not have a significant impact on production but can indice changes in phytoplankton composition. This study involves a model application to the Tagus estuary (Portugal) to evaluate the phytoplankton dynamics focusing on the identification of the light and nutrient control in the system. The model used in the study has been developed recently and reflects the stateof-the-art in marine ecological modeling. Therefore, this application represents the first numerical study of the Tagus estuary using a model with this level of detail.

Methods

Study site

The Tagus estuary (38°44′N, 9°08′W) is a mesotidal system with semi-diurnal tides and mean tidal amplitude of 2.2 m. Intertidal areas, composed mainly of mudflats, cover an area between 20 and 40% of the total estuarine area. Inflow of saline water from the Atlantic and the considerable riverine input of freshwater largely determine the hydrographic conditions of the estuary. The estuary also receives effluent discharges from over 10 WWTP's. The estuary has diverse phytoplankton population, with diatoms being the predominant (Cabrita et al. 1999).

Model application

The MOHID hydrodynamic model (www.mohid.com) was used to characterize the flow regime for the whole study area. Given the intense vertical mixing of the system, the model is set as a 2-D depth-integrated model. Meteorological forcing, boundary conditions, tide and river discharges are explicitly imposed, all with temporal variability. A complex marine ecological model (Mateus 2006) was coupled to the transport model. The model has a decoupled carbon–nutrients dynamics with explicit parameterization of C, N, P, Si, and O cycles. It considers two major groups of producers in the system, diatoms and autotrophic flagellates. All living and organic matter compartments of the model have variable stoichiometry. Synthesis of chlorophyll is simulated (Geider *et al.*, 1998), allowing for a temporal and spatial variation of C: Chla ratios in producer populations. Field data from 4 stations disposed along a NE-SW transect inside the estuary was used to calibrate the ecological model.

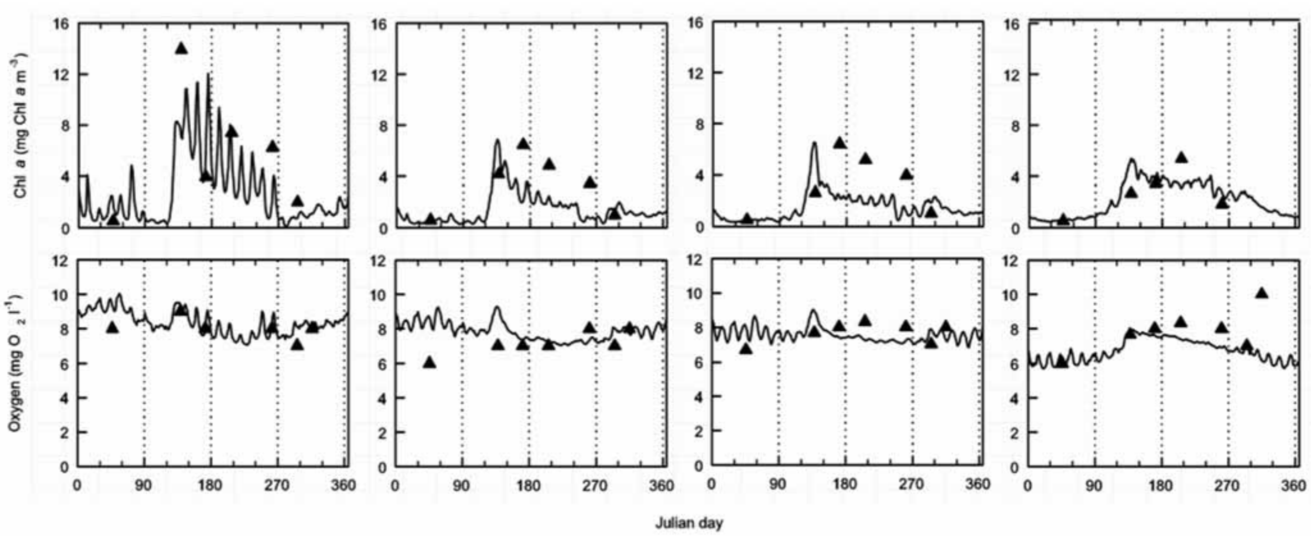

Figure 1 Total chlorophyll and oxygen values from sampling sites (▲) and the results of the model (line)

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Results and discussion

A fairly reasonable agreement is attained between model results for and data for all stations (Fig 1), in respect to the seasonal and spatial patterns, and concentration magnitude. By comparing the oxygen concentrations of model results and measured data (Fig.1) it is possible to see that the general tendency of this property is achieved. The different interval range of dissolved oxygen in data in the various check points is reproduced reasonably well for all sites.

The simulated phytoplankton chlorophyll distribution shows that the model reproduces the observed strong seasonal variation with a late spring/early summer peak in abundance. The spatial distribution of chlorophyll in the estuary for diatoms reveals some curious patterns. In winter, higher concentrations of chlorophyll can be found in mid estuarine areas and in the south banks, while in summer there is a clear gradient from low concentrations in the lower estuarine area to high concentrations in the upper areas (Fig 2). Chlorophyll concentrations in diatoms tends to decrease along the transect. An inverse pattern is observed for autotrophic flagellates. Hence, diatom dominance decreases and autotrophic flagellates dominance increases seaward.

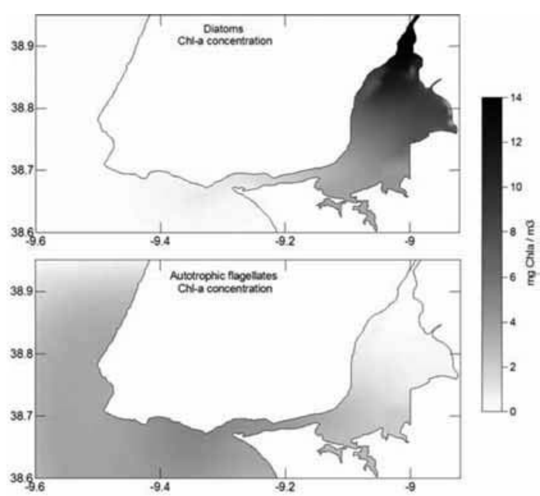

Figure 2 Modelled Chla concentration for diatoms and autotrophic flagellates at the Tagus estuary (results for Julian day 139, 12.00p.m.).

Tidally driven resuspension and riverine source of sediments are important mechanisms influencing suspended matter concentration, determining the photic depth in the water column (Barkmann and Woods, 1996). So, even when nutrient concentrations are relatively high, light availability is the key limitation. The results suggest light availability as the major controlling factor inside the estuary. This is a common feature to other estuaries (Cloern, 2001). The results indicate light as a controlling factor exhibits stronger effect in autumn/winter as a consequence of: (1) higher river discharges and sediments and organic matter in the water column and (2) the natural light regime characteristic of temperate zones. To compensate for lower light levels, the chlorophyll content of the cells is increased in the model.

The model assumes variable elemental composition which enables the quantification the influence of nutrient deficiency at any given time (Fig. 3). Only a mild nutrient limitation in autotrophic flagellates is observed during summer months for phosphorus. The model shows no signs of severe nutrient depletion in the summer, supporting the claim that the production in the system is not controlled by nutrients.

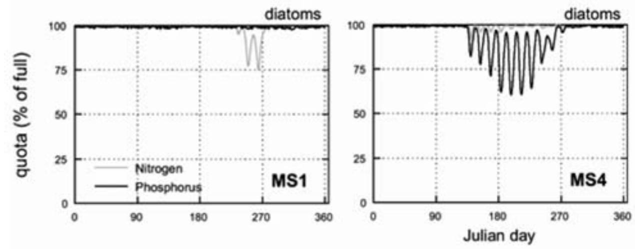

Figure 3 Model results for nutrient limitation at two stations, expressed in cell quota of N and P, for diatoms. Limitation occurs when quota falls below 50% (Redfield ratio).

Conclusions

The results of the model suggest that light acts as a controlling factor inside the estuary, reinforcing the hypothesis of light limitation already proposed by other experimental and numerical studies (Cabeçadas *et al.*, 1999, Cabrita *et al.*, 1999, Alvera-Azcarate *et al.*, 2003). Hypothetically, an increase in anthropogenic nutrient inputs (N & P) will not result in an increase in phytoplankton biomass. However, it may induce a change of Si: N in the system, possibly leading to conditions that allow for the dominance of flagellates over diatoms (Turner and Rabalais, 1994, Rocha *et al.*, 2002). This points to the need to use such complex models to address the phytoplankton dynamics in the assesment of eutrophication in estuarine and coastal systems.

References

Alvera-Azcarate, A., J.G. Ferreira and J.P. Nunes, 2003. Modelling eutrophication in mesotidal and macrotidal estuaries. The role of intertidal seaweeds. *Estuarine Coastal and Shelf Science* 57(4): 715- 724.

Baird, M.E., S.M. Emsley and J.M. McGlade, 2001. Modelling the interacting effects of nutrient uptake, light capture and temperature on phytoplankton growth. *Journal of Plankton Research* 23(8): 829- 840.

Cabeçadas, L., Brogueira and G. Cabeçadas, 1999. Phytoplankton spring bloom in the Tagus coastal waters: hydrological and chemical conditions. *Aquatic Ecology* 33(243-250).

Cabrita, M.T., F. Catarino and G. Slawyk, 1999. Interactions of light, temperature and inorganic nitrogen in controlling planktonic nitrogen utilisation in the Tagus estuary. *Aquatic Ecology* 33: 251-261.

Cloern, J.E., 2001. Our evolving conceptual model of the coastal eutrophication problem. *Marine Ecology-Progress Series* 210: 223- 253.

Geider, R.J., H.L. MacIntyre and T.M. Kana, 1998. A dynamic regulatory model of phytoplanktonic acclimation to light, nutrients, and temperature. *Limnology and Oceanography* 43(4): 679-694.

Mateus, M., 2006. *A process-oriented biogeochemical model for marine ecosystems: development, numerical study, and application*. PhD Thesis. Instituto Superior Técnico, Lisbon, Portugal.

Monbet Y., 1992. Control of Phytoplankton Biomass in Estuaries – a Comparative-Analysis of Microtidal and Macrotidal Estuaries.*Estuaries*, 15(4): 563-571

Rocha, C., H. Galvao and A. Barbosa, 2002. Role of transient silicon limitation in the development of cyanobacteria blooms in the Guadiana estuary, south-western Iberia. *Marine Ecology-Progress Series* 228: 35-45.

Turner, R.E. and N.N. Rabalais, 1994. Coastal Eutrophication near the Mississippi River Delta. *Nature* 368(6472): 619-621.

Is it relevant to explicitly parameterize chlorophyll synthesis in marine ecological models?

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Introduction

Ecological models are expected to be as simple as possible and yet convey the complexity of living systems. A challenge in marine ecological modeling has been to identify which processes must be included in model simulations to address this complexity in a realistic way. The explicit inclusion of chlorophyll dynamics in models is a common example of this challenge. Chlorophyll *a* (Chla) has been used for long time as a measure of algal biomass, especially for its measurement simplicity and because it is a common pigment to all phytoplankton species. Oceanographers and modelers often relate Chla concentrations to primary producers' biomass by means of empirical factors, using it as a proxy to carbon biomass. But because it varies, chlorophyll is a deceptive measure of true biomass, and so this procedure has been recognized to be doubtful given the lack of precision of these empirical factors.

Several approaches have been used in marine ecological models to simulate the role of photosynthesis and account for primary production in phytoplankton (Behrenfeld and Falkowski, 1997). With the increase complexity of ecological models during the last decades, much as a reflex of the natural increase in experimental knowledge, particular attention has been devoted to the explicit parameterization of intracellular Chla production and variable Carbon to Chla quotas (expressed as C:Chla ratios, or simply, C:Chla). The fact that photosynthetic organisms have a regulatory mechanism of adaptation to environmental conditions justifies its inclusion in models. This is particularly relevant in marine ecological models, considering the wide range of conditions found in this ecosystem, mostly involving light, nutrient availability and temperature.

Methods

Chlorophyll synthesis formulation

Phytoplankton growth rates (C-fixation) are determined by available light and nutrients that shape the chlorophyll synthesis. The chlorophyll synthesis algorithm (Geider *et al.*, 1996, 1997, 1998) was adapted to fit an ecological model made from scratch (Mateus, 2006) inside the MOHID modeling system (www.mohid.com), a community model shared by a large user group around the world. The ecological model simulates carbon and nutrient cycles, variable stoiquiometry in organism and organic matter components, and different phytoplankton groups. With this formulation, chlorophyll is explicitly modeled allowing the adaptation to different ambient light, temperature and nutrient conditions. This adaptation is expressed in variable C:Chla ratios.

Model application

The model was used to simulate the dynamics of the River Tagus, Portugal (located at 38º49'N and 09º05'W) for the year of 2004. Known values were used for the forcing conditions (surface radiation and temperature, tide, river flow). This is a 2D dynamic simulation with a horizontal transport scheme to account for the advection of properties. The model was validated with field data for nutrient and chlorophyll.

Results

Phytoplankton Chla distribution in the estuary reveals a typical mid-latitude seasonal cycle, with higher values in spring-summer and lower concentrations in the remaining of the year (Fig. 1). There is a clear seasonal fluctuation in C:Chla ratio consisting of lower values of C:Chla during Autumn/ Winter months and higher values in Spring/Summer.

The values for C:Chla vary around a minimum of ~46 and a maximum of ~114. This seasonal tendency shows a clear adaptation to the changing conditions of the system, expressed in the yearly cycle of radiation and nutrient availability as a function of river discharges. The combination of low radiation and high nitrogen availability in winter months increases Chla synthesis, thus lowering the C:Chla. In spring-summer months, the increase in temperature increases photosynthesis (C-fixation) raising the C:Chla. Also during this period the light ambient in the water is most favorable because the radiation reaching the surface is higher and suspended sediment concentration in the water is reduced because the river discharge is low, compared to the rainy seasons.

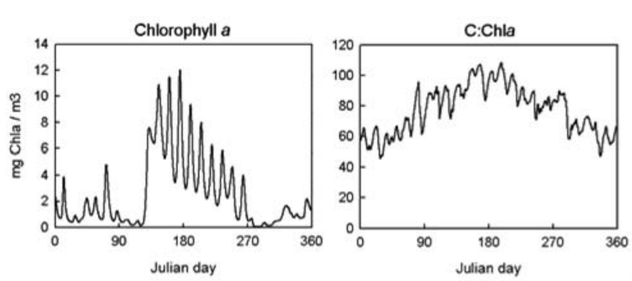

Figure 1. Chla concentration and C:Chla fro diatoms at a station inside the estuary (1 year).

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A spatial pattern in C:Chla is also observed with systematically lower values in inner areas when compared with values at the river mouth as seen in Figure 2 for summer conditions. Again, the spatial pattern is the result of a combination of light and nitrate availability. The C:Chla spatial pattern reflects the simultaneous control on Chla synthesis of the light ambient in the water column (controlled by suspended sediments) and the uptake of nitrogen regulated by its availability.

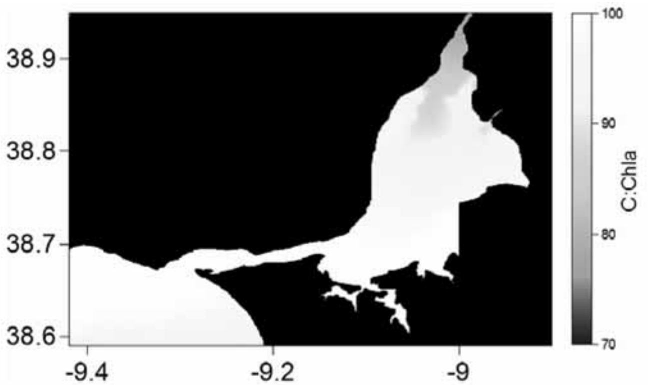

Figure 2. C:Chla for diatoms in the Tagus estuary for Julian day 180 of simulation (summer conditions).

Discussion

Fluctuation in the C:Chla in phytoplankton is known to occurs as a response to changing ambient conditions such the light regime and nutrient availability. The opposing effect of nutrients and light on photosynthesis and Chla synthesis (expressed in C:Chla) seems to sharpen up growth events, allowing models to better simulate both temporal and spatial gradients of carbon and chlorophyll in natural systems (Chapra, 1997). This is particularly evident in the results for the estuary simulation.

Light is less available because of the shading effect of suspended sediments, a common feature in estuaries (Cloern, 2001). As a consequence, higher chlorophyll synthesis production rates are expected to compensate for the low levels of light. Together with the hydrodynamics, these factors shape the chlorophyll a distribution in the system and exert a strong control, on the dynamics of chlorophyll synthesis.

In dynamic system like estuaries or coastal zones, light is a key limiting factor for pelagic primary production (Cloern, 1999). Because the Tagus estuary is well mixed, phytoplankton populations have to adapt to continuously changing irradiance conditions ranging from complete darkness to saturating light. Under such conditions, a photoadaptation mechanism like the production of chlorophyll in response to environment optical conditions enables a better approximation to the estimation of chlorophyll than the use of fixed C:Chla ratios.

Since Chla is the most widespread index of phytoplankton abundance in water, its explicit inclusion in production models has become an important aspect of model development. Fixed C:Chla used in conversion to estimate Chla concentrations in models may produce good results when conditions are more stable, whether from nutrient availability or light climate, but will eventually fail to correctly depict the evolution of a system with a strong seasonal and spatial heterogeneity. Moreover, there is always the problem of which conversion ratio to choose in a simulation, considering the variation that is known to occur (Parsons *et al.*, 1984, Geider, 1987, Chapra, 1997).

Conclusions

Chla synthesis must be a standard feature of marine ecological models because model simulations usually cover a wide range of physical and chemical conditions. Unlike models that assume static C:Chla (usually with no parameterization for Chla), this approach to Chla cell variable content enables the model to respond to different biotic and abiotic conditions, rendering the model more versatile and generic. Our results support the idea that when conditions have strong changes of nutrient availability, temperature and light conditions (either in estuaries or upwelling zones), a photoacclimation mechanism becomes an essential requirement for reliable chlorophyll biomass estimates. This is particularly relevant if model simulations are to be used to study natural systems complemented by data retrieved from direct measurements, using optical instruments like remote sensing of Chla concentration from satellites and aircraft, or by continuous measurement using in vivo fluorescence in ship-based or moored instruments. To conclude, it can be said that when accurate estimates are needed, marine ecological models must consider the explicit parameterization of chlorophyll.

References

Behrenfeld M.J., P.G. Falkowski, 1997. A consumer's guide to phytoplankton primary productivity models. *Limnology and Oceanography* 42: 1479-1491.

Chapra, S., 1997. *Surface water-quality modeling*. McGraw-Hill, New York.

Cloern, J. E., 1999. The relative importance of light and nutrient. *Aquatic Ecology* 33: 3-15.

Cloern, J.E., 2001. Our evolving conceptual model of the coastal eutrophication problem. *Marine Ecology-Progress Series* 210: 223-253.

Geider, R.J., 1987. Light and Temperature-Dependence of the Carbon to Chlorophyll-a Ratio in Microalgae and Cyanobacteria – Implications for Physiology and Growth of Phytoplankton. *New Phytologist* 106: 1-34.

Geider, R., H. MacIntyre, T Kana, 1996. A dynamic model of photoadaptation in phytoplankton. *Limnology and Oceanography* 41: 1-15

Geider, R., H. MacIntyre, T Kana, 1997. Dynamic model of phytoplankton growth and acclimation: Responses of the balanced growth rate and the chlorophyll a:carbon ratio to light, nutrientlimitation and temperature. *Marine Ecology-Progress Series* 148: 187-200.

Geider, R., H. MacIntyre, T Kana, 1998. A dynamic regulatory model of phytoplanktonic acclimation to light, nutrients, and temperature. *Limnology and Oceanography* 43: 679-694.

Mateus, M., 2006. *A process-oriented biogeochemical model for marine ecosystems: development, numerical study, and application*. PhD. Instituto Superior Técnico, Lisbon, Portugal.

Parsons, T., M. Takahashi, G. Hargrave, 1984. *Biological Oceanographic Processes*. Pergamon Press, New York.

Integrating Multiple Ecosystem Elements in Assessing Ecological Quality in the Basque Country: application to the Marine Strategy

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Introduction

The European Water Framework (WFD) and Marine Strategy (MS) Directives are intending to assess the ecological quality, within estuarine and coastal systems (Borja, 2005, 2006). These legislations require to define quality in an integrative way, by using several biological elements (phytoplankton, benthos, algae, phanerogams, fishes), together with physico-chemical elements (including pollutants) (Borja *et al.,* 2004a). These legislations will allow assessing the ecological status at the ecosystem level better than at species level or just at chemical level alone. These European Directives have led to the development of tools for assessing such physico-chemical and ecological status. However, the methodologies integrating all the elements into a unique evaluation of a water body are scarce. This contribution shows a methodology that integrates all this information (including physico-chemical data from water, sediment and biomonitors, together with biological data from phytoplankton, macroalgae, benthos and fishes) into an integrated quality assessment for each of the studied water bodies.

Methods

Very few studies have been published in integrating all physico-chemical and biological elements in an assessment of the ecosystem status (Borja *et al.,* 2004a). This approach was furtherly detailed and extended for some of the elements, such as physico-chemical (Bald *et al.,* 2005), chemical (Borja *et al.,* 2004b; Borja and Heinrich, 2005; Rodríguez *et al.,* 2006), or benthic communities (Borja *et al.,* 2000; Muxika *et al.*, 2007).

The WFD established two different components of the quality status: the chemical and the ecological status. The chemical status is based upon metal and organic compound concentrations, and is determined by comparing measured concentrations with quality objectives. Conversely, the ecological status integrates physico-chemical, chemical and biological indicators. The physico-chemical indicators used in this assessment are those supporting the biological elements (thermal conditions, salinity, oxygen, nutrients, transparency).

We have used data from the Basque Monitoring Network, which includes 19 coastal and 32 estuarine sampling stations, within 18 water bodies (Figure 1). The locations were sampled between 1995 and 2007. We have applied the methodologies described in the abovementioned references in order to assess the ecological status of Basque water bodies, trying to determine the response of the methodology to changes in human pressures. Then, the potential application of this methodology to the European Marine Strategy will be discussed.

Results and Discussion

The integrative assessment of the Basque Country water bodies shows a temporal trend consisting on an increase of locations in high and good ecological status and a decrease of water bodies in bad and poor status (Figure 2). This pattern is similar both in estuarine and coastal locations, being the increase more rapid after 2002. This improvement in the

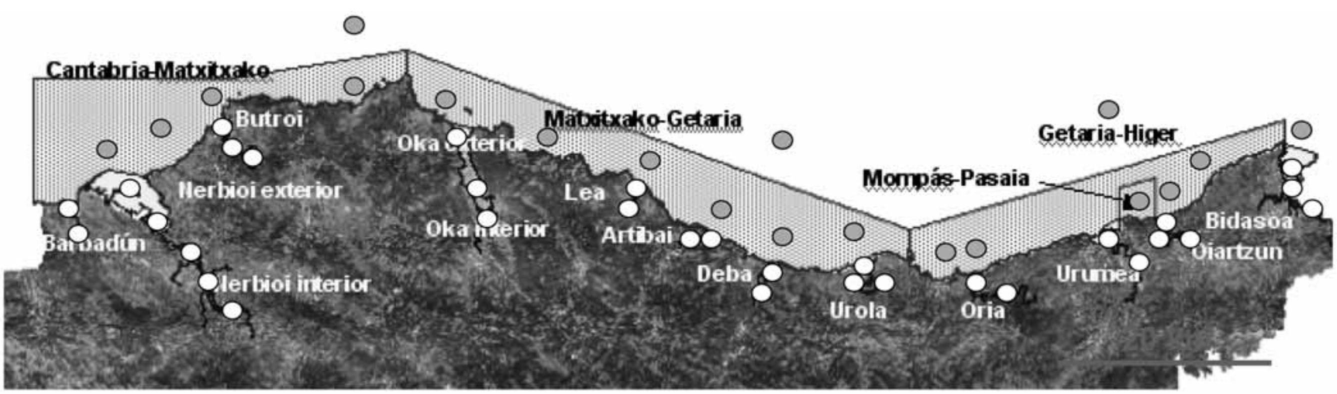

Figure 1. Water bodies and sampling stations in estuarine (white) and coastal (grey) systems, within the Basque Country.

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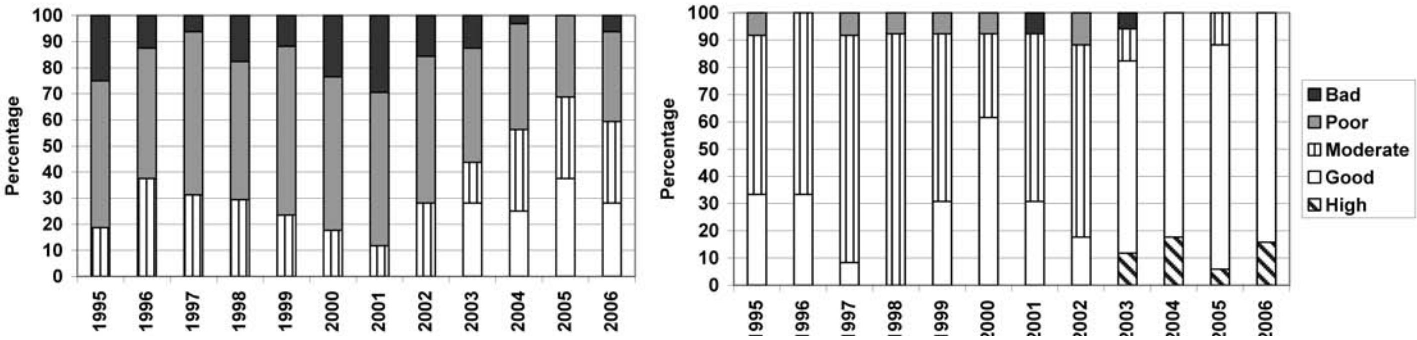

Figure 2. Evolution of ecological status within estuaries (left) and coasts (right) in the Basque Country.

quality is related to the increase of water treatment in the most important estuarine systems (Nerbioi, Butroi, Oiartzun, Bidasoa, etc.) and changes in industrial activities in some river catchments, such as Deba (Borja *et al.,* 2006).

The abovementioned increase of locations in at least good ecological status has been observed both in physico-chemical (e.g. increase of dissolved oxygen) and chemical (e.g. decrease of metal load discharged) elements. This has lead to a recovery of some biological elements. Hence, an increase of fish richness (e.g. Nerbioi) or a decrease in opportunistic species and AMBI index in benthos (e.g. Oiartzun, Nerbioi, Lea) has been detected in some areas.

The results obtained when integrating several biological and physico-chemical elements are coincident with the global knowledge of the aquatic systems from different experts.

The experience gained in assessing ecological quality within the WFD can be applied to the MS implementation, by adapting some of the methodologies to this new Directive. To undertake this study we have started to sample several locations offshore the Basque coast (Figure 1).

Conclusions

The integrative methodology in assessing the ecological status within the WFD has been applied successfully to the Basque estuaries and coasts (in northern Spain). These tools allow policy makers and managers to take decisions in water management, regarding human pressures mitigation and recovery processes, and could be applied to the new Marine Strategy.

Acknowledgements

The Department of Environment and Land Action, of the Basque government, has funded this study.

References

Bald, J., A. Borja, I. Muxika, J. Franco, V. Valencia, 2005. Assessing reference conditions and physico-chemical status according to the European Water Framework Directive: A case-study from the Basque Country (Northern Spain). Marine Pollution Bulletin, 50: 1508-1522.

Borja, A., 2005. The European Water Framework Directive: a challenge for nearshore, coastal and continental shelf research. Continental Shelf Research, 25(14): 1768-1783.

Borja, A., 2006. The new European Marine Strategy Directive: difficulties, opportunities, and challenges. Marine Pollution Bulletin, 52: 239-242.

Borja, A. and H. Heinrich, 2005. Implementing the European Water Framework Directive; the debate continues... Marine Pollution Bulletin, 50(4): 486-488.

Borja, A., J. Franco, V. Pérez, 2000. A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. Marine Pollution Bulletin, 40: 1100-1114.

Borja, A., J. Franco, V. Valencia, J. Bald, I. Muxika, M. J. Belzunce, O. Solaun, 2004a. Implementation of the European Water Framework Directive from the Basque Country (northern Spain): a methodological approach. Marine Pollution Bulletin, 48: 209-218.

Borja, A., V. Valencia, J. Franco, I. Muxika, J. Bald, M. J. Belzunce, O. Solaun, 2004b. The water framework directive: water alone, or in association with sediment and biota, in determining quality standards? Marine Pollution Bulletin, 49: 8-11.

Borja, A., I. Galparsoro, O. Solaun, I. Muxika, E.M. Tello, A. Uriarte and V. Valencia, 2006. The European Water Framework Directive and the DPSIR, a methodological approach on assessing the risk of failing to achieve the good ecological status. Estuarine, Coastal and Shelf Science, 66: 84-96.

Borja, A., A.B. Josefson, A. Miles, I. Muxika, F. Olsgard, G. Phillips, J.G. Rodríguez, and B. Rygg, 2007. An approach to the intercalibration of benthic ecological status assessment in the North Atlantic ecoregion, according to the European Water Framework Directive. Marine Pollution Bulletin, 55: 42-52

Muxika, I., A. Borja, J. Bald, 2007. Using historical data, expert judgement and multivariate analysis in assessing reference conditions and benthic ecological status, according to the European Water Framework Directive. Marine Pollution Bulletin, 55: 16-29.

Rodriguez, J.G., I. Tueros, A. Borja, M. J. Belzunce, J. Franco, O. Solaun, V. Valencia, A. Zuazo, 2006. Maximum likelihood mixture estimation to determine metal background values in estuarine and coastal sediments within the European Water Framework Directive. Science of the Total Environment, 370: 278-293.

Integrative assessment of the ecological status of Cantabrian (N. Spain) coastal water bodies.

Xabier Guinda*[a], José A. Juanes[a], Araceli Puente[a] and José A. Revilla[a]

Introduction

Since the European Water Framework Directive (WFD; 2000/60/EC) came into force, a great effort has been carried out in order to develope and intercalibrate the metrics that are going to be used to evaluate the different quality elements required for the Ecological Status assessment of the coastal water bodies. However, the proposals relating the total or partial integration of these metrics and elements have been scarce and preliminary (e.g. Borja *et al*., 2004; GESHA, 2005; Simboura *et al*., 2005). In this sense, the Guidance Document nº 13 of the Ecological Status Working Group (ECOSTAT WG 2A) provides an overall approach to the classification rules of this process (European Commission, 2003b).

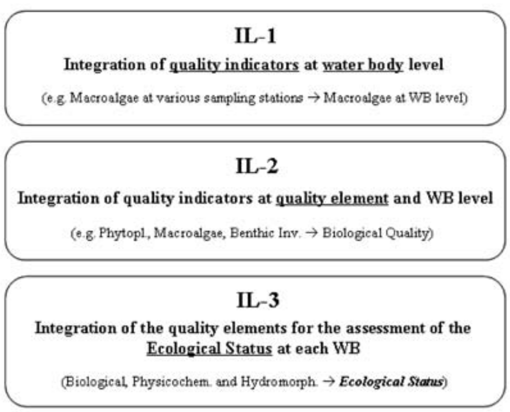

Figure 1 Different steps of the integration process followed for the Ecological Status assessment.

As the Ecological Status assessment process comprises several stages, from the individual application of indicators, to the final status results, different "Integration Levels" (IL) could be identified, each of them with its own data aggregation rules. In this sense, we propose a scheme formed by three integration levels (Figure 1):

The data aggregation methods used at each of these stages will have a considerable influence on the obtained results (Latour, 2007).

In this work we analyze the effects of applying different aggregation procedures at each of the described integration levels, through their application to the Cantabrian coastal water bodies.

Methods

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Data source

The data used for the ecological status assessment of the Cantabrian coastal water bodies during the year 2006 were mainly obtained from the *Cantabrian Littoral Quality Control Network* (GESHA, 2006). Then, the metrics approved or under discussion at the Northeast Atlantic Geographical Intercalibration Group (NEA-GIG) were applied to these data in order to estimate the status of the different quality indicators at individual station level. In those cases for wich no metrics have been agreed yet (e.g. physicochemistry and hydromorphology) specifically developed systems were applied. The selected metrics included the chlorophyll 90th percentile and the blooms frequency for phytoplancton (European Commission, 2007), the CFR index (Juanes et al., 2008) for macroalgae, the M-AMBI method (Muxika et al., 2007) for benthic invertebrates, the OOAO method for physicochemistry and the number of significative hydromorphological pressures criteria (GESHA, 2005) for the hydromorphology.

Methodological design

At each of the three defined ILs the following aggregation procedures were applied:

- IL-1: a) averaged data and b) application of the "one out, all out" (OOAO) principle.
- IL-2: a) averaged data and b) application of the OOAO principle.
- IL-3: a) averaged data, b) weighted data (3*biological, 2*phys-chem, 1*hydrom.) and c) application of the WFD defined procedure (European Commission, 2003a, b).

In addition, the effects of using two different schemes for segregation of water bodies were tested, based on the actual proposal of 7 water bodies for the Cantabrian coast (R1, A1, R2, A2, R3, A3 and R4) (GESHA, 2005) or a reduced number of water bodies (3) obtained by combination of the previous ones (W, C and E).

Results and Discussion

After the evaluation of the different quality indicators (phytoplancton, invertebrates, physicochemical quality, etc) at each of the sampling stations, their integration to water body level (IL-1) produced different results depending on the indicator analyzed. Thus, all the phytoplancton data obtained "high" qualities in all the stations, and, consequently, in all the water bodies, independently of the aggregation method. Macroalgae and benthic invertebrates obtained "high" or "good" qualities in most water bodies, so the differences among the aggregation methods used were not very marked. However, the results obtained for the physicochemical quality differed greatly depending on the aggregation method. As it can be seen in the Table 1, the averaged method produced "high" qualities in most water bodies, while the OOAO method produced "moderate" or "bad" qualities in most cases. As the latter results where considered excessively restrictive, according to the quality estimated by expert judgement, the **averaging** method was considered more adequate for its application at the **IL-1**.

The second integration level (IL-2) is only applicable to the biological quality element, and the obtained results differed notably depending on the aggregation method. With the averaged method all the water bodies obtained "high" qualities except one, which obtained a "good" quality, while, with the OOAO method, the number of water bodies with "good" qualities raised to 4 (of the 7 WB) and 2 (of the 3 WB). In this case, as the biological quality is based upon the worst of the values of the biological elements, the **OOAO** was considered more appropriate for its application at the **IL-2**. However, a more detailed analysis on the causes of quality reductions must be undertaken, in order to precisely define the reference conditions of this coastal area.

Finally, at the IL-3 the results of the biological, physicochemical and hydromorphological quality elements are integrated to obtain the final ecological status of each water body. As in the previous ILs, the averaged method produced the highest qualities, while the weighted and the WFD methods showed a slightly decreasing tendency in the obtained qualities (Table 2).

The latter methods can be considered very similar one to each other because both of them give to the biological elements the highest importance in the evaluation. Moreover, as the WFD method classifies the ecological status based on the lower of the values of the three quality elements, it could be considered as an OOAO method, although the physicochemical and the hydromorphological elements are considered as supporting elements for the biological elements, and so, their capacity to determine the ecological status is limited to the "moderate" and "good" status respectively (see European Commission, 2003a, b).

As a general conclusion, it can be said that the different aggregation methods used at each of the defined ILs produced a great variation in the obtained results, consequently, these procedures should be given their corresponding importance in the Ecological Status assessment process.

Table 1. Results of the physicochemical quality for each of the 7 and 3 coastal water bodies, by applying the averaged and the OOAO aggregation methods.

IL-1 Physicochemical Quality 2006		
Water Body	**Averaged**	**OOAO**
R1	High	Moderate
A1	Good	Bad
R2	High	Moderate
A2	High	Moderate
R3	Good	Bad
A3	High	Moderate
R4	High	High
W	High	Bad
C	High	Moderate
E	High	Bad

Table 2. Results of the ecological status for each of the 7 and 3 coastal water bodies, by applying the averaged, the weighted and the WFD aggregation methods.

IL-3 Ecological Status 2006			
Water Body	**Averaged**	**Weighted**	**WFD**
R1	High	Good	Good
A1	Good	Good	Good
R2	High	Good	Good
A2	High	Good	Good
R3	Good	High	Good
A3	High	High	High
R4	High	High	High
W	High	Good	Good
C	High	Good	Good
E	Good	High	Good

Acknowledgements

This research was funded by the Department for the Environment of the Regional Government of Cantabria (Spain) and constitutes part of the Ph.D. Thesis of Xabier Guinda.

References

Borja, A., Franco, J., Valencia, V., Bald, J., Muxika, I., Belzunce, M.J., Solaun, O., 2004. Implementation of European water framework directive from the Basque country (northern Spain): a methodological approach. *Marine Pollution Bulletin* 48, 209-218.

European Commission, 2003a. Guidance Document nº 5. Transitional and Coastal Waters. Typology, Reference Conditions and Classification Systems. CIS Working Group 2.4 (COAST), Common Implementation Strategy for the Water Framework Directive (2000/60/EC).

European Commission, 2003b. Guidance Document nº 13. Overall approach to the classification of ecological status and ecological potential. CIS Working Group 2.A (ECOSTAT), Common Implementation Strategy for the Water Framework Directive (2000/60/EC).

European Commission, 2007. WFD intercalibration technical report. Part 3 – Coastal and Transitional Waters. Joint Research Centre.

GESHA, 2005. Plan de investigación integral para la caracterización y diagnóstico ambiental de los sistemas acuáticos de la comunidad de Cantabria. Informe Técnico de la Consejería de Medio Ambiente, Gobierno de Cantabria - Universidad de Cantabria. Santander. http://www.dmacantabria.com/.

GESHA, 2006. Red de control de la calidad del litoral de Cantabria. Gobierno de Cantabria - Universidad de Cantabria. Santander.

Juanes, J.A., Guinda, X., Puente, A., Revilla, J.A., 2008. Macroalgae, a suitable indicator of the ecological status of coastal rocky communities in the NE Atlantic. *Ecological Indicators* doi:10.1016/j.ecolind.2007.04.005.

Latour, P., 2007. Effect of aggregation methods on ecological assessment, CIS workshop on national classification systems for the assessment of the ecological status of surface waters, Paris.

Muxika, I., Borja, A., Bald, J., 2007. Using historical data, expert judgement and multivariate analysis in assessing reference conditions and benthic ecological status, according to the European Water Framework Directive. *Marine Pollution Bulletin* 55, 16-29.

Simboura, N., Panayotidis, E., Papathanassiou, E., 2005. A synthesis of the biological quality elements for the implementation of the European Water Framework Directive in the Mediterranean ecoregion.The case of Saronikos Gulf. *Ecological Indicators* 5, 253-266.

An integrated assessment of the ecological and economical status of French fisheries in the Bay of Biscay

Fabienne Daurès,[a] Marie-Joëlle Rochet[b] and Verena Trenkel[b]

While indicators and assessment frameworks are being developed for ecosystems, and tools for determining the economic status of a fishery are readily available, integrated assessment tools are still mostly lacking. However, the development of an ecosystem approach to fisheries management requires the monitoring and assessment of exploited ecosystems in all their dimensions, including ecological, economical and social components. This presentation will bring together indicators of both ecological status, like abundance and average size of target and non-target stocks, or of the fish community, with economic indicators, like fish prices, fishermen wages and profitability. The interaction between the two components is quantified by the matrices of contributions (the share of each fleet in the production of each stock) and dependencies (the share of each stock in the production of each fleet). The analysis will focus on two questions: i) What is the influence of stocks and community status on the performance and dynamics of fleets, as compared to other factors (fish prices, costs including fuel)? ii) What is the influence of fleet status on the dynamics of fish stocks and of the fish community, as compared to other factors (recruitment, environment)?

In the Bay of Biscay, species diversity is high. Many of these resources are exploited by a large variety of fleets from France, Portugal and Spain, and other nations (e.g. Belgium and The Netherlands). In coastal areas, demersal and benthic resources are exploited using a wide range of fishing gears, including trawls and dredges, gillnets and trammel nets, lines, traps, etc. In the offshore zone, trawling is an important activity, but fixed gears are also extensively and increasingly used. Few fleets target single species. So the Bay of Biscay provides an appropriate case-study with a diversity of stocks and fleets to be assessed and managed together. The approach is applied to the French fleets for which detailed economic data are available.

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Implications of the Marine Strategy as framework for marine conservation in the Bay of Biscay

Raúl Castro[a] and Marina Laborde

Abstract

The main objective of the European Marine Strategy is to Project and restore the European seas, ensuring that human activities are carried out in a sustainable manner, providing safe, clean, healthy and productive marine waters; in summary, ''to promote the sustainable use of the seas and conserve marine ecosystems''. Hence, the EMS establishes a framework for the development of marine strategies designed to achieve good environmental status in the marine environment by the year 2021. The first step is to lay down generic qualitative descriptors, criteria and standards for the recognition of good environmental status. This concept of environmental status takes into account the structure, function and processes of the marine ecosystems together with natural physiographic, geographic and climatic factors, as well as physical and chemical conditions including those resulting from human activities in the area concerned.

Our presentation will suggest some ideas based on an ecosystem approach and discuss implications for future management of marine biodiversity.

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A survey on Cetacean Offshore Distribution and Abundance (CODA) in the Bay of Biscay

Ainhize Uriarte,*[a] Carlos Hernández[a] and Raúl Castro[a]

Introduction

The CODA project aims to study the cetacean offshore distribution and abundance in the European Atlantic. It also aims at obtaining information to assess the impact of by catch and recommend safe by-catch limits for common dolphin. Secondary objectives are to obtain information on habitat preferences of cetaceans, distribution and abundance of sperm whales and other deep diving species and to contribute to our understanding of the impact on cetaceans of industrial and military seismic and sonar activities. Target species of CODA are the common dolphin (*Delphinus delphis,* included in Annex IV of Habitats Directive), bottlenose dolphin (*Tursiops truncatus,* included in Annex II of Habitats Directive), sperm whale (*Physeter macrocephalus)* and other deep diving species (Ziphiidae), and fin whale (*Balaenoptera physalus)* the main baleen whale of the study area. In summer 2007 AZTI-Tecnalia was in charge of the CODA survey in the Bay of Biscay (block 4, see Figure 1). The survey was financed by the Department of Agriculture, Fishing and Food of the Basque Government and by Fundación Biodiversidad (Spanish Ministry of Environment).

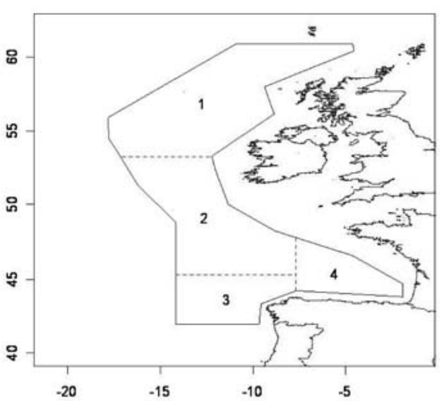

Figure 1. Surveyed area in CODA. The total area is subdivided in 4 blocks: the block 4 corresponds to the Bay of Biscay.

Methods

The survey was carried out between 30th June and 16th July, covering the oceanic area of the Bay of Biscay. The surveyed area and transects are showed in Figure 2. The survey was based on the line-transect method, collecting data from two visual platforms. In this way, the line-transect method allows estimating the probability of detecting an animal, analysing the perpendicular distances of the animal to the trackline. A key assumption in this methodology is that animals on the trackline are certain to be detected, but for animals such as harbour porpoise this assumption is unlikely to be met. Mark-recapture methods can be used to estimate $g(0)$, rather than assuming that it is one. On the other hand, all through the survey passive acoustic monitoring (PAM) was carried out collecting data by 4 hydrophones. The click's bearing are calculated from the Time Difference Of Arrival (TDOA) of click on two hydrophones.

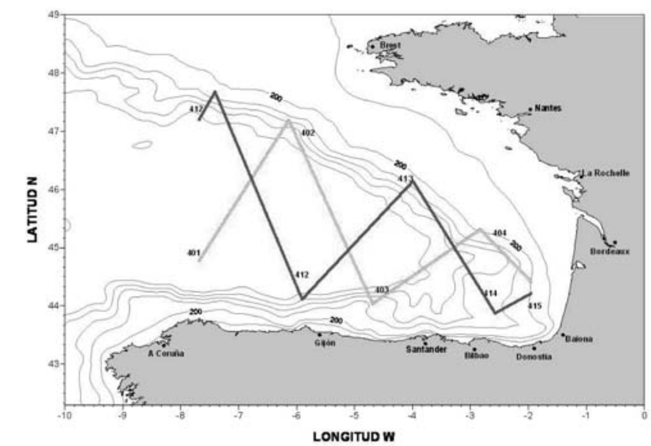

Figure 2. Map of the study area, showing the surveyed transects.

Results

The next table (Table 1) shows the preliminary results of sightings in the Bay of Biscay CODA survey. The most frequently sighted species was the common dolphin, followed by the fin whale. These species were broadly distributed in the Bay of Biscay. Fin whales were more common on the west part of the Bay, while sperm whales occurred throughout the area; beaked whales were more commonly sighted in the inner part of the Bay of Biscay. The analysis of the shipboard data for abundance estimation is based on mark-recapture line-transect methods. The final results will be produced throughout 2008, and abundance estimates based on mark-recapture line-transect methods will be obtained, as well as spatial modelling (by General Additive Models, GAM) and information on habitat preferences based on spatial modelling (GAM) and geostatistics.

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Table 1. Sightings registered in the Bay of Biscay CODA survey.

Specie	Sightings PP Total	Sightings TP Total	% duplicated of TP	Sightings on effort total	Sightings on effort total - duplicates
Bottlenose dolphin	2	5	40	7	5
Common dolphin	71	54	57	125	94
Striped Dolphin	15	15	60	30	21
Risso's dolphin	0	1	0	1	1
Long-finned pilot whale	2	13	15	15	13
Fin whale	33	47	49	80	57
Sperm whale	7	12	50	19	13
Cuvier's beaked whale	5	9	33	14	11
Unid. beaked whale	4	2	0	6	6
Common or striped dolphins	18	42	21	60	51
Unidentified dolphins	3	8	13	11	10
Unidentified medium cetacean	1	2	50	3	2
Unidentified whale	1	4	0	5	5
Fin whale + Unidentified whale	34	51	49	85	62
Common + striped dolphins	104	111	44	215	166
Beaked whales	9	11	33	20	17
Total	162	214	41	376	289

Short-finned Squid fishery based in commercial landings on Northern Iberian Peninsula (NE Atlantic)

Isabel Bruno*[a] and Mario Rasero[b]

Short-finned Squid (Family *Ommastrephidae*) landings are mainly made up of *Illex coinndetii* (Vérany, 1839) and *Todaropsis eblanae* (Ball, 1841), and represent about a 16% of the total cephalopod Spanish landings in Northern Iberian Peninsula.

This study is based on landings of the Spanish fishing fleet operating in ICES Divisions VIIIc and IXa for the period 1994 to 2006. Data were collected by the "Instituto Español de Oceanografía" (IEO) Sampling and Information Network.

Bottom trawl fleet is responsible for main (about 97%) of the total short-finned squid landings in Northern Atlantic Iberian Peninsula.

Landing data come from the main ports in Northern Iberian Peninsula: Santa Uxía de Ribeira, Coruña, Marín, Vigo and Celeiro in the Galician coast and Avilés, Gijón and Santander in the Cantabrian coast.

Weight samples were carried out for both species during all months of year, since 1998 to 2003 in the fish markets of Celeiro, Coruña, Santa Uxía de Ribeira and Marín

Ommastrephidae landing data show a seasonal trend with a maximum values in Spring and Autumn.

Introduction

The fishery of short finned squid (Family *Ommastrephidae*) in Northern Iberian Peninsula waters is composed by three species: *Illex coinndetii* (Vérany, 1839), *Todaropsis eblanae* (Ball, 1841), and *Todarodes sagittatus* (Lamarck, 1798). The presence of European flying squid (*Todarodes sagittatus*) in the fishery is merely anecdotical, and is usually discarded, so this species is not included in the study. The other two short-finned squids (*Illex coindetii* and *Todaropsis eblanae*) made up a relatively important fishing resource and represent about a 16% of the total cephalopod Spanish landings in Northern Iberian Peninsula.

Trawling fleet ("baca" Spanish bottom trawl and pair trawl) is responsible for main of the total short-finned squid Spanish landings in the study area (about 97%).

The present study aims to obtain information on the annual and seasonal changes in short-finned squid landings. Moreover, this work includes information on the landing proportion of each species in both trawling fishing net.

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Methods

This study was carried out on a short-finned squid population from Galicia waters and Cantabrian Sea, which is caught by the Spanish trawl fishery fleet (Spanish "baca" bottom trawl and pair trawl), and landed in Galician and Cantabrian main ports.

Data were collected by the IEO Sampling and Information Network.

Monthly *Ommastrephidae* landing data, from "baca" Spanish bottom trawl and from pair trawl, were collected in several ports for different periods: Ribeira and Coruña since 1994; Marín and Vigo since 1997; and Celeiro, Avilés, Gijón, Santander since 2000. Moreover, low landings from other different ports were collected too.

Because of the unknown proportion of the 2 flying squid in landings species composition and monthly weight samples were carried out since November of 1997 to March of 2004 in Galician ports. A total of 734 samples were taken, 620 of them were from the "baca" bottom trawl, of which 4 corresponded to 1997, 156 to 1998, 133 to 1999, 95 to 2000, 85 to 2001, 77 to 2002, 61 to 2003 and 13 to 2004. Most of them were carried out in Celeiro, Coruña, Marín and Ribeira ports. The other 114 samples were taken from the pair trawl, in Ribeira and Celeiro ports. Twelve of them corresponded to 1998, 9 to 1999, 29 to 2000, 32 to 2001, 21 to 2002 and 11 to 2003. Body weights of 42102 specimens of *Illex coindetii* and 24839 of *Todaropsis eblanae* were obtained to the nearest 5g from samples in Galicia ports. Body weight distributions are available by fishing net, year, month and port.

The monthly average species proportion per fishing net and port was raised to landing data.

Results

Yearly Landing data shows that about a 78% of short-finned squid landed in Galicia waters by trawl were due to the Spanish "baca" botom trawl. In the Cantabrian Sea, "baca" represents 57% of *Ommastrephidae* landings.

Ribeira port presented the largest amount of short-finned squid landed in Galicia (about a 42% of total landings); Coruña reprsents, the 22%; Marín, the 16%, Vigo the 10% and Celeiro the 5%. The most representative *Ommastrephidae* landings of Cantabrian ports were: Avilés (49%), Gijón (25%) and Santander (17%).

In Galicia, short-finned squid yearly average landing data shows a seasonal trend with maximum values in spring (31%) and autumn (26%). For the Cantabrian Sea, a large peak appears in spring, and represents the 45% of yearly landing.

Differences in species composition between the two sampled fishing trawl nets have been observed in Galicia. *Todaropsis eblanae* represents the 62% of short-finned squid landings by Spanish "baca" botom trawl, and *Illex coindetii* the 38%. For paired trawl, species composition observed was opposite: *Todaropsis eblanae* constitutes the 19% of landings, and *Illex coindetii* the 81%.

Moreover, differences in short-finned squid weigth had been observed between two fishing nets. Data show that pair trawl retains a higher proportion of big sizes than "baca" bottom trawl for two *Ommastrephidae* species. For *Illex coindetii*, the majority of sampled specimens from "baca" bottom trawl are included into the body weight ranges of 40-120 g.; in paired trawl landings the majority are included in the range 80-180 g. For *Todaropsis eblanae* these ranges are 30-120 and 70-135 g. on "baca" and paired trawl respectively.

Les flottilles des Pertuis charentais vues du ciel

Jean-Pierre Léauté*[a]

Introduction

Dans le secteur des Pertuis charentais (figure 1) (autour de La Rochelle) un Observatoire de Recherche sur l'Environnement des Ecosystèmes (ORE REPER) a été mis en place en 2003-2004 avec pour but d'étudier par une approche multidisciplinaire intégrée, les évolutions de l'écosystème de ce secteur sous l'effet des pratiques d'utilisation du milieu et à plus long terme, des changements naturels dans une optique de gestion durable de la bande côtière.

Dans le cadre de cet observatoire, une fiche « Fonction de nourricerie à sole des Pertuis charentais » a donc été mise en place avec la réalisation de trois types d'opérations **i)** des survols réguliers des flottilles, **ii)** des embarquements sur des navires professionnels et **iii)** des campagnes annuelles de chalutages à perche (SOLPER) qui permettent le suivi de l'évolution de l'abondance des juvéniles de soles dans les Pertuis charentais.

Dans cette présentation nous traiterons des résultats obtenus au cours des trois années de survols (2004, 2005 et 2006) des flottilles de pêche dans les Pertuis charentais.

Figure 1 : Localisation des Pertuis charentais dans le golfe de Gascogne

Materiel et méthodes

A l'aide d'un petit avion de location les navires de pêche ont été survolés le matin pendant une période de 6 mois (mai à octobre) chaque année. Le reste de l'année la majorité des navires s'orientent vers d'autres types de pêche plus localisés dans l'espace (dragues à coquillages, tamis à civelle dans les estuaires, …) et l'après-midi ils rentrent au port. En 2004 les survols ont été hebdomadaires puis bimensuels en 2005 et 2006. Pour chaque navire survolé a été noté le point géographique (GPS), le métier, le quartier d'immatriculation, et s'il était en action de pêche ou non. De plus une photo a été prise pour identification ou confirmation de son identification.

En 2004, après une première analyse des localisations des navires nous avons élaboré une stratification de l'espace Pertuis, autour des secteurs principaux fréquentés pour approfondir notre analyse des territoires de pêche. Les critères retenus pour l'identification des limites de strates ont été, outre les taches de fréquentation principales, des éléments de bathymétrie et de sédimentologie. En tout 10 strates ont été définies (5 par Pertuis).

Par ailleurs un indice de sélection (Begout Anras *et al.*, 1999) (Léauté, 2006) a pu être établi entre la disponibilité de la nature des fonds et la présence des navires des différents métiers qui les exploitent.

Note: *Indice de sélection = rapport du pourcentage de navires d'un métier sur un type de sédiment sur le pourcentage de la superficie de ce type de sédiment sur la surface totale*

La caractéristique de la pêche dans les Pertuis est la vente de poisson frais, par conséquent les jours de vente se font immédiatement après les jours de pêche, sauf les week-ends. Pour identifier les débarquements de pêche des navires survolés, nous avons utilisé les déclarations provenant du Réseau Inter-Criée (RIC) pour les ventes effectuées le jour même à la criée de La Cotinière (vente à 16 h pour les courreauleurs) par les navires du quartier de Marennes et d'Oléron, ou celles du lendemain (vente à 5 h) pour les criées des Sables d'Olonne et de La Rochelle par les navires de ces quartiers.

Résultats

A l'issue des 40 survols effectués entre 2004 et 2006, 1296 navires ont été observés. A part 3 % restés inconnus tous les autres ont pu être identifiés, ce qui correspond à 133 bateaux car plus de 82 % d'entre eux ont été observés plusieurs fois. Les navires de pêche qui travaillent dans les Pertuis sont de petites tailles avec des caractéristiques moyennes de 7,8 tjb de jauge, une puissance de 89 kW, une longueur de 10 m, et un âge moyen de 29 ans en 2006.

En majorité, ces navires sont polyvalents, et peuvent donc pratiquer plusieurs métiers au cours de leurs saisons de pêche. Quelque soit le métier pratiqué il est nécessaire de posséder des licences (« courreaux », « chalut », « filet » …) ou des permis de pêche spéciaux (PPS) pour travailler dans les Pertuis. Au cours de la période d'étude 4 types d'engins principaux ont été observés : chalut de fond *(CHF)*, filets *(FIL)*, casiers *(CAS)* et palangres *(PAL)*. Les chalutiers représentent 76 % des observations et les fileyeurs 21 %, tandis que les palangriers (2 %) et les caseyeurs (1 %) sont des métiers peu pratiqués dans les Pertuis.

Activités et comportements de pêche

Le Pertuis d'Antioche est un peu plus fréquenté que le Pertuis Breton (figure 2) mais à l'intérieur de chacun d'eux les chalutiers, dominants au cours de nos observations, ont fréquenté à 65 % de préférence les strates PB1 et PB3 du Pertuis Breton et à 59 % les strates PA3 et PA5 du Pertuis d'Antioche. En 2005, nous avons constaté une moindre utilisation du Pertuis Breton certains jours pour cause entre autre de conditions météorologiques défavorables à la pêche dans ce Pertuis (vent fort de secteur nord-ouest), avec un déficit de fréquentation de 7 % par rapport à 2004 au profit du Pertuis d'Antioche plus abrité. Cette tendance s'est inversé en 2006 avec une augmentation de l'utilisation du Pertuis Breton par rapport à 2005 (+3,2 %) mais ce pertuis a quand même été moins fréquenté qu'en 2004 (-3,6 %).

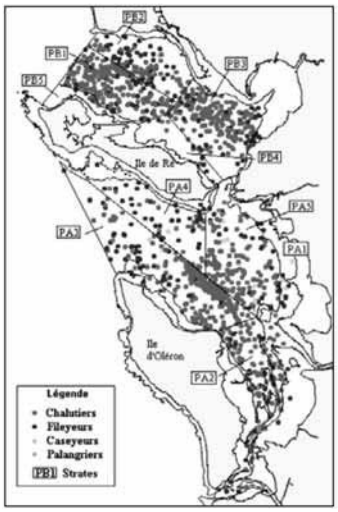

Figure 2 : Fréquentations des strates des Pertuis par métier de 2004 à 2006

Indices de sélection

Un indice de sélection proche de 1 signifie que la fréquentation du fond sédimentaire n'est pas privilégiée, un indice supérieur traduit un choix dans le secteur de travail, et un indice nettement inférieur indique une moindre utilisation des fonds par rapport à la superficie disponible. (tableau 1).

Tableau 1. Indice de sélection des fonds sédimentaires par les différents métiers dans les Pertuis Charentais

Sédiments	**Chalutiers**	**Fileyeurs**	**Caseyeurs**	**Palangriers**
Fonds rocheux	0.3	1.6	1.9	1.3
Graviers	1.9	0.2		1.0
Sables	1.1	1.2	1.1	0.7
Sables - Graviers	0.7	1.6	0.8	1.7
Sables argileux	1.3	0.5	-	1.0
Sables fins	0.6	0.7	-	1.9
Sables fins argileux	1.5	1.2	-	-
Vases	1.1	0.8	1.1	0.9

Rapprochement des navires observés et des ventes en criées

Sur les 133 navires identifiés lors des survols, 104 ont vendu au moins une fois en criée au cours des 3 années étudiées pour un poids total de 121 t (88 % pour les chalutiers et 11 % pour les fileyeurs) et une valeur de 518 k€ (78 % chalutiers, 18 % fileyeurs). En moyenne, près de 80 % de navires vendent entre 2 et 10 espèces à chaque vente

Les 10 principales espèces débarquées (sur 57), par les 104 navires représentent 82 % des poids et 92 % des valeurs (tableau 9). La sole occupe la 3e place en poids (5%) et la 2e en valeurs (16 %) tandis que la première place revient à la seiche (respectivement 44 % et 29 % des poids et valeurs - pour les céphalopodes : seiche+ calmars 49 % et 37 %). La comparaison des débarquements en valeurs des 4 principales espèces (71 % du total) montre leur complémentarité dans les saisons de pêche (figure 3). On observe tout d'abord la fin de la première saison de seiche (avant mi-mai) puis le début de la pêche du bar suivi par le pic de la saison de sole entre début juin et mi juillet remplacé par le début de la pêche du maigre après la mi-juillet avant que la diminution des débarquements de la seiche ne soit compensée par ceux du bar

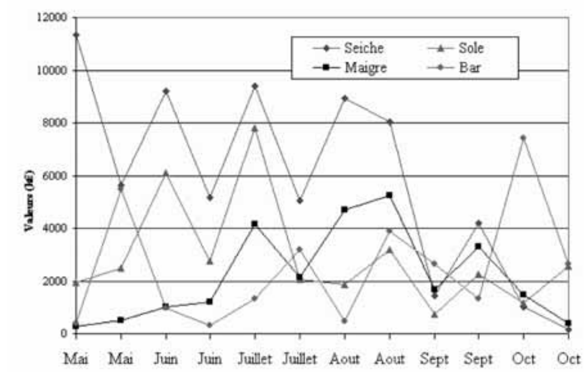

Figure 3 : Saisons de pêche des débarquements des 4 principales espèces (en k€)

Conclusions

A l'issu de trois campagnes de recensement aérien des flottilles de pêche des Pertuis charentais, nous avons la confirmation que la variabilité des facteurs environnementaux et météorologiques d'une année sur l'autre induisent des modifications dans le comportement des professionnels. Les chalutiers côtiers constituent la majeure partie de la flottille des pertuis et ils occupent principalement 3 zones de pêche : au sud-est et au nord ouest du pertuis Breton (de part et d'autre des filières) et le centre du pertuis d'Antioche au nord-ouest de l'île d'Aix en privilègiant les fonds sableux et sablo-vaseux. La sole et la seiche constituent l'essentiel des captures mais au moins 4 espèces sont complémentairest au cours de la saison de pêche pour ces navires qui ont peu d'autonomie pour sortir des Pertuis.

References

Begout Anras M.L., Cooley P. M., Bodaly R.A., Anras L., Fudge R. j. P. 1999, Movement and habitat Use by Lake Whitefish during Spawning in a Boreal Lake : Integrating Acoustic Telemetry and Information Systems. *Trans. of the American Fish. Soc*. 128. 939-952

Léauté J-P. 2006 - Les flottilles de pêche dans la mer territoriale du golfe de Gascogne – *in* « Pêche et aquaculture » Presses Universitaire de Rennes –ISBN 2-7535-0222-6, 337-352.

JUVENA series review of the spatial distribution of anchovy juveniles in the Bay of Biscay

Guillermo Boyra[a], Unai Cotano[a], Udane Martinez[a], Marián Peña[a] and Andrés Uriarte[a]

Introduction

The Bay of Biscay contains an important nursery area for the anchovy population, being this stock of great interest for Spanish and French fisheries. One of the most basic steps in the advice for fishery management is the assessment of the strength of the year classes before they entry the fishery. This might be achieved by assessing early juveniles so as to predict, at least in relative terms, the strength of the future recruitment to the fisheries.

Targeting juveniles for the assessment of recruitment is of special interest for the fisheries of short living species, like anchovies, because of the short time lack between spawning and the exploitation of subsequent emerging recruits. Thus, the Bay of Biscay anchovy fisheries usually obtain the bulk of their respective catches from the 1 and 2 year old classes (ICES 2006, Uriarte et al. 1996). Information from environmental variables is often considered for the prediction of recruitment estimates for these species (Painting et al. 1998, Borja et al. 1998, Allain et al. 2001), although usually lacks of sufficient precision (ICES 2006.

Acoustic methods have traditionally been applied for obtaining recruitment estimates (Dragesund and Olsen, 1965). However, the assessment of anchovy juveniles is not an easy task, because of their small size, their epipelagic distribution and their progressive approximation to shallow waters. These features may cause some problems to acoustic surveys (MacLennan and Simmonds, 1992).

The objective of JUVENA program is the estimation of abundance of anchovy juveniles in early autumn in the Bay of Biscay, as well as the identification and mapping of the different nurseries of anchovy juveniles and the incidence of hydrological and environmental variables in their spatial distribution and growth condition. In this paper we review the results obtained in JUVENA from 2003 to 2007.

Methods

JUVENA surveys take place annually since 2003 (Boyra et al. 2005 & 2007), using acoustics (MacLennan and Simmonds, 1992).Fishing was based on purse seining up to 2005 but since then onwarwds both pelagic trawling and purse seines are being used for species identification and biological sampling, along with hydrological recordings. In addition, the spatial distribution of the juvenile population is studied along with their growth condition. Two boats have been used since 2005 and therefore some extension of the northern limits of the surveys thus facilitated.

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Results and Discussion

Acoustic energy echo-integrated from 0 to 65 m depth during the JUVENA surveys are depict in Figure 1. The colored areas represent the positive area of distribution for anchovy (both adults and juveniles).

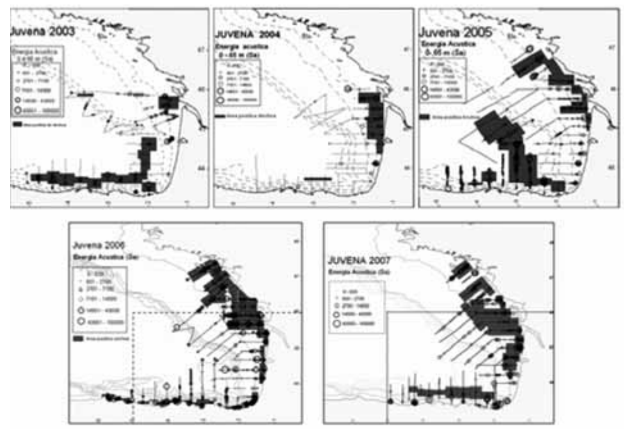

Figure 1: Positive area for anchovy, found during the surveys. The black rings represent the acoustic energy echo-integrated from 0 to 65 m depth.

Two patterns of anchovy distribution are found: off shelf distribution pattern (basically seen in 2003, 2005 and partly in 2007) and shelf and coastal distribution pattern (mainly in 2005-2007). Net differences were found between the anchovy size compositions of the two different distribution patterns, this being consistent for the five years of surveys. In the oceanic area, a pure composition of small anchovy juveniles is invariantly found. These juveniles had most likely been transported by the currents to the offshore waters, off the shelf break, and, by the survey time, have not had time enough to swim back to the coastal areas (Allain 2003). In the coastal areas (mainly around Garonne), the juveniles found are on average bigger than those in the offshore region, and are usually mixed or close to adult schools. This coastal distribution may imply that they will more likely recruit to the adult areas. Whether they were offshore juveniles recruited to coast after achieving sufficient growth and swimming capabilities, or whether or they may have simply be developed and grown over those coastal areas is uncertain. Comparison in recent years with skyppers information collected prior to the surveying time is presented to discuss the potential origin of those juveniles is presented.

The potential relative contribution of these two typical juvenile concentration areas to the final recruitment is not well undestood but final recruitment to the coastal area is understood as a positive step towards final recruitment to the spawning grounds (Irigoien 2007). This recruitment pattern may be favoured by autumn storms and gradual changes to westerly wind regimes.

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Table 1: Synthesis of the abundance estimation (acoustic index of biomass) for the five years of surveys, including sizes (S) and biomass (B) for juveniles (juv) and adults (ad). * estimates for 2006 are still under revision.

Year	Region	s_A	Area	S_juv	S_ad	B_juv	B_ad
2003	South	369	3,303	8.2		97,498	0
	North	444	172	11.1	14.1	1,103	1,383
	Total		3,475			98,601	1,383
2004	South	1	47	6		1	0
	North	562	1,860	11	13.8	2,404	3,451
	Total		1,907			2,406	3,451
2005	South	722	5,390	6.64		125,922	0
	North	326	2,400	9.83	11.91	8,209	20,369
	Total		7,790			134,131	20,370
2006*	South	230	1,200	7.19	11.46	13,224	105
	North	167	5,373	11.05	12.33	30,897	23,857
	Total		6,573			44,121*	23,961*
2007	South	186	1,812	9.0	12.5	6,381	757
	North	248	3,865	10.3	14.4	6,740	34,352
	Total					13,121	35,109

The acoustic estimates produced in 2003 and 2005 cruises (Table I) reported anchovy juvenile abundances one order of magnitude greater or more than the estimates for year 2004 or 2007. The poor result for 2004 was congruent with the subsequent crisis of the stock and collapse of the fishery during 2005. The area occupied by juveniles has changed quite parallel to the abundance estimations during these years. In any case, the acoustic biomass estimates provided by JUVENA series have to be taken as relative values not as absolute. JUVENA surveys are still in a phase of consolidation and testing: Only five surveys have been conducted in the series and just four tested. Although too soon for a proper testing, a preliminary analysis of its performance was made in STECF in June 2007 showing encouraging results some parallelism between recrutiment at age 1 and juveniles estimates: One very low recruitment and 3 low levels of recruitment.

Overall the objectives of the survey series are being achieved. The extension area of occupation of juvenile anchovy is established, both in the southern and in the northern areas. The correct assignation of acoustic echoes is assured by the high number of fishing hauls thanks to the availability of two vessels. And CTD cast sampling allows for examining potential relationships between juvenile distribution and hydrographical conditions. Examples of such analysis will be shown in this work.

Acknowledgements

This work was supported by the Department of Agriculture and Fisheries of the Basque Government and the Secretaría General de Pesca Marítima del Ministerio de Agricultura y pesca del Gobierno Español.

References

ALLAIN G., PETITGAS P. & LAZURE P. 2001. The influence of mesoscale ocean processes on anchovy (Engraulis encrasicolus) recruitment in the Bay of Biscay estimated with a three-dimensional hydrodynamic model. Fisheries Oceanography 10: 151-163.

ALLAIN G., PETITGAS P., GRELLIER P. & LAZURE P. 2003. The selection process from larval to juvenile stages of anchovy (Engraulis encrasicolus) in the bay of Biscay investigated by lagrangian simulations and comparative otolith growth. Fisheries Oceanography 12: 407-418.

BORJA,A, A. URIARTE, J. EGAÑA, L. MOTOS and VALENCIA, V. 1998: Relationship between anchovy (Engraulis encrasicolus L.) recruitment and environment in the Bay of Biscay. Fish. Oceanogr. vol.7: ¾, pp. 375-380

BOYRA, G., ARREGI, I., COTANO, U., ALVAREZ, P. and URIARTE, A. 2005: Acoustic surveying of anchovy Juveniles in the Bay of Biscay: JUVENA 2003 and 2004: preliminary biomass estimates. Working Document to WGMHMSA, 6 – 14 September 2005 at Vigo.

BOYRA, G., MARTÍNEZ, U., COTANO, U. M. PEÑA AND URIARTE, A., 2007: Acoustic surveying of anchovy Juveniles in the Bay of Biscay: JUVENA 2007 Survey Report (Includes an Appendix with the revision of the series). Working Document to the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA), Copenhagen 4-13 September 2007).ICES. 2006. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA), 5- 14 September 2006, Galway, Ireland. ICES CM 2006\ACFM:36. 601 pp

DRAGESUND, O AND OLSEN, S. 1965. On the possibility of estimating year-class strength by measuring echo-abundance of 0- group fish. FiskDir. Skr. Ser. Habunders., 13:47-75.

MACLENNAN D.N. and J.E. SIMMONDS, 1992: Fisheries Acoustics. Chapman and Hall. London 325 pp.

PAINTING S.J., HUTCHINGS L., HUGGET J.A., KORRUBEL J.L., RICHARDSON A.J. and VERHEYE H.M. 1998: Environmental and biological monitoring for forecasting anchovy recruitment in the southern Benguela upwelling region. Fish. Ocenogr. 7: ¾, 364- 374

URIARTE A. P. PROUZET, B. VILLAMOR 1996: Bay of Biscay and Ibero atlantic anchovy populations and their fisheries. Sci. Mar. 60 (Supl.2): 237-255

Growth of early juvenile European anchovy, *Engraulis encrasicolus*, in the Bay of Biscay based on otolith microstructure analyisis

Naroa Aldanondo[a], Unai Cotano[a], Guillermo Boyra[a] and Xabier Irigoien[a]

Introduction

European anchovy, *Engraulis encrasicolus* L. is a short-life species with highly variable recruitment to the population. Anchovy fishery is strongly dependent on 1 year-old surviving adult, which correspond to those juveniles that inhabit the Bay of Biscay (Uriarte *et al*., 2002). Survival during early stages of larval and juvenile fish is critical to explain recruitment. (Brophy and Danilowics, 2002; Takasuka *et al*., 2004). Otolith microstructure analysis is a powerful tool which can be used in recruitment studies as it provides information on growth rates and birth dates (Folkvord *et al*., 2000; Xie *et al*., 2005; Baumann *et al*., 2006).

In the Bay of Biscay low recruitment since 2001 and almost complete recruitment failure of the 2004 year class resulted in stock colapse and fishery closure since 2005 (ICES, 2007). Since 2003 Azti carried out an acoustic survey (JUVENA) focused on estimating the abundance and growth of juveniles in early autumn (Boyra and Uriarte, 2005).

In this study, otolith microstructure analysis was applied to calculate growth curves and individual growth rates of anchovy juveniles. In this way, the birth date distribution of juveniles was estimated.

Methods

The survey JUVENA 2005 took place in September-October onboard two purse seines equipped with scientific echosounders Simrad EY60 (38 and 120 kHz). For acoustic data processing the Ifremer Movies+ software was used. The sampling area covered the waters of the Bay of Biscay, being 5ºW and 46ºN the limits (Figure 1).

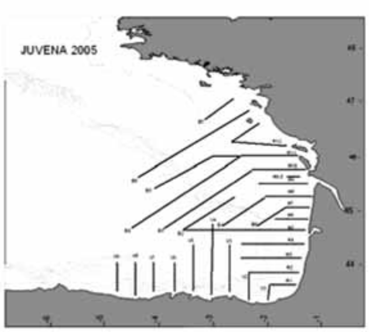

Figure 1. Survey tracks of JUVENA 2005.

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The anchovy juveniles standard length (L_S) was measured and the sagittae otoliths were dissected out. The microstructure analysis was carried out using a light microscope applied to an imagine-analyser *(Visilog, TNPC software, v.3.2, Ifremer, France)*.

The collected material was classified into the following groups, 1: the cantabrian samples, 2: the Gironde samples. The analyses presented here were performed using R-statistical software (http://cran.r-project.org).

Results and Discussion

Age at standar length are presented for each group (Figure 2). In the case of the cantabrian group, the growth curve explained a high percentage of the observed variability (R^2=0.83). In the Gironde group, however, the growth curve gave a very weak fit (R^2=0.29), with high residuals values. Juveniles with L_S<85mm presented negative residual values, while the residuals of larger individuals were positive. This suggest that there could be two different growth tendencies into the Gironde group.

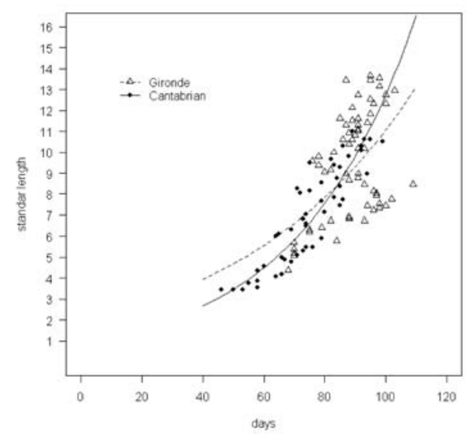

Figure 2. The growth curves for the two *Engraulis encrasicolus* juveniles groups in the Bay of Biscay.

In order to compare the cantabrian and Gironde samples statistically, two subgroups were distinguished in each group (L_S<85mm and L_S>85mm).

The comparison between the growth curves showed that L_S<85 mm juveniles had a significantly faster growth in the cantabrian waters (ANCOVA, P<0.05). However, the larger juveniles presented no significant differences.

The back-calculated hatching date showed anchovy juveniles sampled in the Bay of Biscay in autumn were born between 31 May and 14 August; with the mode on 10 July. The frequency distribution showed no overlap between the cantabrian and the Gironde L_S>85mm groups. In the cantabrian group, the average estimated spawning date was 25 June; while the Gironde group was 10-15 July. Comparing these groups statistically significant differences were found (K-S-test, P<0.001). The average hatching date of the cantabrian L_S<85mm was 15 July, whereas the Gironde L_S<85mm was 5 July. Comparing these last groups significant differences were also found (K-S-test, P<0.001).

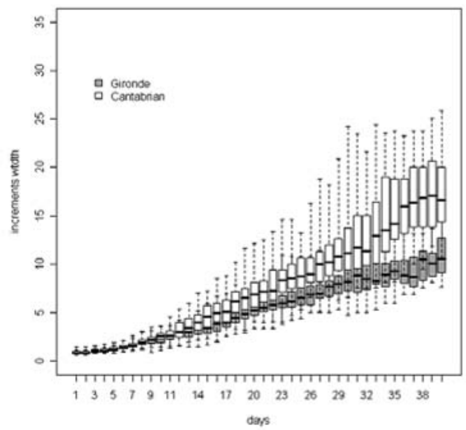

Figure 3. Average otolith increment widths at age for the cantabrian and Gironde L_S<85mm groups of juveniles.

There were significant differences in average increment width at age between L_S<85mm groups (one-way ANOVA, P<0.05). At age 13 days the curves were similar and the average increment width was just above 3 µm. From age 13 days the curves splitted into two components, Gironde group and cantabrian group (Figure 3). The narrowest increments were observed in the Gironde group.

Acknowledgements

This work has been funded by a predoctoral research grant provided from the Education, Universities and Research depart of the Basque Government.

References

Baumann, H., H. Hinrichsen, R. Voss, D. Stepputtis, W. Grygiel, L. Clausen, A. Temming, 2006. Linking growth to environmental histories in central Baltic young-of-the-year sprat, *Sprattus sprattus*: an approach based on otolith microstructure analysis and hydrodynamic modelling, *Fisheries Oceanography,* 15(6):465-476.

Boyra, G., A. Uriarte, 2005. Informe de campaña / Survey Report: Campaña acústica de juveniles de anchoa en 2005. Acoustic survey on juvenile anchovy in 2005:"JUVENA 2005" Working Document to STECF meeting 06-10 November 2005 at Brussels.

Brophy, D., B. Danilowics, 2002. Tracing populations of Atlantic herring (Clupea harengus L.) in the Irish and Celtic Seas using otolith microstructure, *ICES Journal of Marine Science*, 59:1305-1313.

ICES, 2007. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy, ICES Headquarters, 4-13 September 2007 (ICES CM 2007/ACFM :31).

Folkvord, A., G. Blom, A. Johannessen, E. Moksness, 2000. Growth-dependent age estimation in herring (*Clupea harengus* L.) larvae, *Fisheries Research* 46:91-103.

Takasuka, A., I. Aoki, I. Mitani, 2004. Three synergistic growth-related mechanisms in the short-term survival of larval Japanese anchovy *Engraulis japonicus* in Sagami Bay, *Marine Ecology Progress Series,* 270:217-228.

Xie, S., Y. Watanabe, T. Saruwatari, R. Masuda, Y. Yamashita, C. Sassa, Y. Konishi, 2005. Growth and morphological development of sagittal otoliths of larval and early juveniles *Trachurus japonicus*, *Journal of Fish Biology,* 66:1704-1719.

Uriarte, A., B. Roel, A. Borja, G. Allain, C.M. O´Brien, 2002. Role of Environmental indices ia determining the recruitment of the Bay of Biscay anchovy. ICES CM 2002/O

Is the global functioning of the pelagic ecosystem over the continental shelf of the Bay of Biscay (NE Atlantic) mainly driven by rates of rivers discharge? A comparison of two contrasting years with special reference to anchovy (*Engraulis encrasicolus* L.) nutritional state

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Introduction

During fisheries research cruises devoted to small pelagic fishes in the Bay of Biscay, mesozooplankton samples are systematically taken for measurements of enzyme activities with the aim of characterizing the main features of the pelagic ecosystem functioning at mesoscale. In springtime of the year 2000, a first set of simultaneous estimates of three enzyme activities were implemented in order to assess assimilation rates of carbohydrates and protein by the mesozooplankton community and the resulting overall productivity. Moreover a biochemical index was used to determine the nutritional state of breeding anchovies. The same biochemical indices were estimated during the following cruise in the 2001 springtime. Hydrobiological conditions in 2000 and 2001 were strongly contrasting owing to quite different outflow rates of large rivers. We present here 1) their consequences on the pelagic ecosystem main features, 2) the effect on the metabolism of the mesozooplankton community and 3) the resultant nutritional state of adult anchovy.

Methods

The sampling grids of PEL00 (17/04-13/05) and PEL01 (26/04-6/06) cruises covered the entire continental shelf of the Bay of Biscay. At each station, 1) temperature and salinity profiles were determined with a CTD, 2) water samples were taken at 5 depths for measurements of nutrients, chlorophyll and the particulate organic carbon and nitrogen, 3) mesozooplankton were collected by vertical tows of a WP2 net. Adult specimen of anchovies were gathered from pelagic trawls during the acoustic survey of the anchovy population distridution. Enzymes selected for measurements in mesozooplankton samples were trypsin for protein assimilation, pyruvate kinase for carbohydrates assimilation and aspartate transcarbamylase (ATC) for mesozooplankton productivity. Enzyme activities are expressed below as specific activities, i.e. related to protein content. The nutritional condition of adult anchovies was estimated from values of the RNA/DNA ratio measured white muscles.

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Results

In 2000, desalted waters were contained along the coast, but in 2001, according to the large rivers discharge and wind regime, the extent of low salinity in the surface layer covered almost the whole sampled area in the Bay of Biscay (Figure 1) and consequently the nutrients were highly concentrated. This change in hydrological structures affected both phytoplankton distribution and standing stocks : thus higher phytoplankton biomass was observed in desalted waters in 2001 (Figure 1).

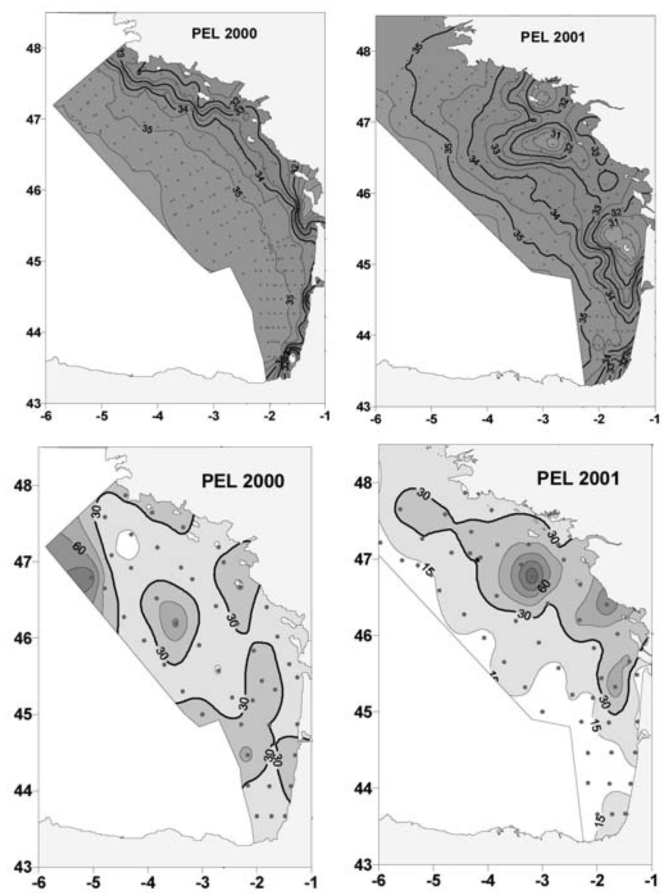

Figure 1. Surface salinity (top) and integrated Chl *a* distribution (bottom) during the two surveys.

Two enzymes of the mesozooplankton community demonstrated outstandingly activated levels (Figure 2), the PK supposedly expressing the assimilation rates of carbohydrates and the ATC providing an estimate of the overall productivity.

Conversely the trypsin activity values were lower than in the year 2000; however, among moderate values almost all over the shelf, maximum specific activities coincided with the Chl *a* highest values in the plumes of the two main large rivers. Concerning ATC it is worth noting that a special distribution was observed in 2001: almost the whole of the high specific actvities were measured in southern stations and the northern river plume did not lead to a similar rise. Nutritional states of the breeding anchovies also showed contrasting trends between both years: in the year 2000, only 6 trawled samples out of 18 were above the threshold of 2 considered as the upper limit under which the individuals are graded in poor condition, whereas in 2001 only 4 samples out of 23 were <2 and 19 were > 2, among which 8 were even beyond 3, i.e. in quite satisfying condition.

Discussion

Among different other items of the discussion, a most important one lies in the magnitude of the considerable difference, between both years, of the levels reached by the metabolic descriptors of the mesozooplankton community. Certainly, owing to strong differences in the outflow rates of rivers and under the influence of different consequent enrichments in nutrients, the two years presented different features at the primary levels of the pelagic food web. But the huge values taken by the metabolic descriptors, principally PK and ATC, do not appear in proportion with the rates observed in these primay levels. It must be underlined that there exists between the two years a difference in the stage of the seasonal cycle at which the sampling has been carried out: the southern half of the Bay, where highest ATC activities were recorded, has been covered one month later in 2001 (18 may-4 june) than in 2000 (18 april-1st may). Consequently the daily period of sunshine, as well as its intensity, were more important in 2001 than in 2000. Therefore it is very probable that the primary production in 2001 was noticeably higher than that in 2000. Actually a slightly higher phytoplankton biomass may be observed in 2001 mainly in the river plumes, but this increase in comparison with the biomass found in 2000 is rather moderate and this is a static view of a dynamic process: as the pelagic environment is regularly and outstandingly supplied with nutrients by the rivers outflow, the so enhanced primary productivity may be compensated by high levels of grazing by the mesozooplankton community, it is what would signify the strong PK activities. Within such a context, high ATC specific activities measured in 2001 would reveal the resultant effect of enhanced primary productivity and mesozooplankton grazing. This gap in the dynamics of the pelagic food web processes between the two consecutive years has repercussions on the nutritional condition of the zooplanktivorous breeding anchovies, obviously higher in 2001 than in the year 2000. An important consequence would be a possible enhancement of the whole fecundity of the anchovy population during its breeding season in 2001.

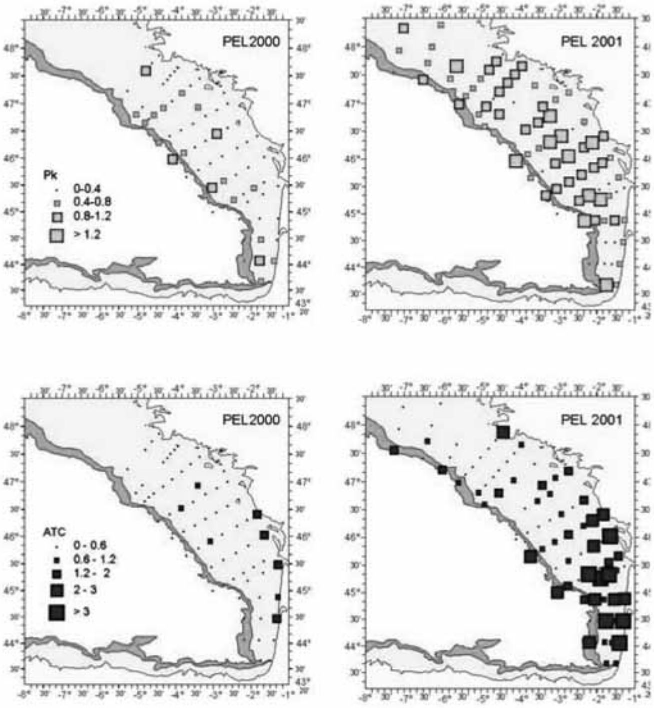

Figure 2. Spatial distribution of mesozooplankton pyruvate kinase (PK) and aspartate transcarbamylase (ATC) activities during the surveys.

Conclusions

Enzyme activities measured in mesozooplankton samples as metabolic descriptors of the ecosystem functioning provide precious information about the dynamics of the pelagic food web processes. It must be recognized that, by good fortune, contrasting environmental conditions, linked to different enrichment rates by rivers outflow, prevailed on the two consecutive opportunities to early implement simultaneous estimates of the activities of three enzymes which had been the object of several works in the past, but had never been processed together before. This chance helped to demonstrate interesting capabilities of our biochemical tools. Although other nutrient enrichment processes, such as internal waves-induced upwelling of deep waters along the continental slope or coastal upwelling under certain wind regimes, occur in the Bay of Biscay, the role played by rivers outflow variations on the functioning of the pelagic ecosystem seems to be most often prevailing.

Does Le Danois bank (El Cachucho) influence albacore catches in the Cantabrian sea?

Cristina Rodríguez-Cabello*[a], Francisco Sánchez[a], Victoria Ortiz de Zárate[a] and Santiago Barreiro[a]

Introduction

The seamount of El Cachucho, also known as Le Danois Bank (Le Danois, 1948), is located in the north of Spain, in the Cantabrian Sea, in front of Asturias at a distance of 65 km from the coast, longitude 5º W and has an elongated E-W disposition (50 km x 10 km), with depths on the plain ranging between 450 and 600 m (Figura 1).

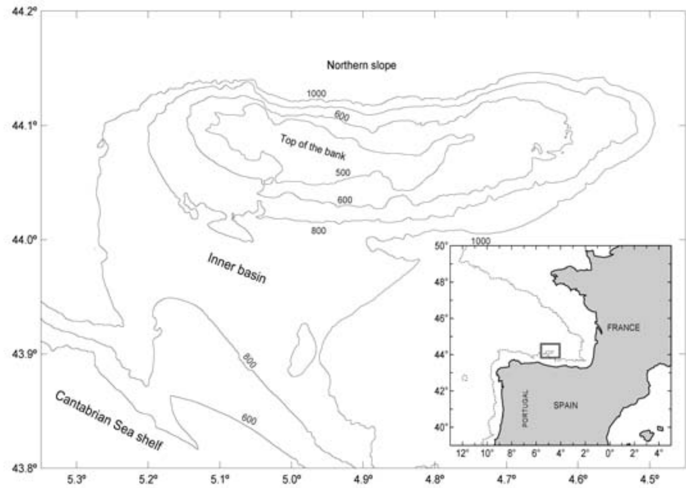

Figura 1. Location of Cachucho Seamount in the Cantabrian Sea and the area defined in the study.

Seamounts are known to produce a strong influence on the behaviour and distribution of tunas and other large, highly migratory pelagic species. The two commonly stated hypothesis to explain the aggregation of pelagic fish around seamounts are the existence of enhance phytoplankton production which in turns supports a rich ecosystem and food availability and second is that seamounts may play a role as navigation aids in fish movements (Holland and Grubbs, 2007). In some fisheries available catch data indicate that catch per unit effort (CPUE) is higher around seamounts than in adjacent areas of ocean (Fontaneau, 1991; Campbell and Hobday, 2003).

The albacore surface fishery in the north of Spain is one of the most important economical activities carried out by the Spanish artisanal surface fleet from the Galician and Cantabrian fishing ports during summer and autumn months (June-October). The marked seasonality of this fishery is due to the highly seasonal migratory behaviour of immature albacore into the north-eastern Atlantic temperate surface waters (Aloncle et Delaporte, 1973; Bard, 1981; Cort et al. 1992; Ortiz de Zarate and Cort, 1998).

Albacore is characterized for being an opportunistic species which feeds on pelagic species like anchovy, sardine, mackerel, horse mackerel and squids. However, it can also prey on demersal species like blue whiting (Ortiz de Zárate, 1987) crustaceans (Hassani *et al.,* 1997) or mesopelagic species like *Maurolicus muelleri, Scomberesox saurus* (Pusineri *et al*., 2005) due to the high capacity of this species to make vertical migrations (Laurs *et al*., 1980; Bertrand *et al*., 2002) in search of food or for the optimal thermal habitat.

The aim of this paper is to analyse the influence of this feature on the productivity and enrichment process in the adjacent waters and consequently on the Spanish albacore surface fishery by means of comparing CPUE series in different areas inside and outside of Le Danois Bank.

Methods

Two different sources of information have been used. In a first step data collected through interviews of landings and fishing effort at main fishing ports located along north western coast and the Bay of Biscay for each fleet during the period (2000-2006). Secondly data from logbooks collected from 1992 to 1998. The first data set is used for monitoring this surface fishery, provides a high coverage of the fishery area, however in most cases only a mean position of the catch is recorded. From each trip sampled the following information was recorded: date of landing, gear, number of fishing days, number of skippers, number of lines, fishing area (latitude and longitude), catch in number, catch in weight (k) and fish length. Fish were measured to the fork length (FL) and to the nearest centimetre according to commercial categories in the fishing markets. In the second data set less area is covered nevertheless daily positions were recorded jointly with the number of fish, catch weight and mean weight.

Fish were grouped in three categories according to fish market: Cat1 small individuals less than 5 kg, usually 3-4 kg, Cat2 medium size fish from 5 to 7 kg and Cat3 large fish up to 7 kg. Thus catch, nominal effort (fishing days) and length distribution were processed by gear on monthly basis.

Three different areas were defined: Area 1 which comprises the actual limits of the proposal as MPA, defined by the following coordinates: 43º53'N–44º 12'N and 4º26 – 5º16' W, covering approximately 2330 km2: Area 2 which includes Area 1 and nearby adjacent waters, defined by: 43º40'N – 44º20'N and 4º00 – 5º30' W, and Area 3 which comprises the rest of the Bay of Biscay waters were the fleet operates (Figure 1). In each of these areas nominal CPUE were estimated and compared among areas.

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Results and Discussion

Nominal albacore CPUE obtained from logbooks reveals higher catches, particularly in Area 2 (Cachucho and nearby waters), in certain months and in some fishing seasons, however there is not a strong evidence of a notably influence of the Cachucho in the albacore CPUEs. Nevertheless nominal albacore CPUEs obtained from the monitoring of the fishery showed significant higher CPUEs in some periods (Figure 2).

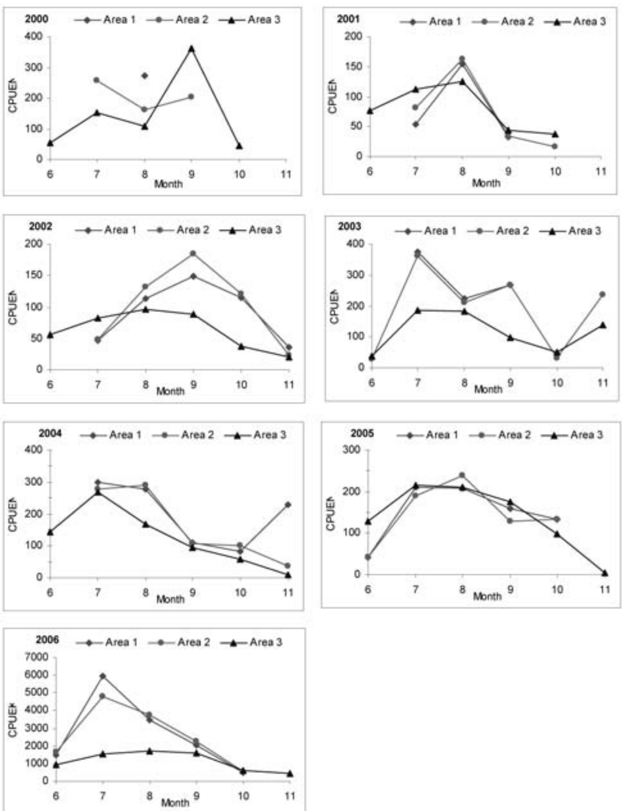

Figure 2. Nominal CPUE series by month and fishing season in the study area.

Most of the fish caught corresponded to medium and large fish, 5-7 kg and 7-12 kg respectively. Differences in the proportion of the catch size were remarkable between months, however no significant differences existed between different areas thus, differences are probably due the migratory behaviour of this species rather than to the fishing area.

In general terms the albacore fishing area remains similar in all the fishing seasons. The troll vessels operated in a larger area from the coastal waters in the Bay of Biscay to the most western (25º W) and northern waters (52º N) while the bait boats were localised mainly in the Bay of Biscay waters as had been for the latest years (Ortiz de Zárate and Rodríguez-Cabello, 2001). (Figure 3).

The high complexity of different habitats, richness and diversity of species, presence of vulnerable species, etc. in the Cachucho o Le Danois Bank, makes this area of high interest (Serrano et al., 2006; Sánchez *et al*., 2007) that not only deserves legal protection but could also contribute to support optimal conditions for surface pelagic fisheries like albacore. Thus the importance of implementing studies on seamounts ecology to improve their knowledge and their potential impact on pelagic fisheries and vice versa.

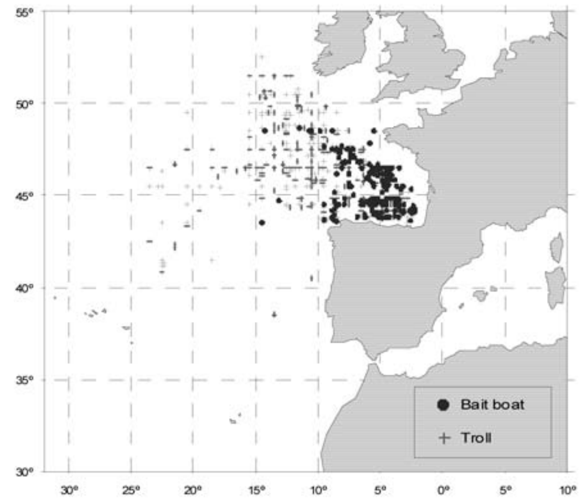

Figure 3. Spatial distribution of the Spanish albacore surface fishery in the Bay of Biscay.

References

Aloncle, H. et F. Delaporte, 1973. Populations, croissance et migrations du germon (*Thunnus alalunga*) dans le nord-est Atlantique essai de synthèse. *Rev. Trav. Inst. Pêches marit*., 37(1): 97-115.

Campbell, R.A. and A. Hobday, 2003. Swordfish-Environment- Seamount-Fishery interactions off eastern Australia. *Report to the Australian Fisheries Management Authority*, Canberra, Australia.

Fonteneau, A., 1991. Seamounts and tuna in the tropical Atlantic. *Aquatic Living Resources*, 4, 13-25.

Hassani, S., L. A. and V. Ridoux, 1997. Diets of albacore, *Thunnus alalunga*, and dolphins, *Delphin delphis* and *Stenella coerulaeoalba*, caught in the northeast atlantic albacore drifnet fishery: a progress report. *J. Northw. Atl. Fish. Sci.*, 22: 119-123.

Holland, K. N. and R.D. Grubbs, 2007. Fish visitors to seamounts: tunas and Billfish at seamounts. Chapter 10. Section A pp 189-201 in Pitcher, T.J., Morato, T., Hart, P.J.B. Clark, M.R., Haggan, N. and Santos R.S. (eds) Seamounts: Ecology, Conservation and Management. *Fish and Aquatic Resources Series,* Blackwell, Oxford, UK.

Ortiz de Zárate, V. and C. Rodríguez-Cabello. 2001. Spatial distribution of Spanish bait boat fleet targeting albacore, Thunnus alalunga, in the northeast Atlantic ocean from 1981 to 1999. *Col. Vol. Sci. Pap. ICCAT* 52: 1429-1434.

Pusineri, C., Y. Vasseur, S., Hassani, L. Meyner, J. Spitz and V. Ridoux, 2005. Food and feeding ecology of juvenile albacore, *Thunnus alalunga*, off the Bay of Biscay: a case study. *ICES Journal of Marine Science,* 62: 116-122.

Sánchez, F., A. Serrano, S. Parra, M. Ballesteros and J.E. Cartes, 2007. Habitat characteristics as determinant of the structure and spatial distribution of epibenthic and demersal communities of Le Danois Bank (Cantabrian Sea, N. Spain). *Journal of Marine Systems* (in press).

Serrano, A., F. Sánchez, J. E. Cartes, J.C. Sorbe, S. Parra, I. Frutos, I. Olaso, F. Velasco, A. Punzón, A. Muñoz, M. Gómez, C. Pola & I. Preciado, 2005. ECOMARG Project: A multidisciplinary study of Le Danois Bank (Cantabrian Sea, N Spain). *ICES CM 2005/P:11*, 17 pp

Robustness of European Hake Management Strategy to stock recruitment relationship in the context of alternative indices of stock reproductive potential

Hilario Murua[a], Dorleta Garcia[b], Maria Korta[a] and Iñaki Quincoces[b]

Abstract

The stock-recruitment relationship forms a cornerstone in the management process of fishery systems, as the biological reference points are usually dependent on the stock-recruitment model. Commonly, the relationship is estimated assuming that the number of recruits are a function of the adult biomass, which implies that the survival rates of offspring are independent of parental age, body size, and that relative egg production per unit weight of adult stock are invariable over time. In general, however, the estimation of SSB does not incorporate sex ratio and often does not include a variable maturity ogive at age, both factors showing temporal variation. Moreover, fecundity is not usually used in the estimation of "spawning stock" and is know to be variable over time. However, different studies suggest that the age structure of the population may affect the fecundity and spawning success of the population and that the maturity/fecundity of the individuals may exhibit temporal variability. Therefore, it has been suggested that other measures of reproductive potential, incorporating some of these variable reproductive characteristics, can better reflect a population's recruitment potential. In other words, the reproductive biology of a species determines productivity and, therefore, a population's resiliency to exploitation by fisheries or to perturbation caused by other human activities.

In the case of the European hake management the sex-ratio is not applied, a constant and sex aggregated maturity is used, and population egg production is not considered when estimating the SSB. The main objective of this work is to use the Management Strategy Evaluation approach to analyze the robustness of northern hake management strategy to uncertainties in the stock recruitment relationship. More precisely, the objective is to test the influence of the real and observed stock-recruitment relationship in the success of the management strategy, and hence, in the dynamics and recovery prospects of the population using a more biologically "realistic" data of sex ratio, sex disaggregated and variable maturity data and fecundity to simulate the real population and assessing the population as it is done at present.

In summary, this paper provides an overview of variation in reproductive characteristics in European hake to estimate different indices of reproductive potential and, hence, stock-recruitment relationships. It also examines the impact on perceived productivity and therefore on advice for fisheries management, of taking such variation into account.

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Management Strategy Evaluation of Northern Hake and associated fisheries: TAC versus Effort based Management

Dorleta Garcia,[a] Raúl Prellezo[a], Arantza Murillas[a] , Estibaliz Diaz[a], Leyre Goti[a] and Marina Santurtún[a]

The management of fisheries by means of TACs and quotas has not been sufficiently effective in Europe for many reasons. Effective enforcement is difficult and costly, which makes underreporting and misreporting a real problem. Also, species are not managed on a mixed fisheries basis creating inconsistencies in the effort/TACs relationship. These inconsistencies have been solved by fleets, apart from underreporting through discards . The different prices of fishes of different size, leads also to discard of less valuable fishes in a TAC management regime.

All of these problems could, however, be avoided, in principle, by controlling fishing effort directly, rather than using TACs and quotas to do so indirectly.

In this work the performance of a long term management plan for Northern Hake using TAC and Effort based management is compared from a bioeconomic perspective. For doing so, montecarlo simulations are used following Management Strategy Evaluation (MSE) approach.. Alternatives for a long term management plan for Northern Hake are analyzed, concretelly those presented in the STECF 2007 in order to replace the current emergency plan for the stock. These management strategies are based on a target fishing mortality corresponding to maximum sustainable yield.

In order to give a management advice, the target fishing mortality must be transformed to catch or effort, depending on whether the management system is TAC-based or effort-based, so in the management process a relationship between fishing mortality and catch or effort should be assumed. In an effort management regime, given that a long term management plan gives, by definition, a long term perspective, in order to solve the problems of “uncontroled” rise of technical effciencies of the fleets, which in fact is one of the most propable reaction to this type of management scheme, besides the effort advice a total catch limit is also imposed. But if the advice given is not completely consistent within the effort-fishing mortality-catch relationship, it will create another source of under-reporting and misreporting. Fleets will continue fishing until the effort limit imposed is exhausted, even exceeding the catch limit. This is why the effect of the non coincidence between the relationships used in the management process and those acting in the real world are also are taken into account.

In this work apart from comparing the performance of TAC and Effort based management regimes, the effect of inconsistencies between the effort-fishing mortality-catch relationship used in the mangement procces and the relationship going in the real world have been analyzed.

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Spanish bottom trawl surveys in Cantabrian Sea and Galician waters (North of Spain). Overview of horse mackerel historical series

Francisco Velasco [a] , Pablo Abaunza [a], and Mª Angeles Blanco [a]

Data from bottom trawl surveys carried out in autumn in the Cantabrian Sea and Galician coasts (North of Spain) are analysed in relation with horse mackerel species. The surveys provided valuable information on horse mackerel dynamics. In this sense, the length distributions showed a gap in length range 18-23 cm which could be related with the particular exploitation pattern of this species. Juveniles are more abundant in the eastern part of the Cantabrian Sea although the depth strata < 120 m, in which the young horse mackerel is also distributed, are very poor sampled in the Galician coasts. The recruitment in 1994 appeared to be strong in the data series. The evolution of the cohorts through the data matrix showed poor information on mortality. This could be possibly due to migration to and from other areas, especially the French continental shelf.

Introduction

Fishing in Cantabrian Sea and Galician waters is conducted over the whole continental shelf by a plea of different fishing gears (bottom trawl, pair trawl, purse seines, gillnets, hooks, etc.). These fleets target several fish and shellfish species (e.g. hake, anchovy, sardine, megrims, blue whiting, monkfish, mackerel, horse mackerel, Norway lobster, etc.) with a great commercial value for local economies. Many of the stocks of these species are fully exploited and others clearly overexploited, being the area under study an interesting place for tracking the dynamics of their populations. Bottom Trawl Surveys are used to obtain data used to determine the appropriate regulatory measures and to monitor changes and assess trends in population size and recruitment of fish populations, mainly for demersal and benthic species. Horse mackerel is a pelagic species, but its demersal behaviour is much more intense than in other pelagic species like mackerel or sardine. Therefore, bottom trawl surveys could provide valuable information on the dynamics of this species. This document deal with the description of the historical series of horse mackerel data obtained from the bottom trawl surveys carried out over the continental shelf of the North of Spain. In addition, we analyze if the survey is really indicative of the horse mackerel population trends.

Material and Methods

The Spanish autumn groundfish survey covers the Spanish continental shelf between the Portuguese and French borders. All surveys were performed on board RV "Cornide de Saavedra", except 1989 that was carried out on board RV "Francisco de Paula Navarro", using the Baca 44/60 otter trawl gear with 20mm cod end mesh size and synthetic wrapped wire core ground rope. The survey area was stratified according to depth and geographical criteria and a stratified random sampling scheme was adopted. The number of hauls per stratum was proportional to the trawlable surface and the sampling unit was made up of 30-minute hauls at a speed of 3.0 knots. Three depth strata and 5 geographic sectors have been used. Approximately between 115 -124 hauls per survey were made in the period from 1997-2007 (Fig. 1). Although we made the detailed analysis of the survey results for this period, the catch rates are shown for a longer period: 1983-2007.

From each haul, a length frequency distribution is estimated for the total catch of each species. These length distributions are then used with an age-length key, to estimate the age distribution in each haul.

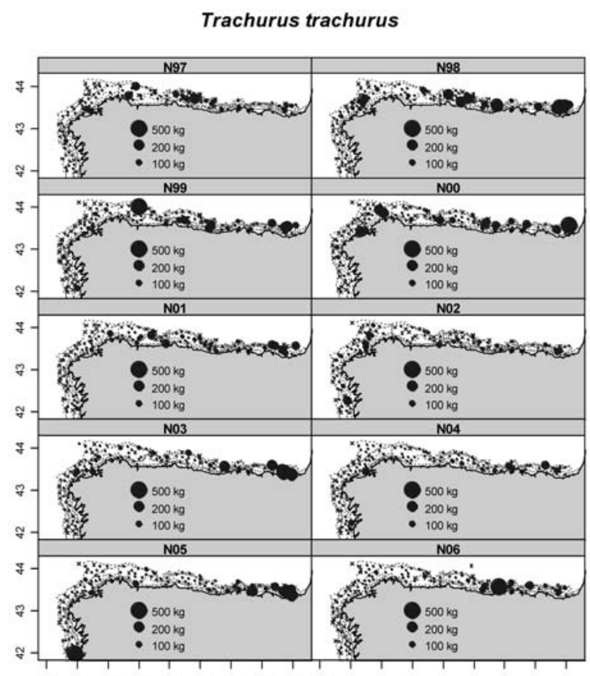

Figure 1. Distribution of horse mackerel catches in biomass in surveys carried out between 1997 and 2006.

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Results and Discussion

Catch rates

The mean catch rate in yield for the period 1983-2007 is 19.73 ±10.51 kg/haul. There is no any clear trend in the historical series, although the catch rates and the associated standard errors obtained in the very first years (1983 and 1984) are significantly higher than those obtained in the rest of the period. The mean yield was higher in Subdivision VIIIc east with a mean catch rate of 27.74 ±17.54 kg/haul, which represents more than the double of the catch rates obtained in Subdivisions IXa north and VIIIc west.

The historical series of catch in numbers shows also the same pattern as catch in biomass: in Subdivision VIIIc East the numbers are always higher than the numbers obtained in the other Subdivisions. The mean of the numbers obtained in each Subdivision are: Subdivision VIIIc East = 472 ± 505; Subdivision VIIIc West = 82 ± 73; Subdivision IXa North = 201± 744. The only exception is in 2005, in Subdivision IXa north, where an outstanding catch of juveniles were obtained (as it can also be inferred for the large standard deviation from the series in Subdivision IXa north).

Length distributions

The surveys are carried out during the autumn, which in the study area is the recruitment season for the majority of demersal-benthic species and for some of the pelagic ones Therefore the numbers of horse mackerel obtained during the surveys are very variable depending on the abundance or the availability of juveniles (roughly specimens < 20 cm in length, Abaunza et al., 1995). The length structure obtained in the catch showed two main groups: juveniles and adults greater than 25 cm (25-33), but the length group between 17 and 23 cm is usually scarcer. This group roughly corresponds to the length at which horse mackerel attain its first maturity. These length classes are also poorly represented in the length compositions of landings by purse seine and bottom trawl fleets fishing off Galicia and the Cantabrian Sea (Abaunza et al., 1995). It seems that horse mackerel on reaching the length of first sexual maturity becomes less accessible to fishing gear (purse seine and bottom trawl).

Length distributions did not show any appreciable difference between sexes.

Recruitment and age structure

The recruitment is estimated as the abundance of horse mackerel age 0. The survey in theory is carried out in the adequate season to obtain an index of the strength of the incoming year classes. In the time series, the 1994 and the 2005 year classes appear to be strong ones. However, these results should be taken with caution. Due to the massive presence of rocky grounds in the Spanish inner shelf, the sampling effort in Spanish waters is mainly placed in waters deeper than the 100 m isobath. Given the clear preference of younger fish for shallow waters, the Spanish survey may provide a biased index of recruitment.

The juveniles were obtained mainly in the eastern part of the Subdivision VIIIc East.

The catches from the survey contained a good representation of the horse mackerel age-range (from 0 to 15+) and the adult segment of the population seems to be well represented. Various cohorts like the 1982 and 1994 year classes can be followed through the proportion at age in the catch matrix. The 1982 year class was an outstanding year class that dominated the catches of the western horse mackerel stock during more than 10 years (ICES 2000).

Information on mortality

The slope of the log catch curves by year class gives us an estimate of total mortality Z.

The slopes of the year classes from the catch at age matrix had values close to 0. This means that we have almost no information on mortality. However, this could be also a signal of migratory movements. The study area is the southern limit of the horse mackerel Western Stock, and it is likely that age or length dependent migrations with adjacent areas, mainly with French Atlantic coast, are produced. Recently Murta et al. (In press) showed that there are limited ontogenic migrations of horse mackerel through the study area and probably it is the cause of the flat catch curves observed. Surveys are also used for tuning analytical stock assessments. If the surveys have little information on cohorts mortality, their use as tuning index in an age structured model is limited.

Conclusions and Remarks

The surveys provide very useful information on the dynamics of horse mackerel in the Cantabrian Sea and Galician waters, although the information on cohort mortality is limited.

The data are not split by stock (Subdivision IXa north belongs to the southern stock and Division VIIIc to the western stock) and it is expected to show the analysis by stock in the future.

Acknowledgements

Authors wish to thank to all the people involved in the Spanish bottom trawl surveys, and to the crew of the research vessel Cornide de Saavedra.

References

Abaunza, P., Fariña, A.C., Carrera, P. 1995. Geographic variations in sexual maturity of the horse mackerel, Trachurus trachurus, in the Galician and Cantabrian shelf. Sci. Mar., 59(3-4): 211-222.

Murta, A.G., Abaunza, P., Cardador, F. and Sánchez, F. 2007. Ontogenic migrations of horse mackerel along the Iberian coast. Fisheries Research (in press).

Sanchez, F., Blanco, M., Gancedo, R. 2001. Atlas de los peces demersales y de los invertebrados de interés comercial de Galicia y el Cantábrico. Otoño 1997-1999. Ed. CYAN (Madrid), 158 pp

Effects of trawl exclusion in a set of indicators in the Cantabrian Sea inner shelf (Southern Bay of Biscay)

Alberto Serrano, Cristina Rodríguez-Cabello, Francisco Sánchez, Ignacio Olaso, Francisco Velasco and Antonio Punzón

Introduction

Bottom trawling is forbidden by Spanish legislation in depths shallower than 100 m in the Cantabrian Sea. Nevertheless, illegal trawling operations are common. To avoid this, artificial reefs (concrete blocks) were placed by fisheries local authorities, in some of these shallow soft grounds. Previous studies in the area have been focused in the effects of trawl exclusion in sensitive groups as elsmobranchs (Rodríguez-Cabello et al, in press). In the present study we analyze the shifts in a set of indicators time series aiming to detect fishing impact effects.

Methods

To estimate the effect of this management measure we analyse the autumn demersal survey time series (1983-2006) of the IEO. The study areas are: i) Llanes, where artificial reefs were deployed in 1993, ii) Calderón where reefs were placed in 2003). Shifts in abundance since the reefs deployment of some indicator species have been studied. Shifts in size-based indicators are also analysed (ICES, 2005; Greenstreet & Rogers, 2006).

Result

The main species profiting of the trawl exclusion are elasmobranches (dogfish and rays), sparids (sea breams), mullet, gurnards and great weever in both areas (Fig. 1). On the contrary, the main fishery target species (hake, monkfish, megrim, etc) have shown a progressive decrease in abundance during the whole period considered; decrease also shown by their respective stocks. Benthic indicator species have improved their abundance, specially urchins, cephalopods and gastropods (Fig. 2). Community structure change as a consequence of reefs settlement (Fig. 3). Increase in habitat complexity, measured as biomass of sessile-structural species has been reported. Shifts in size-based indicators is also analysed.

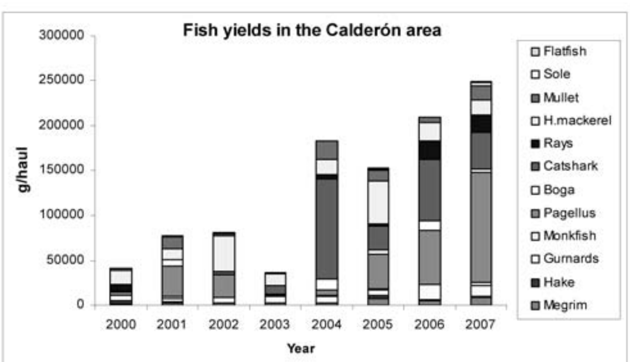

Figure 1. Fish yields in the Calderón area

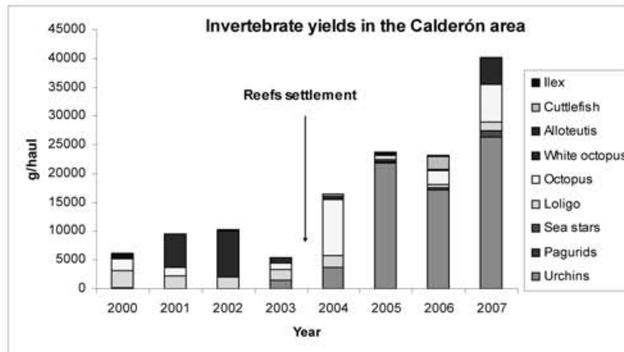

Figure 2. Invertebrate yields in the Calderón area.

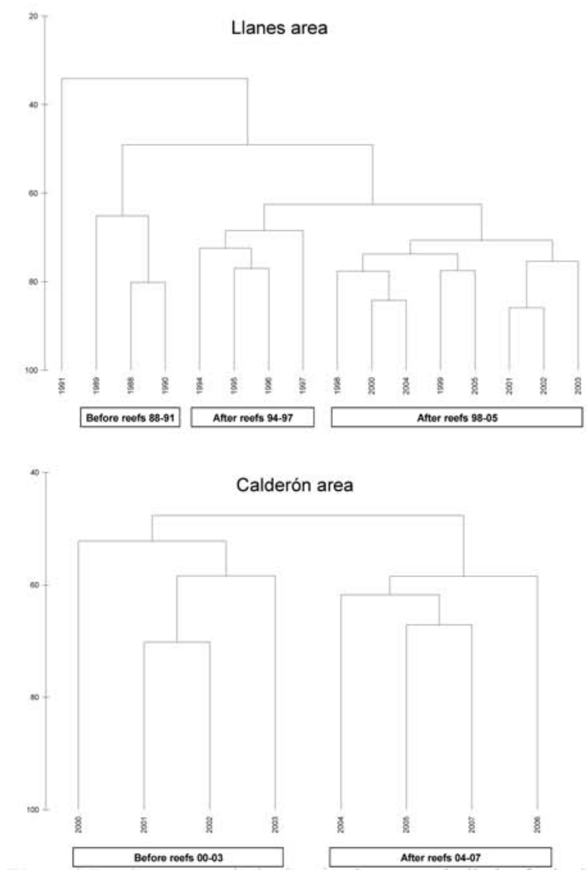

Figure 3. Dendrogram analysis showing interyear similarity for both areas.

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Discussion

Benefits of trawl exclusion are evident in sensitive species and therefore in an improvement of habitat complexity and ecosystem quality.

Acknowledgements

This study has been made possible thanks to the invaluable work of all the participants in the North of Spain bottom trawl surveys and the crew(s) of the RV "Cornide de Saavedra".

References

Rodríguez-Cabello, C., Sánchez, F., Serrano, A., Olaso, I.. Effects of closed trawl fishery areas on some elasmobranch species in the Cantabrian sea. *Journal of Marine Systems,* in press

ICES, 2005. Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO). *ICES ACE:04*, 146 p

Greenstreet, S., Rogers, S., 2006. Indicators of the health of the North Sea fish community: identifying reference levels for an ecosystem approach to management.. *I.C.E.S. Jour. Mar. Scien.,* 63: 573-593

Placing Bay of Biscay key trophic compartments in their fisheries context

Jérémy Lobry,*[a] François Le Loc'h[b] and Nathalie Niquil[c]

Introduction

The implementation of the Ecosystem Approach to Fisheries (EAF - FAO, 1995; 2003; Garcia et al., 2003) as well as the recent questioning about functioning and health of world's ecosystems (e.g. Convention on Biological Diversity: UN, 1992) put forward the imperative need to better understand processes linking community structure to ecosystem functioning (Pascual and Dunne, 2006). In order to maintain integrity of ecosystem functions and biological diversity, fisheries need to be placed in their ecosystem context in the way to measure and/or quantify their total impact on the whole ecosystem.

Measuring the influence of fisheries on Ecologically and/or Biologically Significant Species (EBSS - Rice, 2006) or key compartments and processes is, for instance, one of the tools prescribed for setting Ecosystem Objectives for Large Ocean Management Areas (LOMAs) by Fisheries and Oceans Canada (Koen-Alonso and Stenson, 2006).

The Bay of Biscay is of high commercial interest for fisheries. Numerous studies coordinated at the scale of the Bay of Biscay underlined the great influence of human activities (fisheries, industry, leisure activities…) on the structure and dynamics of exploited marine populations.

The main aim of this study is to use the results of a trophic model of the continental shelf ecosystem based on data from numerous French research programs (National Coastal Environment Program (PNEC) - Clavier et al., 2007, Ifremer Défi Gascogne) in order to identify main ecological processes, key trophic compartments and structuring interactions and to place Bay of Biscay fisheries in their ecosystem context.

Methods

The Ecopath modelling approach

By using a mass-balance, the Ecopath model (Polovina, 1984; Christensen and Pauly, 1992) quantifies the trophic flows in an ecosystem (i.e. a food web in a study area). The parameterisation of the Ecopath model is based on satisfying two 'master' equations. The first describes the production term for each compartment (ecological group) included in the system:

Production = fishery catch + predation mortality + net migration + biomass accumulation + other mortality

The 'other mortality' term includes natural mortality factors such as mortality due to old age, diseases, etc. The second equation expresses the principle of conservation of matter within a compartment:

Consumption = production + respiration + unassimilated food

Constructing and balancing the model

The system described in this study is the continental shelf part of the Bay of Biscay. The structure of the trophic network included 26 functional groups and a Fisheries compartment (Table 1). For each biological groups, only main species were taken into account. Data from various scientific surveys were used in order to estimate biomass and/or production data for most of the groups. Other biological parameters and diets were estimated using local studies and data from literature and ICES stock assessment reports.

Calculating total impacts and identifying key species

Both direct and indirect trophic interactions were assessed using the Mixed Trophic Impacts (MTI) approach which allows for the consideration of the total impacts of fisheries on the whole ecosystem. The index of keystoneness defined by Libralato et al. (2006) was used to identify key trophic species.

Results and discussion

The food web topology (figure 1) and keystoneness index values (table 1) underline the main role of primary producers and detrital organic matter (influenced by river inputs) in the trophic structure of the Bay of Biscay ecosystem. Among the other key compartments, we find functional groups at various trophic levels from highest predators (suprabenthivorous demersal fish such as blue whiting and small hake; mackerel) but also primary or secondary consumers. Most of the trophic compartments have a top-down effect upon the system. Thus, the food web seems predominantly structured by predation.

In this context, Fisheries has a strong impact on the food web. It utilises more than 30% of the total primary production and consequently a large proportion of the productive capacity of the shelf ecosystem. The level of fisheries impact is comparable to the Cantabrian Sea shelf ecosystem (Sanchez and Olaso, 2004).

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These results indicate that the Bay of Biscay is amongst the most intensively exploited continental shelves. The estimated total impact of fisheries on all the compartments is the second most important.

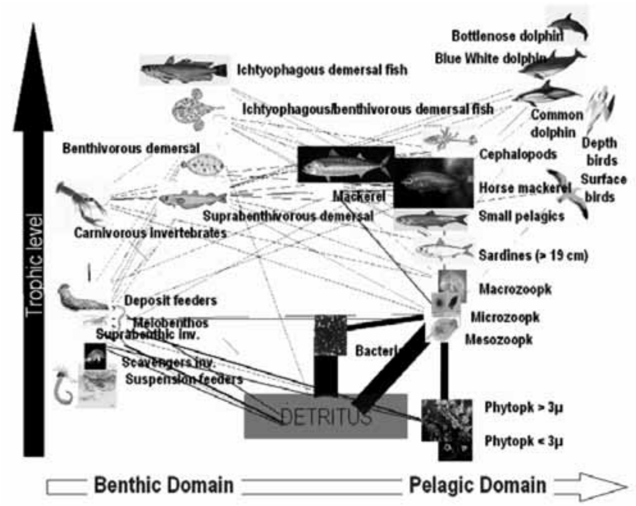

Figure 1. Flow diagram of the Bay of Biscay food web. Only the most important flows (arrows) are presented (>90% oft the total flow value). The width of each arrow is scaled to the trophic flow value.

Table 1. Trophic level (TL), total impact on the system (Impact), keystoneness index (Ksi) and top-down effect (Td) for each compartments of the trophic network.

Group.name	TL	Impact	Ksi	Td
Puirsuite birds	3.97	0.02	-4.14	93
Surface feeders birds	3.25	0.02	-3.99	98
Blue White dolphin	4.27	0.05	-3.01	61
Bottlenose dolphin	4.30	0.11	-2.22	75
Common dolphin	4.13	0.07	-2.67	95
Ichtyophageous demersal fishes	4.26	0.18	-1.74	87
Benthivorous and ichtyophageous demersal fishes	3.92	0.32	-1.15	75
Benthivorous demsersal fishes	3.39	0.33	-1.10	98
Suprabenthivorous demersal fishes	3.21	0.75	-0.34	70
Mackerel	3.31	0.56	-0.68	98
Horse mackerel	3.26	0.37	-1.08	79
Large sardine	2.76	0.32	-1.17	6
Small pelagic fishes	3.11	0.40	-0.95	11
cephalods	3.60	0.17	-1.79	53
Carnivorous benthic invertebrates	3.16	0.73	-0.34	97
Scavengers benthic invetebrates	2.00	0.04	-3.18	2
Sub-surface deposit feeders invertebrates	2.35	0.54	-0.66	97
Suspension feeders and surface deposit feeders inv	2.00	0.50	-0.74	26
Benthic meiofauna	2.00	0.25	-1.40	21
Suprabenthic invertebrates	2.11	0.32	-1.14	8
Macrozooplankton	2.45	0.28	-1.28	58
Mesozooplankton	2.11	0.80	-0.35	13
Microzooplankton	2.15	0.76	-0.46	88
Bacteria	2.00	0.11	-2.28	0
Large phytoplankton	1.00	1.13	0.01	2
Small phytoplankton	1.00	0.21	-1.58	47
Discards	-	0.24	-	-
Detritus	-	1.42	-	-
Fisheries	-	0.94	-	-

Conclusion

The results highlights that some key trophic compartments are highly exploited and that, consequently, some structuring trophic interactions of the ecosystem are highly impacted by fisheries.

Acknowledgements

We thank all the participants of the French PNEC programme on Bay of Biscay who provided data to *feed* the model.

References

Christensen, V. and Pauly, D., 1992. ECOPATH II - a software for balancing steady-state ecosystem models and calculating network characteristics. Ecological Modelling, 61:169-185.

Clavier, J., Joanny, M. and Carlotti, F., 2007. New developments in coastal environment research: results from the national coastal environment program Aquatic Living Resources, 20:1-2.

FAO, 1995. Code of Conduct for Responsible Fisheries, Rome, FAO.

FAO, 2003. The ecosystem approach to fisheries. FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2, FAO, Rome.

Garcia, S.M., Zerbi, A., Aliaume, C., Do Chi, T. and Lasserre, G., 2003. The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook No. 443, FAO Fisheries Technical Paper.

Koen-Alonso, M. and Stenson, G., 2006. Keystone species: definitions and related concepts in an applied context. In: J.C. Rice (Editor), Background Scientific Information for Candidate Criteria for Considering Species and Community Properties to be Ecologically Significant. Canadian Science Advisory Secretariat, Montreal, pp. 9-20.

Libralato, S., Christensen, V. and Pauly, D., 2006. A method for identifying keystone species in food web models. Ecological Modelling, 195:153-171.

Pascual, M. and Dunne, J.A. (Editors), 2006. Ecological Networks: Linking Structure to Dynamics in Food Webs. Oxford University Press, New York.

Polovina, J.J., 1984. Model of a coral reef ecosystem. The Ecopath model and its application to French Frigate Shoals. Coral Reefs, 3:1-11.

Rice, J.C. (Editor) 2006. Background Scientific Information for Candidate Criteria for Considering Species and Community Properties to be Ecologically Significant. Canadian Science Advisory Secretariat, Montreal, 82 p.

Sanchez, F. and Olaso, I., 2004. Effects of fisheries on the Cantabrian Sea shelf ecosystem. Ecological Modelling, 172:151-174.

UN, 1992. Convention on Biological Diversity, Rio de Janeiro.

Comportamiento de la angula (*Anguilla anguilla*) durante la migración estuarica en el rio Oria

Jaime Castellanos,*[a] Estibaliz Diaz [a]

Introduccion

La población de anguila europea (*Anguilla anguilla*) está en franca situación de declive y calificada como vulnerable en el "Libro Rojo de Vertebrados". Por esta razón, la Comisión Europea el 18 de septiembre de 2007 estableció el Reglamento (Ce) No 1100/2007 del Consejo por el que se establecen medidas para la recuperación de la población de anguila europea. Para poder tomar las medidas de una manera adecuada, es necesario ampliar el conocimiento de la biología de la especie. Una de las fases mas críticas de esta especie es la migracion estuarica, por lo que el reclutamiento y el comportamiento migratorio de de esta fase resultan espceialmente interesantes. Para ello se han realizado 10 muestreos experimentales en el estuario del Oria entre octubre de 2005 y marzo de 2006.

Material y métodos

Las pescas experimentales se llevaron a cabo empleando cedazos, el arte utilizado por los pescadores de embarcación del Oria. Se realizarón arrastres en dos puntos del estuario, desembocadura (200 metros de arrastre) y en la parte media a 4,5km de la desembocadura (400 metros de arrastre), con dos cedazos uno situado a profundidad maxima y otro en superficie. A cada cedazo se le instalaron 2 flujometros uno exterior y otro interior.

En el punto inicial del transepto, y depués cada dos arrastres, se midió cada metro la salinidad y la temperatura mediante la miniCTD.

Depués de cada arrastre se midió la velocidad media, la distancia recorrida, el tiempo empleado y el número de vueltas de los flujometros, para determinar el volumen de agua filtrado y la corriente tanto en el fondo como en la superficie.

Las angulas obtenidas en cada cedazo y cada arrastre fueron almacenadas de forma independiente.

Los muestreos comezaron cinco horas antes de la última pleamar nocturna en la desembocadura. Cuando tras alcanzar los valores máximos de capturas, las capturas comenzaban a descender, se pasaba a realizar los muestreos en la parte media del estuario siguiendo el mismo protocolo.

Las angulas obtenidas fueron procesadas posteriormente en el laboratorio, donde se tallaron y pesaron y se determinó el estadio pigmentario (Elie *y cols.,* 1982).

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Resultados y discusion

Los valores de salinidad, indican que existe una fuerte estratificación en la ría del Oria y que el frente mareal entra por el fondo (Figura 1). Por otro lado, la coincidencia del incremento en las CPUES (capturas por unidad de esfuerzo) con el incremento de la salinidad en profundidad, indica que las angulas comienzan a entrar aprovechando el frente mareal y por tanto por el fondo en la ría del Oria.

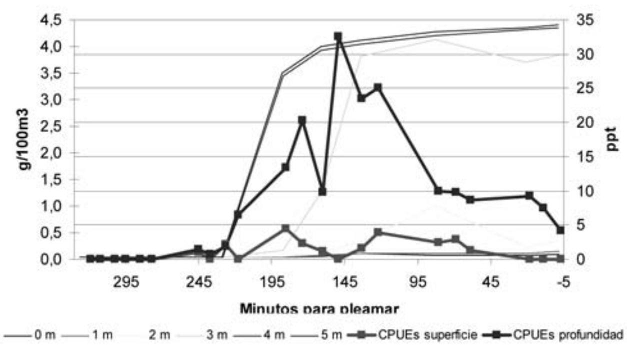

Figure 1. Capturas por unidad de esfuerzo en superficie y profundidad frente a salinidad en la columna de agua. Muestreo en la desembocadura el 31/11/05

En la parte media del estuario las diferencias entre CPUEs de superficie y fondo son menores que en la desembocadura cuando aún no ha llegado el frente mareal, y prácticamente desaparecen cuando a causa de la llegada del frente mareal, a menos de 150 minutos para alcanzar la pleamar aparece la estratificación de las aguas (Figura 2).

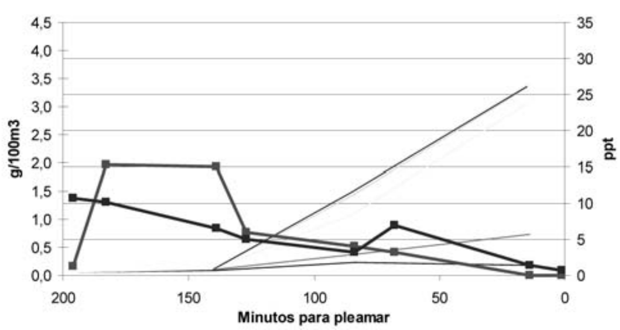

Figure 2. Capturas por unidad de esfuerzo en superficie y profundidad frente a salinidad en la columna de agua. Muestreo en la parte media del estuario el 27/02/06

Las CPUEs tanto en la desembocadura como en la parte media del estuario, se incrementan cuando la corriente alcanza valores de entre 0.65 y 0.7 m/s (Figuras. 3 y 4). Al llegar al valor máximo de corriente mareales ascendente se alcanza igualmente el máximo en las capturas de angula. En la parte media del estuario, al inicio de los muestreos la corriente y las

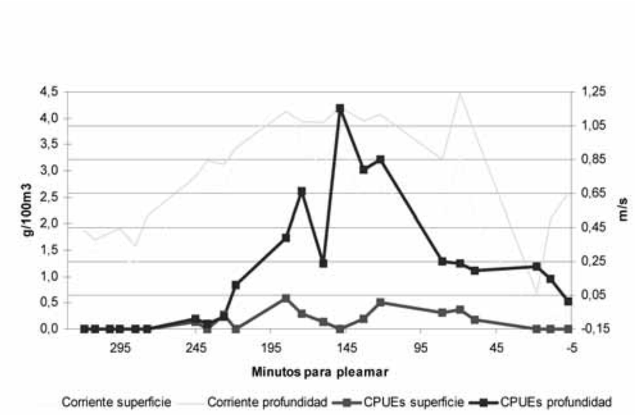

Figure 3. Capturas por unidad de esfuerzo en superficie y profundidad frente a corriente en superficie y profundidad. Muestreo en la desembocadura el 31/11/0

CPUEs son mayores que en el fondo. Sin embargo, al entrar el frente salino, cuando faltan menos de 150 minutos para alcanzar la pleamar (Figura 2), la corriente en profundidad aumenta y se incrementan las CPUEs en profundidad igualandose con las de supeficie.

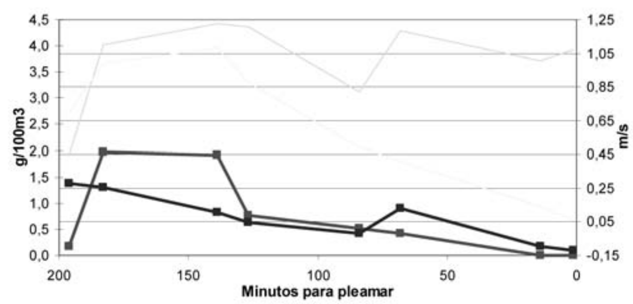

Figure 4. Capturas por unidad de esfuerzo en superficie y profundidad frente a corriente en superficie y profundidad. Muestreo en la parte media del estuario el 27/02/06

Respecto al comportamiento migratorio, durante la temporada de pesca se observan incrementos muy notables del porcentaje de las fases pigmentarias menos desarrolladas (VA y VB) en ambos puntos por lo que son el reflejo de la entrada de angulas en el estuario (Figura 5). Estos picos, coinciden con la luna nueva, cuando la amplitud de la marea es mayor y por otro lado existe menor luminosidad, característica que favorece a las angulas que son fotófobas. Por otro lado, el porcentaje de estadios avanzados en la desembocadura es bajo, indicando que las angulas tienden a migrar aguas arriba tan pronto como entran en el estuario. Sin embargo, en el punto intermedio, se pueden observar tanto fases tempranas como más desarrolladas, señalando que una vez alcanzado este punto, las angulas permanecen en el mismo tramo hasta realizar la migración fluvial. De esta manera, en el punto intermedio, al ser el porcentaje de las fases avanzadas mayor, el incremento porcentual de las fases menos desarrolladas, sólo es apreciable cuando la entrada de angulas en el estuario es muy notable.

Conclusiones

Las angulas entran en el estuario por el fondo aprovechando las corrientes ascendentes producidas por el frente mareal y coincidiendo con los días de luna nueva por la mayor amplitud de marea y su carácter fotófobo.

Al descender las corrientes maréales las angulas permanecen en el estuario sin migrar y retoman la migración cuando las corrientes en la parte media del estuario alcanzan valores de 0.65 m/s.

Agradecimientos

Ignacio Renteria, I. Onaindia, A. Arrate y J. Martinez por sufrir los duros y fríos muestreos experimentales.

References

Elie, P. Lacomte-Finiger, R., Cantrelle, Z., N. Charlon 1982. Definition des differents stades pigmentaires durant la phase civelle d'Anguilla anguilla. Vie Milieu. 32 : 149-157.

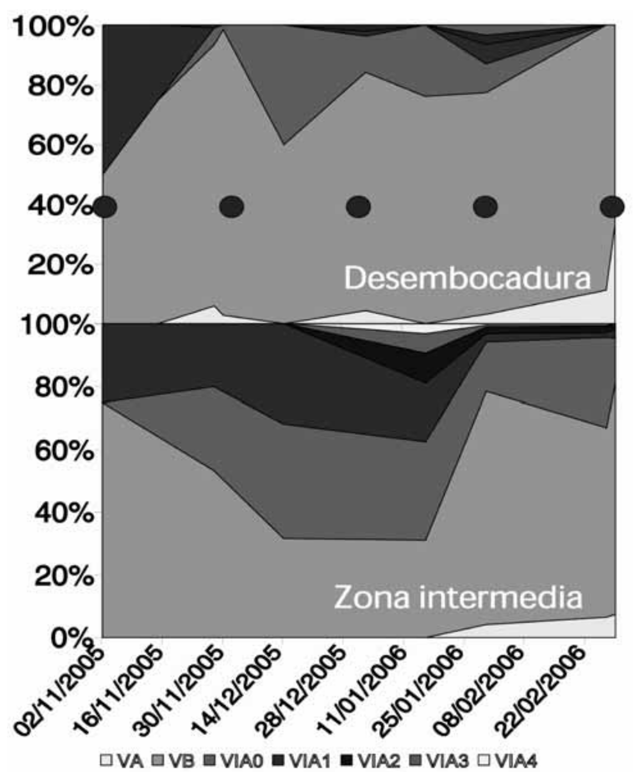

Figure 5. Porcentaje de los niveles de pigmentacion de las angulas capturadas en la desembocadura durante la temporada 05 / 06.

Basque trawl metier consistency among years 2003-2007

Ane Iriondo,[a,b] Raúl Prellezo[a] , Marina Santurtún, Dorleta García[a] and Iñaki Quincoces[a]

Fisheries data collection, advice and management have traditionally been based on stock by stock analysis. However this approach has long been recognized as inadequate, particularly when applied to mixed fisheries. In the new Data Collection Regulation (DCR, EC 2006, 1543/2000) the process of moving towards a fishery-based data collection system is followed. Therefore, tha aim of this paper is to define Basque trawl metier in which the the new regulation for data collection is based.

Based on trip by trip catch data profile, Principal Component Analysis (PCA) and Cluster analysis approach are used to obtain homogeneous groups of trips/vessels and to characterize them taken into account target species, fishing area, gear and period of the year. In this paper, the approach described in Prellezo et al. (2004) is used for defining Basque trawl fisheries using 2003-2007 data series. The objective is to explore if metier definition obtained using PCA and Cluster analysis is consistent along years and sensitve to the supected changes in metiers ocurred in the last years of the series.

Introduction

Under the new DCR, fishery-related data should be collected by type of fishing activity or métier and population-related data by stock.

The firs step is to define the different approaches for the fishing unit. ICES (International Council for the Exploration of the Sea) considers three types of fishing units: the fleet, the fishery and the métier (ICES, 2003). A fleet is a physical group of vessels sharing similar characteristics in tems of tehcnical features and/or major activity. Finally, a métier is a homogeneous sub-division, either of a fishery by vessel type, or of a fleet by voyage type. Two out of the three fishing units defined are sufficient to fully categorize both fishing vessels and fishing trips.

To agregate the information to a métier group, multivariate approaches are able to provide reduced descriptions of large data sets. In that sense it is a helpful tool when describing fleets by each fishing trip done by each individual vessel along the year.

Furthermore, multivariate approaches as the principal component analysis (PCA) and the cluster analysis, are able to provide linear factors that accumulate the mayor part of the variance of the data (PCA) and that classify vessels into homogeneous groups (cluster analysis).

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Following this idea, the literature provides examples of using these procedures in order to obtain and classify fisheries (Biseau and Gondeaux (1988) and Laurec *et al*. (1991), Murawski *et al*. (1983) and Lewy and Vinther (1994)).

In this document PCA and Cluster analysis combined are used. Using PCA the number of variables of the series are reduced obtaining what could be called as the "main face" of the data. Using these principal components, clusters of homogeneous trips are generated and characterized in order to obtain fisheries. Even if the main objective of the paper can be summarized as defining fisheries, the idea is to focus it in a dynamic way (taking time –year- into consideration).

The analysis is focused on the trawl fishing fleet of the Basque Country operating in ICES Division VIIIa,b,d & Subareas VI & VII (Fig. 1). Specifically, the three main characteristics of the fleet are:

-The gear classess are Otter bottom trawlers ("Baka"), and Bottom Pair trawlers operating with Very High Vertical Opening nets (VHVO)

-The base fishing ports are Ondarroa and Pasaia .

-Fishing areas are ICES Div. VIIIa,b,d and Subareas VI & VII.

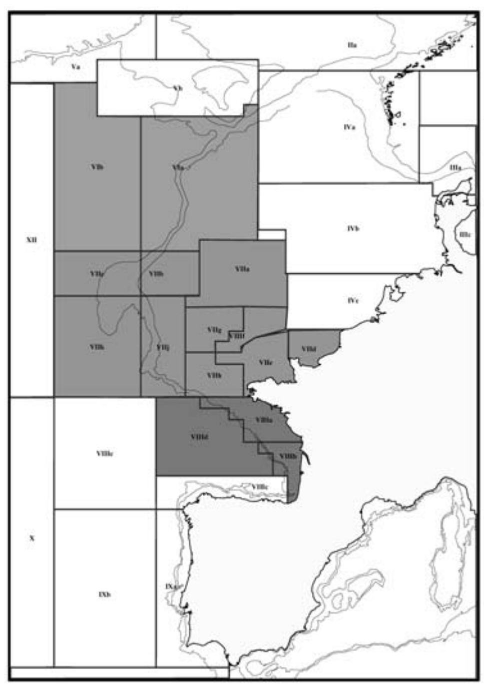

Figure 1. Basque trawl fihing areas.

Material and methods

Trip by trip data obtained from selling sheets, including species landed, fishing area, fishing days and vessels characteristics from year 2003 to 2007 were used in the analysis. The specific variables included are: the base harbour of the vessel, the gear used (Otter trawl or Bottom Pair trawl), landings by species per trip and the landing date.

The main objective of this work is to explore if the métier defined using the approach defined in Prellezo et. al (2004) is consistent year by year, i.e, if the métier definition obtained using this approach is independent of the year specific data. Also, the aim is to check whether this analysis is able to detect the ligth changes in metiers detected, qualitatively, in the last years.

A principal component analysis (PCA) is carried out in order to obtain a reduced description of the large data set used and to analyze the relationships between the variables. In a second step, a cluster analysis is performed on the principal components extracted. The main objective is to group homogeneous trips and to characterize them using the explanatory variables.

Results

As preliminar results for year 2005 analysis (Garcia et al., 2006), six are the groups obtained form this cluster analysis (see Table 1). The groups obtained can be characterized in terms of the size of the cluster (in number of trips) the target species (one if there is a single species fishery or two or more if there is a mixed fishery), fishing area, gear of the vessel, the typical time allocation (in order to see if we are facing a seasonal fishery) and the reliability of the cluster.

Table 1. Example of fisheries characterization

Cluster	Fishery	Gear	Ports	Area	Species	Quarter	Trips %	Reliability
1	**1.1**	Pair VHVO	Ondarroa	VIIIabd	Hake	All	34%	90%
	1.2	Pair VHVO	Pasaia	VIIIabd				
2	**2**	Baca	Ondarroa	VIIIabd	Hake	All	23%	92%
					Mackerel			
3	**3**	Baca	Ondarroa	VIIIabd	R. Mullets	4	6%	75%
					Pout			
					Squid			
4	**4**	Baca	Ondarroa	VIIIabd	H. Mackerel	1	17%	51%
					Pout			
5	**5**	Baca	Ondarroa	VII	Megrim	All	13%	53%
					Anglerfish			
					Hake			
6	**6**	Baca	Ondarroa	VI	Hake	All	7%	87%
					Anglerfish			
					Blue Ling			

The interpretation of the results can be as follows:

Fishery 1: “Typical” single species fishery targeting hake accounting for the 34% of the total trips. Performed in Divisions VIIIabd and composed only by trips made by VHVO bottom pair trawler.

Fishery 2: A mixed fishery, but with Hake as a preferred species). It accounts for the 23% of all the trips of the sample. Performed in Divisions VIIIabd, it is composed specially by trips made by “Baka” otter trawlers but also by a few trips made by VHVO bottom pair trawler. It can be divided in multiple sub-fisheries depending on the species accompanying hake, or the quarter when trips are performed.

Fishery 3 and Fishery 4: Both are pure mixed fisheries, accounting for the 6% and 17% of the total trips. Performed in Divisions VIIIabd and composed only by trips made by “Baka” otter trawlers. The difference between them is the species composition and the seasonality, which is not completely clear.

Fishery 5: “Typical” pure mixed fishery accounting for the 13% of the total trips. Performed in sub-area VII and composed only by trips made by “baka” otter trawlers. Based on Megrim, Anglerfish and Hake (even if there are other species in their landing compositions).

Fishery 6: Pure mixed fishery with Hake as predominant species and a large number of other species, performed in sub-area VI and composed only by trips made by “baka” otter trawlers.

References

Castro J., Rasero M. and Punzón A. (2004). A preliminary identification of fisheries for the Spanish trawl fleets in the European Southern Shelf. Working Document presented in the ICES SGDFF

Garcia et al (2006). Definition of the year 2005 Basque trawl fisheries. Working Document presented in the Working Group for the assessment of Hake, Megrim and Monkfish, Bilbao, 2006.

ICES (2003). Report of the study group on the development of fishery-based forecasts. Boulogne, France, ICES: 37.

Prellezo R., Lazkano I., Santurtún M., Lucio P., Iriondo A., and Quincoces I. (2004). The use of catch profiles for defining the Basque trawl fisheries from 1996 onwards. Poster presented at the ICES Annual Science Conference. Vigo, 2004.

Prellezo R., Lazkano I., Castro J., Punzón A., Santurtún M., Lucio P. and Iriondo A. (2005). The use of catch profiles for defining the Spanish North Eastern Atlantic trawl fisheries. Working Document presented in the Working Group for the assessment of Hake, Megrim and Monkfish, Lisbon, 2005.

Rogers, J. B. and E. K. Pikitch (1992). Numerical definition of groundfish assemblages caught off the coasts of Oregon and Washington using commercial fishing strategies. Canadian Journal of Fisheries and Aquatic Science 49: 2648-2656.

Ward, J.H. (1963). Hierarchical grouping to optimize an objective function. Journal of American Statistical Association. 58: 236-244.

The use of Fcube as the method for managing mixed fisheries in the Bay of Biscay

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Fisheries advice and management have traditionally been based on stock by stock analysis and TAC and Quota systems. However, this approach has been recognized as inadequate, particularly when applied to mixed fisheries because of inconsistencies between TACs of species caught in the same fishery resulting in discards and unreported catches. For that reason, alternative management methods for managing mixed fisheries are being developed and examined.

Only one, the Fleet and Fisheries Forecast (Fcube) method, is supported by ICES at the moment, whose development is being carried out under the AFRAME project Its original algorithm was developed at DIFRES within the larger development of the multifleet multi-species bioeconomic simulation framework TEMAS (DIFRES, unpublished; Marchal et al, 2006), In this method, forecast of stocks and metier dynamics are performed in order to evaluate the consequences of different management scenarios. The basis of the method is to predict effort levels by fleet corresponding to the set of single-species Total Allowable Catch (TAC), based on fleet effort distribution by fishery. This level of effort is finally used to forecast landings and unallocated catches by metier and stock. The baseline assumption is that the effort have a linear relationship to the fishing mortality and that metier's catchability is constant in time.

In this paper, the application of the Fcube method to the fisheries defined during the EC Fleet-Fishing Activity Working Group (Nantes, 2006) and the data collected under the European Data Collection Regulation (EC 2006, 1543/2000) is tested for feasibility. The stocks considered in this exercise were those demersal assessed stocks of the Southern Shelf (ICES Subarea VII and Div. VIIIabd). The results appear to confirm Fcube as a useful method for managing mixed fisheries providing the improvement proposed related to include species with no TACs and Quotas, other than linear relationships between effort and fishing mortality and economic issues.

References

Marchal et al. (2006) Technological developments and tactical adaptations of important EU fleets (TECTAC). Final report of the EU project no. Q5RS-2002-01291, 652 pp.

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Application of the double disector method to investigate the seasonal variation of oocyte density in European hake (*Merluccius merluccius*, L.)

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Introduction

The estimation of fish individual reproductive investment relays on the number of oocytes that are present in the ovary. Inaccuracy when counting small or atretic oocytes may significantly underestimate the appraisal of fecundity; which, in turn, influences the estimation of stock reproductive potential.

European hake exhibits an asynchronous ovarian development; where the ovary contains a significant size range among co-dominant oocytes populations at different maturity stages. Reproductive potential of this fish specie is not fixed prior to the spawning season and the continuous oocyte development difficults the estimation of oocyte distribution/density using traditional methods (Murua et al., 2003).

The double disector technique allows unbiased and precise estimation of the total number of particles, in this case oocytes, within a known reference volume, the ovary (Gundersen, 1986; Marcussen, 1992). It does not requiere the secction thickness to be known and estimates unbiasedly the ratio of "small oocytes" to "big oocytes".

The main objective of this study is to demonstrate the usefulness of the double-dissector method to estimate the number of oocytes in European hake ovaries and to investigate the seasonal variation of pre-vitellogenic (>35μm) and vitellogenic oocytes (> 350 μm) during hake spawning season in the Bay of Biscay.

Methods

Formalin (3.6%) fixed ovaries from mature European hake were used in this study (Fig.1-A, B). Only one of the two lobes of each ovary was embedded in agar (7%) and then it was systematically sectioned in parallel slabs (2·5mm in width), starting at random in an interval of 0-2·5mm (Fig.1-C). Cavalieri method (Cavalieri, 1635; Gundersen and Jensen, 1987; Howard and Reed, 1998) was used to estimate the volume (Fig.1-D). Five slices were chosen from each lobe by uniform random sampling for further histologically processing.

A ribbon of 4μm sections, first section and the pair for each of the oocyte population, were collected from each block (Fig.1-E). The first and last sections from the ribbon were used as a "large disector" to estimate the numerical density of largest oocytes. In the same way, first and adjacent sections were used to estimate the number of smallest oocyte populations. Six different oocyte populations were chosen: *Chromatin nucleolar, Perinucleolar, Pre-Cortical alveoli, Cortical alveoli, Early vitellogenic and Advanced vitellogenic*.

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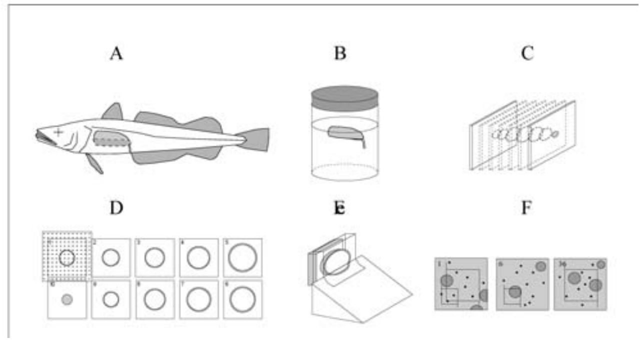

Figure 1. (A) Ovary in a hake; (B) formaldehyde fixed ovary; (C) slabs cut from lobe embedded in agar; (D) Cavalieri volume estimation; (E) sectioning histologically processed tissue; (F) Counting fields on sections pairs. (Adapted from Dorph-Petersen et al., 2001)

A counting field (Fig.1-F) was placed randomly onto the first sections (reference planes) and section pairs (look up planes) of the different oocyte populations.

The volume fraction ($V_{v;i}$) and the numerical density ($N_{v;i}$) of each oocyte class were estimated applying the "counting rules": on the reference sections, only the number of points hitting oocyte profiles were counted (P_i). On the other hand, all oocyte profile showing the nucleus in the reference section, and not in the look-up field, was counted ($Q_{i;1}$). The same operation of estimation of ($Q_{i;2}$) was then performed by sampling on the field of each second section and using the first field as look up field.

Results and Discussion

Advanced oocytes occupied 58% of the volume of the ovary while the volume of immature oocytes did not exceed 5% in any of the consecutive developmental stages.

The estimates of numerical density obtained with the double disector method ranged from 180.000 advanced vitellogenic oocytes (550 μm) to 27.000.000 smallest immature oocytes (> 35 μm).

The average coefficient error of volume and number estimates (CE(V), CE(Q^-)) was around 0·10 which was deemed precise.

The estimation of total number of oocytes indicated the potential fecundity stored in the ovary. Pre-cortical alveoli and cortical alveoli oocytes together was found to be 10 times more than the amount of advanced oocytes, which could be considered the total number of oocytes for the next batch. This pointed out that up to 10 potential batches were at least kept in the ovary at a time.

The sum of smallest oocytes counted was a hundred times higher than the mature oocytes that may constitute a batch;

which gave an idea of the stock of reservoir oocytes this specie has for further spawning seasons.

In a next step, this study will clarify the seasonal variability of the reservoir oocytes stock and their recruitment into advanced oocytes.

Acknowledgements

The study has been carried out with financial support from from European Commision (QLRT-2001-01825 “RASER”) and from a Ph.D fellowship of the Department of Agriculture and Fisheries of Basque Country Government. The authors are grateful to Carlos Avendaño from Universidad Autónoma de Madrid who helped us to carry out the work.

References

Dorph-Petersen, K.A., Nyengaard, J.R., and Gundersen, J.G. 2001. Tissue shrinkage and unbiased stereological estimation of particle number and size. J. Microsc. 204, 232-246.

Gundersen, H.J.G. 1986. Stereology of arbitrary particles. A review of unbiased number and size estimators and the presentation of some new ones, in the memory of William R. Thompson. J. of Microsc. 143, 3-45.

Gundersen, H.J.G., and Jensen, E.B. 1987. The efficiency of systematic sampling in stereology and its prediction. J. of Microsc. 147, 229-263.

Howard, CV and Reed, MG. Unbiased Stereology. Three-dimensional Measurement in Microscopy, Oxford: BIOS Scientific Publ., 1998.

Marcussen, N. 1992. The double disector: unbiased stereological estimation of the number of particles inside other particles. J. Microsc. 165, 417-426.

Murua, H., Kraus, G., Saborido-Rey, F. Witthames, P.R., Thorsen, A. and S. Junquera. 2003. Procedures to estimate fecundity of European Hake Merluccius merluccius (L.) in the Bay of Biscay. J. Northw. Atl. Fish. Sci, 33, 33-54.

Fishery-based sampling: implementation test on the Spanish Bottom Trawl Fleet (ICES area).

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Introduction

The effective management of ecosystems requires knowledge of how they function and the ability to predict their productive capacity and the consequences of management actions with some degree of reliability. Data collection programmes must develop a new sampling procedure in order to provide this information. It is necessary to change traditional systems of management, which have tended to focus on individual stocks or species to a metier-based market sampling.

In the PGCCDBS of ICES held in Malta in 2007, Portugal presented the results of a concurrent sampling attempting to simulate the new metier sampling strategy, taking as an example the sampling of three metiers over two months in the harbour of Matosinhos. In view of the results obtained, the European Commission decided to finance analogical experiments in other countries.

Spain will carry out 3 concurrent samplings: two in the ICES area and another in the Mediterranean. Of the two in the ICES area, one will be carried out by the IEO and the other by AZTI.

The IEO's concurrent sampling in the ICES area is been carried out from november 26th to december 21th,2007.

Objectives

Identification of the strategic and technical problems in the implementation of the new metier based sampling system proposed by the new Regulation on European Fishing Data Collection.

Methods

Two ports have been chosen for this concurrent sampling, A Coruña and Santa Eugenia de Ribeira, which between them present most of the difficulties that might be expected at ports in the ICES area. In the case of the metiers, those with the greatest degree of complexity have been selected, which are mixed bottom trawl in A Coruña and Santa Eugenia de Ribeira and bottom trawl targeting horse mackerel in Santa Eugenia de Ribeira only. Sampling more than one metier is considered to be of interest in order to meet with different kinds of problems. The identification of metiers used was that resulting from the fleet segmentation performed in the IBERMIX project (Castro et al., 2007).

Sampling consisted of the following:

- Selection of fishing trips to sample
- Sampling of the landing:

Length sampling. In each fishing trip sampled the priority list of species to sample is:

Group 1. - Species in a recovery plan and target species (according to the metier).

Group 2. - Species with TAC and quota and important species by weight landed.

Group 3. - Other species.

The results of this concurrent sampling will be used to choose a suitable sampling scenario for the metier in question.

Results

Schematic representation of the results for the concurrent sampling.

Discussion

Several problems are foreseen in connection with the required changes in sampling scheme. One of the problems is associated with the difficulty in tracking the origin (vessel/fishing trip) of the samples collected during market sampling. This is not a new problem but is likely to become critical in the new sampling framework and has to be resolved if we are to perform the sampling in accordance with the new DCR. Another group of problems may be related to the physical access to the fish to obtain the samples required. The first group of problems can only be resolved if certain improvements in the handling procedure at the market can be made, while the other group probably needs restructuring of the sampling procedures and schemes.

All these issues will be dealt with when the experiment ends.

References

Castro, J., Cardador, F., Santurtún, M., Punzón, A., Quincoces, I., Silva, C., Duarte, R., Murta, A., Silva, L., Abad, E. and Marín, M., 2007. Proposal of fleet segmentation for the Spanish and Portuguese fleets operating in the Atlantic national waters. Working paper to Working Group on the Assessment of Hake, Monk and Megrim (2007), *ICES CM: 2007* / ACFM: 21

DCR: http://datacollection.jrc.cec.eu.int/regulations.php

Feijó, D., Gonçalves, M., Jardim, E., 2007. Fishery-based sampling: implementation test on the Portuguese Trawl Fleet operating off Matosinhos, Portugal. *Working Document to the 2007 ICES Planning Group on Commercial Catch, Discards and Biological Sampling* (PGCCDBS) (26 Feb.-2 March)

PGCCDBS 2007. Report of the planning group on commercial catch, discards and biological sampling. 5-9 March 2007. Valetta, Malta.

SGRN, 2006.. Revision of the Biological Data Requirements under the Data Collection Regulation. SGRN 06-03 Brussels, 27 November-1December 2006.

SGRN: http://stecf.jrc.cec.eu.int/events_list.php?sg=SGRN&y=&pl=&o=ASC

Hernández, C., Punzón, A. and Pereda, P. 2007. Effects of the ecosystem approach on the analysis of fishing activity: Samplings, statistics and procedures.ICESCM2007/R:09

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Spatial distribution and biology of commercial cephalopods off Galician and Cantabrian shelf

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Introduction

Studies on cephalopods spatial distribution patterns in the Galician and Cantabrian continental shelf are scarce. A large bottom-trawling fleet operates in these waters. Although the target species are several valuable fish and *Nephrops norvegicus*, cephalopod species are also caught (Fariña *et al*., 1997, Sánchez and Olaso, 2004). These species of Decapoda and Octopoda represent an important group in fishing landings of trawl fleet in the area and constitute an important economic resource.

Rasero *et al.* (1996) studied the size distribution and stomach contents of *Todaropsis eblanae* and *Illex coindetii* from commercial landings and González *et al.* (1994) presented some biological aspects of these species. Both studies were focused only on Galician waters.

In the present paper, the faunal composition, abundance and bathymetric distribution of the commercial cephalopod exploited by bottom trawlers are described for Galician and Cantabrian shelf. In addition, biological data on length distribution, sex ratio and maturity are given.

Methods

The study area includes the Galician and Cantabrian continental shelf and shelf break between 70 m and 500 m depth. Data used herein derive from IEO scientific survey ‘Demersales 2007’ carried out on board of the oceanographic vessel “Cornide de Saavedra”. Sampling was undertaken with a standard “baca” otter trawl in a randomly stratified scheme by depth with following strata: A, 70-120; B, 121-200; C, 201-500 m. There were also some special hauls in depths lower than 70 m (strata X) and others in depths higher than 500 m (strata D). A total of 127 standardized hauls of 30 minutes long were carried out during the survey in autumn of 2007. Details on the sampling gear, survey design and information collected are described by Sánchez and Serrano (2003).

All specimens of *Sepia officinalis, Loligo vulgaris, Illex coindetii, Todaropsis ebalanae, Todarodes sagittatus, Octopus vulgaris* and *Eledone cirrhosa* were used for biological sampling. Specimens were weighted (to nearest gr.) and measured the mantle length (ML) to the nearest mm. (Octopus: mantle length to the eye; other species: total mantle length) following Clyde et al, (1983). All sex determination was made by internal examination and ligula presence and maturity stage was determined.

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Results and Discussion

All specimens were caught by demersal trawling over sandy-muddy bottoms on the continental shelf. As Table 1 shows, 18 species of cephalopods were obtained, being *E. cirrhosa* the most abundant in weight, followed by *O. vulgaris* and *Alloteuthis sp*. Spatial distribution and number of individuals by haul of commercial species (Figure 1) show spatial patterns related to depth and geographical areas. *E. cirrhosa* was mainly distributed in South Galicia waters while *T. eblanae* was most abundant in North and North western Galician waters. *I. coindetii* and *L. vulgaris* were more abundant in Cantabrian Sea. *T. sagittatus*, *S. officinalis* and *O. vulgaris* presented a bathymetric segregation, being a typical deep hauls species the first one and the others two species of shallower waters

Length distributions of species with a number of sampled individuals greater than 100 are presented in Figure 2.

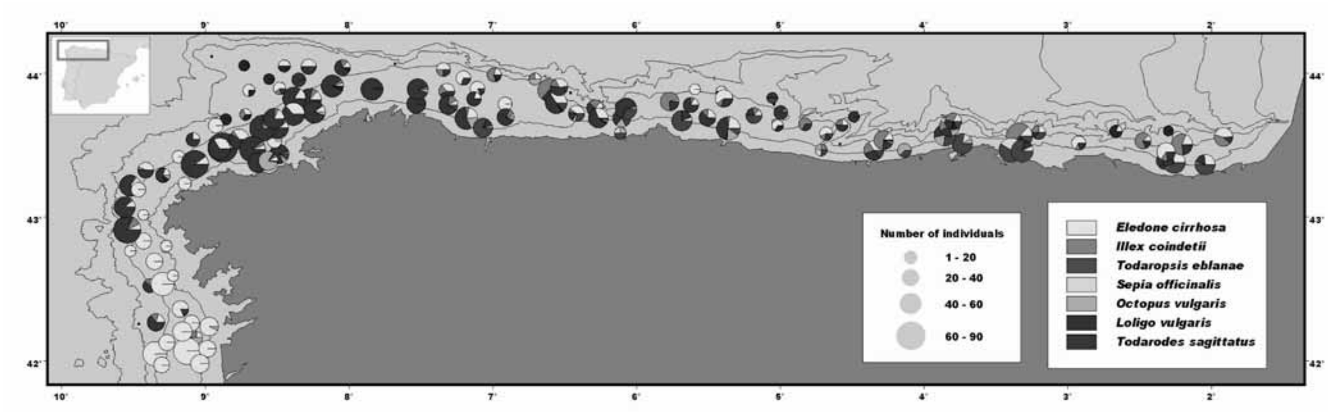

Figure 1 Spatial distribution of commercial cephalopods.

Table 1 Total weight of cephalopods caught in the survey and weight by depth strata

	Total weight (gr)	<70 m	70-120 m	120-200 m	200-500 m	>500 m
Eledone cirrhosa	141081		23330	91015	26736	
Octopus vulgaris	97885	8175	58965	30745		
Alloteuthis sp.	88546	995	58130	29021	400	
Todaropsis eblanae	52161		10420	31611	10090	40
Loligo vulgaris	48150	10690	11830	16095	9535	
Illex coindetii	24132		2690	16677	4765	
Opistoteuthis agassizii	13705					13705
Todarodes sagittatus	12040		870	1460	7890	1820
Sepia officinalis	7350	6525	825			
Rossia macrosoma	5328			1233	4045	50
Loligo forbesi	4805			4115	690	
Octopus salutii	4495			3355	1140	
Sepietta oweniana	1761		17	412	1332	
Sepia elegans	1727		662	1033	32	
Bathypolipus sponsalis	635				335	300
Sepiola sp.	320	5	43	229	41	2
Rondeletiola minor	274		17	139	118	
Sepia orbignyana	98		30	68		

A total of 808 individuals of *E. cirrhosa*, 269 of *I. coindetii*, 1196 of *T. eblanae* and 263 of *L. vulgaris* were analysed. *E. cirrhosa* length ranged from 2.0 to 13.8 cm. *I. coindetii* ranged from 5.6 to 25.8 cm, *T. eblanae* from 2.5 to 22 cm and *L. vulgaris* from 4.1 to 34.2 cm. *E. cirrhosa* and *L. vulgaris* showed two separated groups, one first group made up of immature individuals and a second group of males and females. *E. cirrhosa* males and females had similar length distributions while males of *L. vulgaris* were more abundant at smaller length than females.

In *I. coindetii* and *T. eblanae*, these groups were not clearly represented.

Sex ratios of the four species were near to 1:1, especially in *E. cirrhosa* and *T. eblanae* (Figure 3).

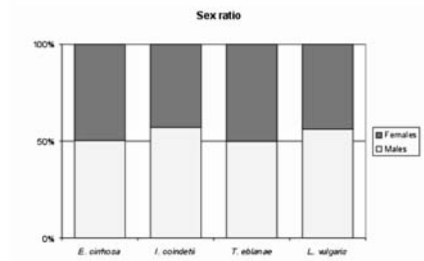

Figure 2 Length distributions of *Eledone cirrhosa*, *Illex coindetii*, *Todaropsis ebalanae*, and *Loligo vulgaris* by sex.

Acknowledgements

This study was developed in the framework of the IEO project-ERDEM. We are grateful to the crew of the RV Cornide de Saavedra and the scientific participants in the "Demersales 2007" survey.

References

Clyde, F.E., E. Roper, G.L. Voss, 1983. Guidelines for taxonomic descriptions of cephalopod species. *Memoirs of the National Museum Victoria*, 44: 49-63.

Fariña, A.C., J. Freire, E. González-Gurriarán, 1997. Megabenthic decapod crustacean assemblages on the Galician continental shelf and upper slope (north-west Spain). *Marine Biology*, 127:419-434.

González, A. F., M. Rasero, A. Guerra, 1992. Preliminary study of *Illex coindetii* and *Todaropsis eblanae* (Cephalopoda: Ommastrephidae) in northern Spanish Atlantic waters. *Fisheries Research*, 21: 115-126.

Rasero, M., A.F. González, B.G. Castro, A. Guerra, 1996. Predatory relationship of two sympatric squid, *Todaropsis eblanae* and *Illex coindetii* (Cephalopoda: Ommastrephidae) in Galician waters. *Journal of Marine Biological Association U.K.*, 76: 73-87.

Sánchez, F., A. Serrano, 2003. Variability of demersal fish communities of the Cantabrian sea during the decade of the 1990s. *ICES Marine Science Symposium*, 219: 249-260.

Sánchez, F., I. Olaso, 2004. Effects of fisheries on the Cantabrian Sea shelf ecosystem. *Ecological Modelling*, 172: 151-174.

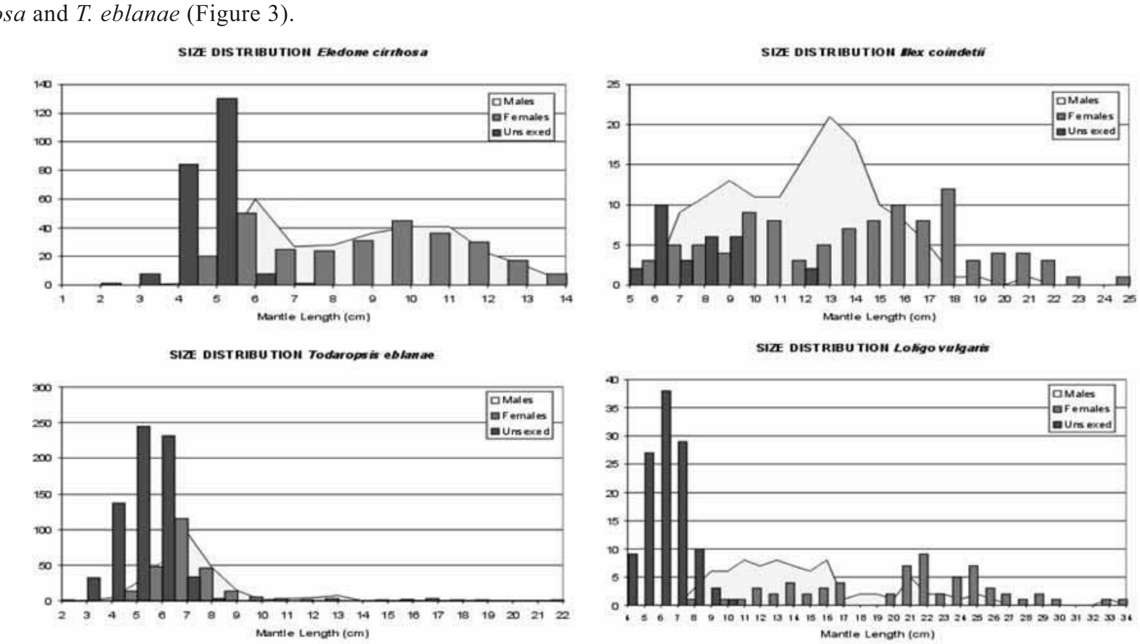

Figure 3 Sex-ratio of *Eledone cirrhosa*, *Illex coindetii*, *Todaropsis ebalanae*, and *Loligo vulgaris*.

Giving an alternative model for the analisys of the European Hake population in the Bay of Biscay.

Eider Andonegi,*[a] Iñaki Quincoces[a] and Gunnar Stefansson[b]

Introduction

One of the most relevant commercial species in the Bay of Biscay is the European Hake *Merluccius merluccius* (Linnaeus, 1758). Hake is considered one of the dominant predators in the demersal ecosystem. However, many aspects of this species are poorly known, making it difficult to accurately assess the state of the population.

European hake is distributed in the Northeast Atlantic, from the coast of Mauritania at about 21ºN to 62ºN off the western coast of Norway and the waters of Iceland, including the Mediterranean Sea (Alheit and Pitcher 1995). At present the population is divided into two stocks by ICES, the northern and the southern stock.

This study focuses on the Bay of Biscay area, covering ICES divisions VIIIabd (from 48ºN to 44º 30'N and from 11ºW to the coastlines of France and North-western Spain), that corresponds biogeographically to a subtropical/boreal transition zone, as classified by the OSPAR Commission for the Protection of the Marine Environment of the North East Atlantic (OSPAR 2000). This population is a fraction of the Northern Stock of Hake, which comprises also Division IIIa and Sub-areas II, IV, VI, and VII.

Material and Methods

In the present study a length-based model (Begley 2004) was applied to the Bay of Biscay European Hake population using the modelling environment GADGET (Globally applicable Area Disaggregated General Ecosystem Toolbox). This is a first attempt to provide an alternative which avoids the current assessment problems (i.e. uncertainty on the hake growth pattern).

The internals of GADGET (www.hafro.is/gadget) and the various potential submodels and options available are described in detail in the GADGET User's Guide (Begley 2004) and in the Overview of Gadget (Begley and Howell 2004).

Initial data used to simulate the population have been obtained from the sampling of commercial catches.

Results

A total of 35 parameters have been estimated (8 for the initial population, 17 for the recruitment and 10 for the selectivity pattern) in the model and the weight for each component is shown in Table 1.

Following the iterative weighting procedure, the minimum sum of squares obtained for each likelihood component are showed in Table 1, compared with those obtained in the last run. The ratio of final score to minimum sse shows that more information is retained from the commercial catches than for the survey, relatively speaking.

Growth parameters have been fixed.

Looking at the stability of the model (how the model fits the survey indices):

- Figure 1 shows how the indices fit the model being the slope of the regression fixed to 1 and the sse estimated and shown in each plot. As expected, the first two indices fit quite well (the smallest individuals which EVHOE is targeting) but the last ones don't, especially in the second time period when the survey is targeting the smallest ones even more.
- Observed and modelled CPUEs by quarters are represented in Figure 2. It is clear that the best fittings of the model with the available data are got when the amount of data is bigger, which is during the quarters 2 and 4.

Table 1. Weights and scores of each likelihood component during the optimization

COMPONENT	WEIGHT	sse_f / sse_w
LD fleet1	1505..376	1.681
LD fleet2	3354.037	1.263
LD survey1	4817.895	1.977
LD survey2	3994.769	2.376
Index 1.1	14.696	5.842
Index 1.2	788.643	36.581
Index 1.3	16.702	4.089
Index 1.4	5..355	3.098
Index 2.1	262.172	26.134
Index 2.2	3.1978	0.984
Index 2.3	1.983	1.189
Index 2.4	6.244	1.159
CPUE1	8.405	1
CPUE21	11.246	1

Table1: First column contains the name of the likelihood component in the model. In the second one, the weights of each component in the last optimization are presented and the last one the relation between the minimum sum of squares from the weighting procedure (ssew) and the final score (ssef) for each component are shown.

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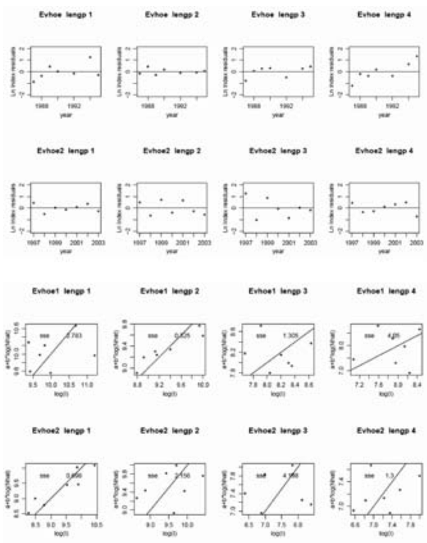

Figure1. a) Survey indices by length (from EVHOE 1987-2003). b) Residuals of the regression.

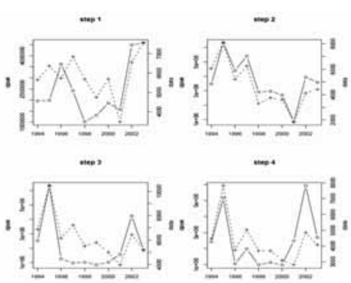

Figure2. modelled (lines) and observed (dots) CPUEs by quarter**.**.

The most recent information available for this stock is shown in the last report of the assessment WGHMM (ICES 2006). A summary of the most important parameters of this stock is represented in this Figure 3, both from the new model and from the XSA.

Most significant differences in the results of the compared models are shown in the last picture of this figure, the number of recruits. These differences could give us an idea about the recruitment spatial pattern of this species in this area.

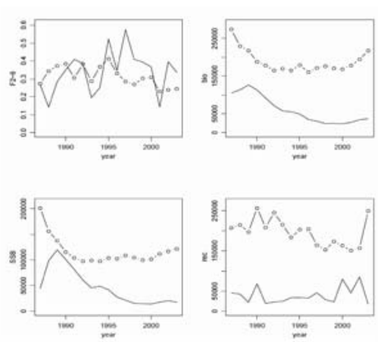

Figure3. Fishing mortality (ages 2-6), total biomass, SSB and recruitment of European hake both, in the Bay of Biscay (modelled with GADGET and represented by lines) and in the whole area of the Northern stock (modelled with XSA and represented by line and dots).

The new growing pattern for the European Hake (de Pontual et al. 2006) has been tested by implementing their new growing parameters into this model and the obtained results have been similar in general.

And to complete this work, some projection have been carried out trying to simulate the control rules that are currently been implemented in the European Hake Recovery Plan.

Conclusions

Even if the Bay of Biscay is considered a not really rich area concerning to the amount of data available, a stable GADGET model has been set for the Northern Hake population in the region. To validate the results of this model somehow, a comparison between them and the official assessment will be shown (ICES 2006). This is the only way available at the moment to test the results of the new model. The results don't have to be similar, but at least it will be expected to get more or less the same tends in both models. Notice that when comparing the results, there could be, and there is in fact, a big difference in the numbers of individuals between both data sets. This difference is due to the area covered in each model: the assessment WG model covers the whole Northern Hake stock area (including ICES Division IIIa and Sub-areas II, IV, VI and VII) and the new model covers only de ICES Division VIIIabd, as mentioned before.

This study opens some ways to future works dealing with this kind of analysis of the fisheries in the Bay of Biscay. More specifically, there are some works being carried out with Gadget at the moment, trying to:

• Make predictions from these results trying to extend the model for the whole area covered by the real stock. This could give an alternative way to the current hake stock assessment in this area.

• Implement a new Gadget model for Anchovy (*Engraulius encrasicolus*) in the Bay of Biscay

• Implement the first multispecies model using Gadget in the Bay of Biscay, based mainly on the relation between hake and anchovy in this area.

Acknowlegement

We thank the individuals involved in the European BECAUSE project for helpful discussions, in particular the Modelling Department of MRI (Iceland) for the technical support with GADGET and the dst2 data warehouse (Lorna Taylor, James Begley and Vojtech Kupja) and the Demersal Resources Management Area of the Marine Research Division of AZTI-Tecnalia.

References

Alheit, J., and Pitcher, T.J. 1995. Hake: biology, fisheries and market. Chapman & Hall.

Begley, J. 2004. Gadget User Manual. Marine Research Institute, Reykjavik.

Begley, J., and Howell, D. 2004. An overview of Gadget, the Globally applicable Area-Disaggregated General Ecosystem Toolbox. ICES CM 2004/FF 13: 16.

ICES. 2006. Report of the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM). ICES CM 2006/ACFM:29: 792 pp.

OSPAR. 2000. Quality status report 2000. Region IV: Bay of Biscay and Iberian Coast. London

Adaptive behavoir of the Mackerel hand-line fishery in the Cantabrian Sea

Antonio Punzón[a], Begoña Villamor[a], Rosa Gancedo[a], Marta Sanz[a] and Marco Amez[a]

Mackerel (*Scomber scombrs,,* L. 1758) migrates annually to northern Spanish coasts for spawning in the first half of the year, and it is the timing of this migration which determines the annual opening of the mackerel fishery. The hand-line fishery solely targeting this species accounts for 50% of the mackerel caught in the study area. Since 2000, and more pronouncedly in most recent years, the timing of the fishing activity has come earlier, and doubts have been raised as to whether this change is due to shifts in the migratory behaviour of the species or to a change in the activity and behaviour of fishing fleets. This study analyzes the behaviour of the fleet and the possible reasons why fishing activity has been brought forward and the consequences for the management of this resource.

Introduction

is a pelagic species that moves mainly around the area of the continental shelf and upper slope. Its distribution area covers both sides of the Atlantic Ocean, although the mackerel from each side of the North Atlantic are considered to be different breeds (Garstang, 1898). In the Northeast Atlantic sexual maturity is reached at 25-32 cm at the age of 2-3 years (Villamor, 2007). Northeast Atlantic mackerel spawns at the edge of the continental shelf from the south of the Iberian Peninsula to Scotland and its main spawning areas are: to the west and southwest of Ireland, the Celtic slope and the Cantabrian Sea (Reid, 1997). For the purposes of assessment and management, ICES (1996) has considered Northeast Atlantic mackerel to be a single stock since 1995, and assumes the existence of three spawning components (ICES, 2000): the Western component, made up of those spawning in western European waters (ICES Areas VI, VII and VIIIabde); the Southern component, those that spawn in southern European waters (ICES Areas VIIIc and IXa) and the North Sea component, those that spawn in the North Sea and Skagerrak (ICES Areas IIIa and IV).

The species' migratory routes in the Northeast Atlantic are well known (Uriarte and Lucio, 2001; Uriarte et al., 2001). Once they have spawned, adult mackerel from the Southern and Western components make a trophic migration northwards (post-spawning migration) at the end of spring and the beginning of summer through the area to the west of the British Isles. Between June and August they reach the Norwegian Sea and the North Sea, where they mix with local spawners. Juveniles born in the Iberian Peninsula area concentrate to the south of Finisterre until reaching sexual maturity, at which point they join the adult migration. The pre-spawning migration (return) towards spawning areas begins when the water cools to below 8.5ºC (Reid et al., 2001).

Several fleets and gears exploit this resource when the mackerel go to waters of the Cantabrian Sea for spawning, mainly hand-line, purse seine, 'baca' trawl and to a lesser extent gillnet. In the first half of the year hand-line targeting mackerel lands the greater part of catches made in ICES Division VIIIc, made up of adult fishes. In the second half of the year catches comprise juveniles and are mainly taken in Division IXa using purse seine gears (Villamor et al., 1997). The hand-line fleet targeting mackerel works in northern Spanish waters, in the eastern part of Division VIIIc (ICES Sub-división VIIIc East) and in waters of Spanish jurisdiction in Division VIIIb (Punzón et al., 2004).

There is some recent evidence of changes in the distribution of Northeast Atlantic mackerel juveniles and adults, which points to a northward displacement (ICES, 2007). It now seems that the stock is exposed to an increase in the variability of its recruitment and to possible changes in distribution. In the case of the Southern component, the Spanish fishery in Division VIIIc since 2000, and more pronouncedly since 2005, has seen both its start and its end come earlier than in previous years. In the last period the fishing season was between January/February and April, with the peak of catches coming in March, whereas in previous years it began in March and ended in May, with catches peaking in April. This has been confirmed by the acoustic surveys of the last two years, in which there has been a sharp fall in mackerel biomass during April (ICES, 2007). This indicates a temporary change of around one month in the migratory pattern of mackerel in the southern areas and may be related to a more northerly distribution pattern. However, there are still doubts as to whether this change is due to a modification of the species' migratory behaviour or to a change in the activity and behaviour of the fishing fleets.

The aim of this study is to analyze the behaviour of the fleet (based on commercial data sources) and its adaptation to mackerel migratory behaviour, and to report on recent changes seen in the pattern of spawning migration in the southern area.

Methods

The Catch per Unit of Effort (CPUE) was taken and standarized in order to eliminate deviations in CPUEs by vessel unrelated to species abundance. Generalized linear models (GLM) (Maunder and Punt, 2004) were used to standarize CPUE for the period 1995-2006.

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The hand-line fleet from the port of Santoña was analyzed since it is one of the fleets that is most representative of the Cantabrian Sea mackerel fishery. Data were used from the census of landings by fishing trip, fleet characteristics (vessel length, gross tonnage (GT), gross registered tonnage (GRT) and power (HP)), vessel type and year built, and month and fortnight in which the landing was made. Catches by vessel and day registered in the weight register book and on the sales sheets were compiled in order to obtain landing per fishing trip. The information of fleet characteristics came from the official census of the Secretaría General de Pesca Marítima.

In order to evaluate the extent to which the timing of the fishing season has moved forward using the catch standarized by fishing trip, the day of the year on which 50% (T_50%) had been taken was calculated (the cumulative sum of catches by standarized fishing trip) from the total catch made throughout the entire fishing season. Similarly, in order to see the evolution of the beginning and the end of the season, the points at which 20% (T_20%) and 80% (T_80%) of the total catch had been taken were calculated, taking these moments to be the beginning and end of the fishing season.

Results

Given the distribution of the variable response, the model proposed was a GLM model with a Gamma distribución. For this distribution of CPUE the most suitable function link is the “log” (McCullagh and Nelder, 1989). The final formula of the model was:

CPUE~Year+Fortnight+Length+Vessel Age+Year: Fortbight, family=Gamma (link=”log”)

The mean day of the whole series on which 50% of the total catch had been made was day 92, i.e. the first week in April (Figure 2). Prior to 1999 and 2001, in which 50% of the catch had been made by day 94, T50% was reached on day 100 approximately, 1996 being the year in which this volume of catches was reached the latest (day 105). After 1999 (except 2001), 50% of the weight of the landing was reached before day 92 (day 79 in 2000, 84 in 2002, 86 in 2003 and day 78 in 2004). As described earlier, both in 2000 and in 2003 a reduction is observed in the duration of the fishing season.

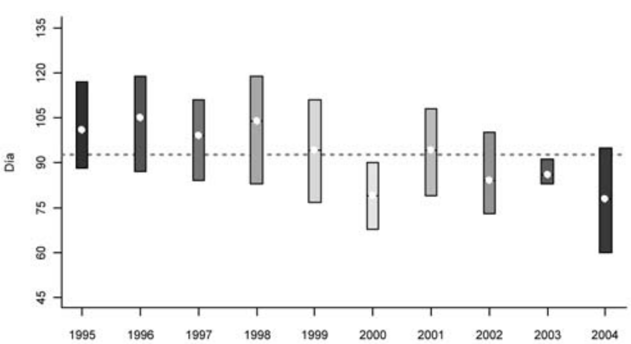

Figure 1. Evolución del día del año en el que se había realizado el 20%, 50% y el 80% de la captura total (la línea indica el día medio de todos los años en el que se realizó el 50% de la captura total)

References

Garstang, W., 1898. On the variation, races and migrations of the mackerel, Scomber scombrus. J. Mar. Biol. Assoc. U.K., 5, 235-295

McCullagh, P., Nelder, J.A., 1989. Generalized Linear Models, second ed. Chapman & Hall, London, 511 pp.

Maunder, M.N., & Punt, A.E., 2004. Standardizing catch & effort data: a review of recent approaches. Fisheries Research, 70, 141-159.

Punzón, A., B. Villamor & I. Preciado. 2004. Analysis of the handline fishery targeting mackerel (*Scomber scombrus*, L.) in the North of Spain (ICES Division VIIIbc). Fish. Res. 69: 189-204.

Reid, D. (ed.), 1997. Final Report of Shelf Edge Fisheries and Oceanography Study (SEFOS). Project, Contract AIR No. CT93-1105.

Reid, D.G., M. Walsh & W.R. Turrell. 2001. Hydrography and mackerel distribution on the shelf edge west of the Norwegian deeps. Fish. Res., 50: 141-150.

Uriarte, A., Lucio, P., 2001. Migration of adult mackerel along the Atlantic European shelf edge from a tagging experiment in the south of the Bay of Biscay in 1994. Fisheries Res. 50 (1–2), 129–139.

Uriarte, A., P. Alvarez, S. Iversen, J. Molloy, B. Villamor, M.M. Martins & S. Myklevoll. 2001. Spatial pattern of migration and recruitment of North East Atlantic Mackerel. ICES CM 2001/O: 17, 40 p.

Villamor, B., P. Abaunza, P. Lucio & C. Porteiro. 1997. Distribution and age structure of mackerel (*Scomber scombrus*, L.) and horse mackerel (*Trachurus trachurus*, L.) in the northern coast of Spain, 1989-1994. Sci. Mar., 61 (3): 345-366.

Villamor, B, 2007. La caballa (*Scomber scombrus*, L. 1758) del Atlántico Nordeste: Estudio Biológico y de la Población en aguas del Norte y Noroeste de la Península Ibérica. Tesis Docotoral Universidad de Cantabria, 260 pp.

Fish diversity in the Bay of Biscay is higher on the continentale slope than on the shelf

Pascal Lorance*[a]

Diversity of the fish communities on French Bay of Biscay shelf and slope was analysed and compared based on species diversity and taxonomic diversity indices in an attempt to elucidate the factors structuring diversity in both systems. For measuring species diversity, Hill's indices (Hill, 1973) were used. Hill's indices are a generalisation of commonly used indices such as Shannon and Simpson indices and evenness. Taxonomic diversity indices measure taxonomic distinctness (Warwick an Clarke, 1995; Clarke and Warwick, 1998,2001) based either on the proportion of species in the samples or their presence/absence. Of the 10 indices calculated, some are correlated by construction. Hence a reduced set of 6 indices is sufficient for the analysis.

The analysis was carried out at the scale of trawl stations of the annual western IBTS cruise in the Bay of Biscay and available trawl sampling of the mid and lower continental slope (700-2000m) fish assemblages. Due to limited data for the Bay of Biscay slope, additional data from the slope of the Celtic Sea and the west off the British Isles, collected with different trawl types, was also included. For the Bay of Biscay conctinental shelf, a set of 1367 trawl haul samples for the period 1987 to 2006 was available.

The comparison of the diversity structure on the shelf and the slope was based upon Principal Components Analysis (PCAs) of the diversity indices in both systems and the distribution of index values. The PCAs showed that the correlations between the different indices and between the indices and the observed fish density were different on the shelf and on the slope indicating a different structure of the diversity. For example, on the slope, species richness was positively correlated with the number of individuals caught while no such correlation was found on the shelf. In other words, tows where more individuals were caught did not have more species on the shelf while they did on the slope. Taxonomic distinctness indices were more strongly correlated to species richness on the slope than on the shelf. The statistical distribution of the number of individuals per tow was more skewed on the shelf than on the slope, indicating more aggregative behaviour and thus more clustered spatial distribution of fish density. All diversity indices were higher on the slope than on the shelf. Although on average a similar number of individuals were caught in trawls on the slope and on the shelf (tows were shorter on the shelf), more species per tow were observed on the slope. These species were also more taxonomically distinct.

For each ecosystem, possible explanatory factors of diversity (depth, latitude) were investigated and compared.

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References

Clarke, K.R., Warwick, R.M., 1998. A taxonomic distinctness index and its statistical properties. *Journal of Applied Ecology*, 35(4): 523-531.

Clarke, K.R., Warwick, R.M., 2001. A further biodiversity index applicable to species lists: variation in taxonomic distinctness. *Marine Ecology Progress Series*, 216: 265-278.

Hill, M.O., 1973. Diversity and evenness: a unifying notation and its consequences. Ecology, 54, 427-432.

Warwick, R.M., Clarke, K.R., 1995. New 'biodiversity' measures reveal a decrease in taxonomic distinctness with increasing stress. *Marine Ecology Progress Series*, 129(1-3): 301-305.

Hake daily feeding cycle on spawning time in the French continental-shelf of Bay of Biscay

Ignacio Olaso, Francisco Velasco, Izaskun Preciado and José Luis Gutiérrez-Zabala

The present paper analyses the daily cycle of the feeding intensity of hake (*Merluccius merluccius*) in the Northern part of the Bay of Biscay, in a spawning area. Hake is defined as a serial spawner as the female spawn several times during spawning season, and although hake puts along the whole year, the period of greater spawn are the first months of year.

In this paper we analysed quantitatively the diet composition of 1452 stomach contents of hake in the Grand Vassiere. The sampling was carried out in 34 hauls during 4 days during the period of maximum reproduction at the end of winter. The variability feeding intensities with the different states of maturity are studied taking also into account hake size.

It is the first time in which stomach contents have been analyzed in periods of two or three hours during several days at spawning time. We also compared the results obtained with those of hake feeding in areas different from the Bay of Biscay.

Introduction

European hake is one of the main predator species in the marine continental shelf of Bay of Biscay and its diet composition and food habits have been documented by several authors (González *et al*. 1985; Olaso, 1990; Olaso, 1993; Guichet, 1995; Velasco and Olaso, 1998; Velasco, 2007). However there is few information on its feeding daily cycles and changes in feeding intensity at spawning time, since most of the times stomach contents analyzed come from the diurnal hours and very few of them are hakes in state spawn and prespawn.

The objective of this paper is to investigate hake feeding habits in spawning period and all along the daily cycle, trying to estimate hake food consumption at spawning time. In addition to analyze the stomach contents of this study, we used all the information available about hake in this area.

Methods

During 8th – 11th March the commercial vessel Amuko made 34 hauls in the Grand Vassiere (Figure 1), and hake stomach contents were analysed. Sampling was carried out at 3-4 hours intervals during 82 h, at different hours of the day and night. Fishing was carried out with a bottom trawl gear, and the samples were caught at depths between 120 and 350 m.

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In each haul, 10 specimens per length range of hake (30-40 cm, 40-50cm, 50-60 cm, > 60 cm) were analysed. Length to the lowest cm and sex were recorded for each hake sampled. The use of the state of the gallbladder to determine regurgitation (Robb, 1992) prevented the overestimation of the incidence of empty stomachs. The stomach contents of each fish were analysed individually on board. The volume of total stomach contents (cc) was measured using a trophometer, Olaso (1990) and Olaso et al. (1998).

The different preys were separated and identified to the species level whenever possible. For each prey type, the following data were collected: percentage contribution to the total volume of stomach contents, number of items per stomach, state of digestion (1: intact prey; 2: partially-digested prey; 3= well-digested prey). When it was not possible to identify the prey due to its digestion stage, it was assigned to the lowest possible taxonomic level. Fresh prey or items presumably eaten in the net were excluded from analysis. When possible, prey length was also recorded and otolith length was also recorded to estimate total length through regression.

Food data are presented in terms of volume and percentage of empty stomachs. To allow comparison of prey quantities in hake of various sizes, stomach contents were also expressed in volume as percentage of the body weight (V%BW) considering the occurrence of regurgitated stomacs using the formulae:

$$V\%BW = (F + R)/F(F + R + E) x \sum_{j=1}^{k} V_j / W_j 10^2$$

where F is the number of full stomachs, R the number of regurgitated stomachs, E the number of empty stomachs, V_j the volume of stomach j, *k* the total number of stomachs, and W_j the weight of the predator. The relationship between the body weight and the size was estimated by means of regression model taken from the literature.

Results

A total of 1447 stomach contents of hake (30 – 92 cm) were analysed, 38% with food, 44% empty and 18% regurgitated. An important proportion of the preys were pelagic fish, like pilchard (12 % of total stomach contents), mackerel (15 %), horse mackerel (6 %), being blue whiting (65 %) the most abundant prey. Cannibalism hardly occur in our results, and it is because the predator hakes are big juveniles and adults, sizes in which hake cannibalism seldom occurs (Velasco 2007)

In the next figures we represented the day cycle considering the sampling times and: replection state and digestion state (Fig. 2), digestion stage in percentage of preys (Figure 3), and in the Figure 4 we also represented the back-calculation between the weight of blue whiting prey in the stomach, and the alive weight corresponding its size throughout the 82 hours of sampling.

At the moment we are exploring the data to analyze how feeding intensity it varies according to sexual maturity stage. On the other hand, the percentage of prey digestion stage diminishes according to increase the hours that the food has ingested, the empty stomachs it can increase when the adults are spawning.

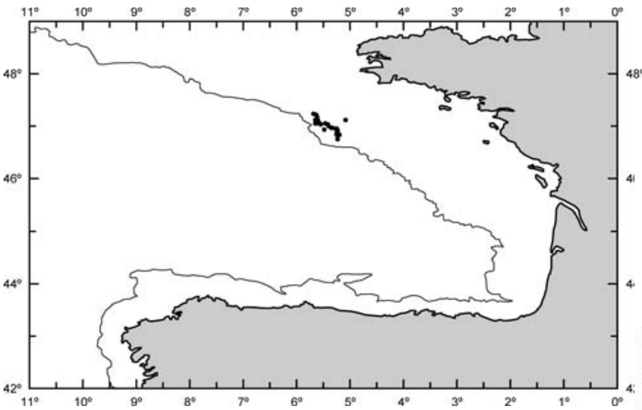

Figure 1. Location hauls in Grand Vassiere

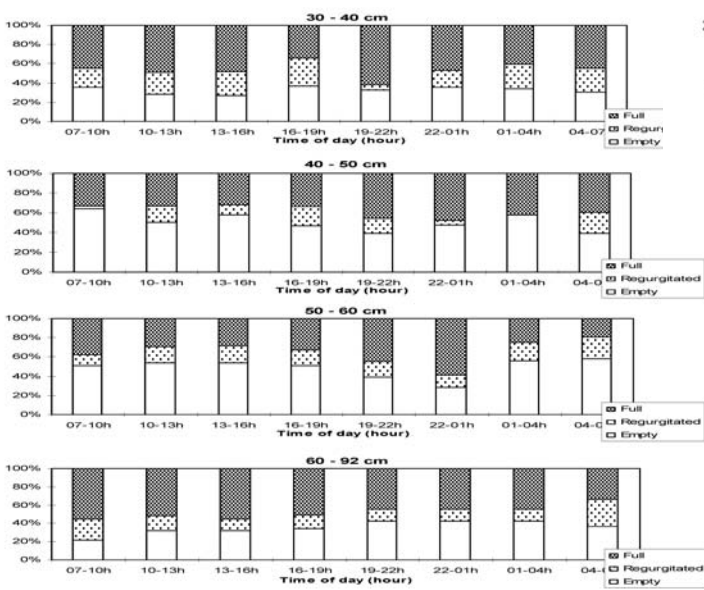

Figure 2. Replection state of stomach contents of hake in time of day

Acknowledgements

The authors wish to thank vessel owner for the invitation to embark in the Amuko commercial vessel. We also want to express our gratitude to the crew for all the collaboration received during our stay on board.

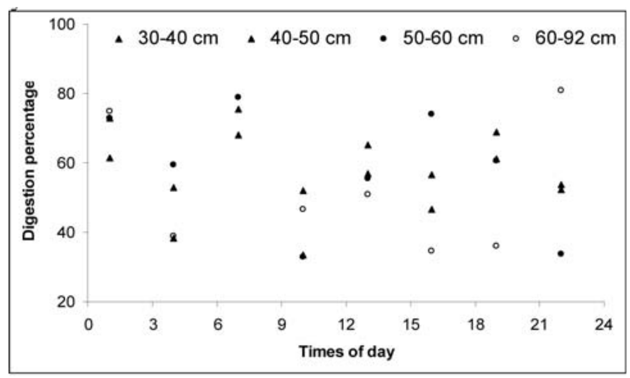

Figure 3. Digestion stage in percentage of preys

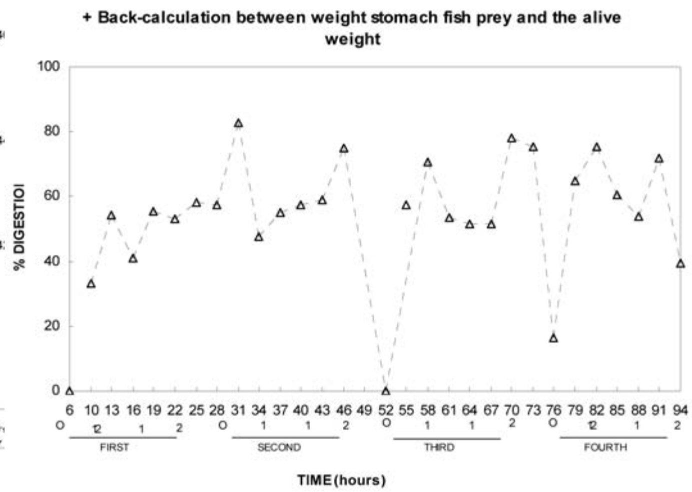

Figure 4. Back-calculation between weight of blue whiting prey in the stomach, and the alive weight corresponding its size throughout the 82 hours of sampling.

References

González, R., Olaso, I. and Pereda. 1985. Contribución al conocimiento de la alimentación de la merluza (*Merluccius merluccius* L.) en la plataforma continental de Galicia y el Cantábrico. Bol. Inst. Esp. Oceanogr. 29 (1-3), 211-222.

Guichet, R. 1995. The diet of European Hake (Merluccius merluccius) in the northern part of the Bay of Biscay. ICES J. mar. Sci. 52, 21-31.

Olaso, I. 1990. Distribución y abundancia del megabentos invertebrado en fondos de la plataforma cantábrica. Publ. Espec. Inst. Esp. Oceanogr. n° 5, 128 pp.

Robb, A. P. 1992. Changes in the gall bladder of whiting (Merlangius merlangus) in relation to recent feeding history. ICES J. mar. Sci., 49: 41-436.

Velasco, F. and Olaso, I. 1998. European Hake *Merluccius merluccius* (L., 1758) feeding in the Cantabrian Sea: seasonal, bathymetric and length variations. Fisheries Reasearch 38, 33-44.

Velasco, F. 2007. Alimentación de la merluza europea (Merluccius merluccius L.) en el Mar Cantábrico. Mimeo. Universidad Complutense de Madrid.

Reconstruction of life history events of the European eel (*Anguilla anguilla*) in the Adour estuary (South West, France) by laser ablation-ICP-MS

Hélène Tabouret*[a], Fanny Claverie[b], Christophe Pecheyran[b], Gilles Bareille[b], Patrick Prouzet[a] and Olivier Donard[b]

Introduction

The "Groupe De Recherche Adour" (GDR Adour) is focused on the evaluation of the anthropogenic factor influence on the Adour estuary (South West, France). This interdisciplinary working group sets out to improve scientific knowledge allowing a better understanding of contaminant effects on eel (*Anguilla anguilla*) resource and the pressure it undergoes in different habitats of colonization. Several mathematical, biological or chemical tools are engaged in this way and one of these is the use of otolith microchemistry. Otoliths are well known calcified structured widely used for the determination of fish age, growth rate or population stock. The succession of calcite layers called annuli able to trap elements during the calcification process provides a record of historical migration between aquatic environments of various chemical characteristics (salinity, pollution, …) or past environmental condition changes. The main objective of this study was to reconstruct life history events of the European eel (*Anguilla anguilla*) in the Adour estuary and associated wetlands according to trace element variations in otoliths.

Methods

The investigation of trace elements in the yellow eel otolith (less than 2mm diameter) requires a very sensitive analytical method. According Campana et al. (1997), laser ablation connected to an inductively coupled plasma mass spectrometer (ICP-MS) is one of the best relevant methods for the analysis of trace elements such as Ba, Cu, Fe, Mg, Ni, Pb and Zn in otoliths. In this study, trace element distribution was assessed using a coupling between a femtosecond laser ablation system and an ICP-MS. Ablation raster scan were made through the annuli of 33 otoliths of yellow eel caught on four sites from the Adour estuary (figure 1), one in the saline zone at the mouth of the estuary, two from wetland areas located at saline upper limit and one in a tributary (gave de Pau) affected by anthropogenic trace metal pressure.

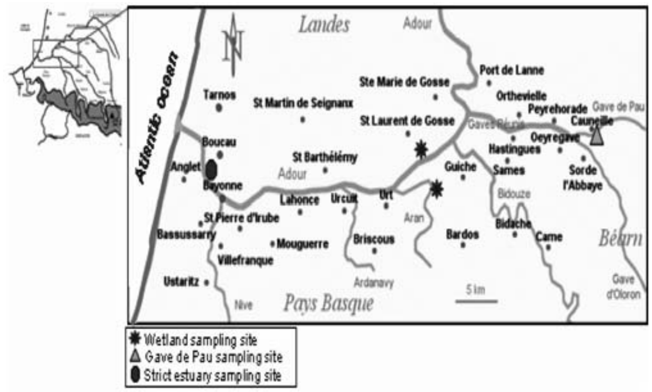

Figure 1 Map of the study area, showing the sampling stations.

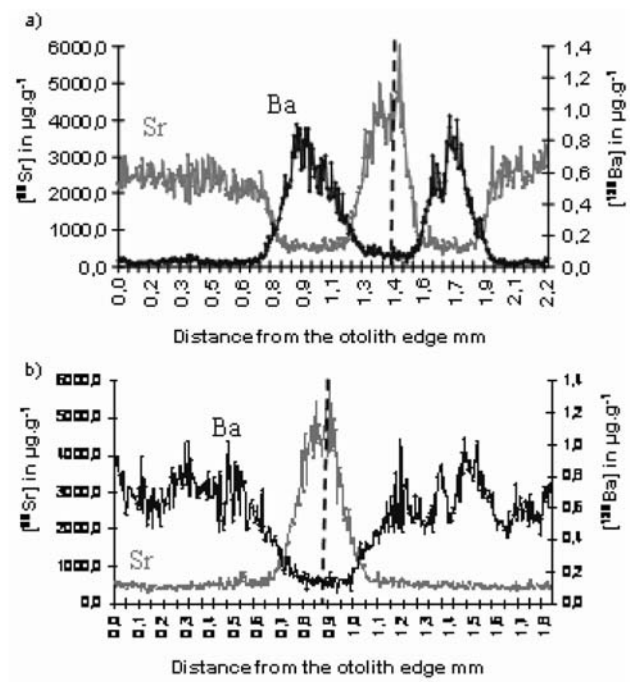

Figure 2 Example of ^{86}Sr and ^{138}Ba concentration distribution (in µg.g^{-1}) in yellow eel otolith from the strict estuary (a) and a wetland sampling site (b). Doted line marks the otolith nucleus localization.

Results and Discussion

For the 33 otoliths, no significative variation were observed for lead, cadmium, copper and zinc concentration within otolith annuli. Outside oceanic larval zone, strontium (Sr) showed two types of profile (figure 2): 1) a profile with an increase of the concentration from two to five years after the estuarine arrival for the individuals examined, 2) a profile with a constant

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concentration with a mean of 500ppm. In the first type of profile, Sr:Ca ratios were around 4.10^{-3} corresponding to the ratios described by other authors as an estuarine one, whereas in the second one the ratios observed are in agreement with the ratios found for freshwater resident individuals (Daverat et al., 2005 ; Tzeng et al., 2003 ; Tsukamoto and Arai, 2001). All individual caught in the strict estuary were of type 1.

Inversely to Sr, no significant difference of Ba:Ca average outside the elver mark was observed between each sampling site. However variations of Ba concentration, as for other elements like Mn and Mg, might illustrate changes in the environmental conditions.

Conclusions

These results support the use of the laser ablation-ICP-MS coupling in order to reconstruct life history events of migratory species such as eel. They also support the relevance of this method as a tool for a better understanding of habitat use, a factor which could play a major role in the contaminant exposure of this declining species in the Adour estuary.

Acknowledgements

This work is a contribution to the “GDR Adour” sponsored by the IFREMER, the University de Pau et des Pays de l’Adour and the CNRS. H. Tabouret acknowledges IFREMER and the Aquitaine Region for her PhD grant. The authors are also grateful to N. Caill-Milly (LHA IFREMER), the Conseil Supérieur de la Pêche and MIGRADOUR for their help in the field logistic and fish sampling.

References

Campana, S. E., S.R. Thorrold, C.M. Jones, D. Günther, M. Tubrett, H. Longerich, S. Jackson, N.M. Halden, J.M. Kalish, P. Piccoli, H. de Pontual, H. Troadec, J. Panfili, D.H. Secor, K.P. Severin, S.H. Sie, R. Thresher, W.J. Teesdale, J.L Campbell, 1997. Comparison of accuracy, precision, and sensitivity in elemental assays of fish otoliths using the electron microprobe, proton induced X-ray emission, and laser ablation inductively coupled plasma mass spectrometry. *Canadian Journal of Fisheries and Aquaculture Sciences* 54: 2068-2079.

Daverat, F., J. Tomas, M. Lahaye, M. Palmer, P. Elie, 2005. Tracking continental habitats shifts of eels using otolith Sr/Ca ratios: validation and application to the coastal, estuarine and riverine eels of the Gironde-Garonne-Dordogne watershed. *Marine and Freshwater Research* 56: 619-627.

Tzeng, W.-N., Y. Iizuka, J.-C Shiao, Y. Yamada, H.P. Oka, 2003. Identification and growth rates comparison of divergent migratory contingents of Japanese eel (*Anguilla japonica*). *Aquaculture* 216(1-4): 77-86.

Tsukamoto, K. and T. Arai, 2001. Facultative catadromy of the eel *Anguilla japonica* between freshwater and seawater habitats. *Marine Ecology Progress Series* 220: 265-276.

What type of information do we gain by including non commercial and epifauna species when assessing the functionality of nursery habitats?

Anik Brind'Amour*[a]

Integrated approaches such as the Water Framework Directive and the Marine Strategy Directive require the development of indicators based on community attributes. These indicators are often meant to be use in long time-series to assess the ecological state of the ecosystem. However, datasets from early sampling surveys were often not developed in such context and they do not always correspond to the new requirements, notably the ones regarding the censused of all the species within a haul. As such protocols are labour force and time consuming, it is legitimate to ask what type of information are we missing by selecting the species within a haul? Our study addressed that question by comparing two datasets composed of a different number of species sampled during the same surveys. It aimed at identifying the functional gains of including non commercial and epifauna species when assessing the community structure of nursery habitats. Preliminary results indicated a functional loss of information when analyses were conducted on a subset of species. The later displayed lower functional diversity index which was explained by the absence of the omnivorous feeding guild. The results also suggest that by using a subset of species, we likely underestimate the functional redundancy of the nursery habitats.

Introduction

Coastal and estuarine environments are among the most productive ecosystems in the aquatic environment (Costanza et al. 1997). They provide many services to the human population (food, recreational areas, …) and they play an important role as nursery habitats for many commercial fish species and invertebrates. Several studies have noticed indirect evidences that habitat conditions (quality and quantity) prevailing in coastal nurseries are affecting the size of some fish populations (Pihl et al. 2005).

Necessity of conserving biodiversity and ecosystem functions to ensure water quality or sustainable fisheries, has lead to the development of the Water Framework Directive, the Marine Strategy Directive and to a certain extent, the Ecosystem Approach to Management (Garcia et Cochrane 2005). All these intergrated strategies share the need to embrace an ecosystem overview which go beyond the portray of single population to a broaden view of the community. In nursery habitats, this extended overview pratically implies to conduct intergrated sampling protocols in which all the trawled species are surveyed. Such protocols are however often criticized as being labour force and time-consuming. It is indeed scientifically justified to ask and judge the gains that such protocols may provide.

he objective of the study was to compare two dadasets composed respectively of all species sampled in a haul (referred herein as the "complete" dataset) and a list of commercial species routinely surveyed (referred herein as the "subset" dataset). The comparison was conducted in the context of identifying the functional information that we could gain by surveying (non commercial) demersal and benthic fish, echinoderms, molluscs, and arthropods. Interpretations of the potential gains were based on functional aspects of the community (i.e species assemblages, functional diversity and groups of species traits).

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Methods

Study area and sampling surveys

The study focused on surveys that have been conducted on four consecutive years, from 2000 to 2003, in the Bay of Vilaine. This bay has been described as an important nursery ground and is characterized by an open shallow muddy estuarine area under the direct influence of freshwater inflows (Gilliers et al. 2006). The nursery-dedicated surveys were carried out from the end of August to the end of October. They were conducted using a stratified sampling design according to depth and sediment type. The surveys were carried out in depths ranging from 5 to 25 m using a 2.9 m wide and 0.5 m high beam trawl with a 20-mm stretched mesh net in the cod-end. A total of 131 hauls were conducted over the four years of sampling. Each haul were conducted on homogeneous sediment and depth and lasted 20 min covering a mean area of 4500 to 5000 m2. All the species caught were counted and total weight of the haul was recorded.

Species datasets

The first dataset ("complete" dataset) included all the species sampled in a haul and which composed at least 1% of the total abundance in the four-year surveys. The second set of data ("subset" dataset) was built using a selection of species from the "complete" dataset. The species were chosen because they corresponded to a list of species routinely censused in nursery surveys along the coast of the Bay of Biscay (Désaunay and Guérault 2002).

Species were described by a set of 22 trait attributes classified in five categories (Table 1). The traits were compiled using values mainly from the literature (Tillin et al. 2006, Laptikhovsky et al. 2002, Raya et al. 1999, Elliott and Dewailly 1995) and were completed with information found on Fishbase (Froese and Pauly 2006) and on the Marine Life Information Network (http://www.marlin.ac.uk). The traits have been used in previous studies describing the structure of estuarine fish assemblages (Elliott and Dewailly 1995).

Table 1 Species traits list used in the analyses.

Category	Trait
Feeding guilds	Plankton
	Invertebrates (molluscs, crustaceans)
	Fishes
	Invertebrate and Fish
	Carnivorous
	Omnivorous
Reproductive guild	Viviparous
	Oviparous
	Pelagic eggs
	Eggs garded by parents
	Eggs deposited in vegetation or attached
	Eggs protected in a shed, pouch or case
Substrate preference	Sandy bottom (sand exclusively)
	Soft bottom (sand, mud, fine gravel)
	Rough bottom (rock, stone, pebble)
	Mixed or various (no apparent preferences)
	Vegetation (seeweeds)
Commercial	Commercial interest
Ecological guild	Marine migrant (irregularly in the estuary)
	Marine seasonal migrant
	Marine juvenile migrant (estuary as nursery)
	Estuarine resident (entire life in the estuary)

Statistical analyses

Analyses were conducted on the data from the four years. The community structure analyses were done using Principal Component Analyses (PCA) on the matrix of species traits. Functional aspects of the community were adressed by estimating a functional diversity index and by clustering the species traits. The functional diversity was estimated using a dendrogram-based approach (Petchey and Gaston 2002). Gower's dissimilarity coefficient was used on the standardised species-traits matrix to estimate the distance among the functional traits. This coefficient has been chosen because it can handle mixed variable types (quantitative, categorical, and binary) and missing values (Podani and Schmera 2006). A dendrogram was produced by hierarchical clustering using Unweight Pair Group Method with Arithmetic mean (UPGMA) method. The latter method was chosen after estimating the correlations between the original distances (Gower's species-traits matrix) and the cophenetic distances at each nursery grounds. Results showed that UPGMA effectively preserved the dissimilarity structure from the distance species-traits matrix (average Pearson's correlations: 0.71 ± 0.2). The functional diversity which corresponds to the total branch lengths of the dendrogram was afterward estimated using the formula described by Petchey and Gaston (2002). All analyses were done in R (Team 2005).

Results and discussion

Preliminary results indicated a higher functional diversity index for the complete dataset (FD = 5.07) in comparison to the subset dataset (FD = 3.92). That difference was also observed in the cluster analyses in which the complete dataset displayed 5 groups of traits whereas to the subset dataset displayed 4 groups. The two datasets showed however some similarities as indicated by the identity of the group members in four groups. The fifth group identified using the complete dataset was composed of omnivorous species with guarded eggs and using mixed substrates and was completely absent from the subset dataset.

The assessment of the relationship between the functional diversity and the species richness might be a way of estimating the functional redundancy of a system (Micheli and Halpern 2005). In our study, that relatiosnhip indicated higher functional redundancy in the complete dataset in comparison to the subset dataset. This result suggests a functional loss of information when using a subset of species. Closely related to functional diversity, the concept of functional redundancy implies that the disappearance of one or more species does not affect the ecosystem process because species represent "redundant information" with respect to that process.

Acknowledgements

This study was partly supported by the European program CHALOUPE. The author will like to thank all the scientists and crews of the R.V. Gwen Drez who participated to the cruise NURSE 2000, 2001, 2002, and MISOLRE in 2003.

References

Costanza, R., Darge, R., Degroot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., ONeill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., and vanden Belt, M. 1997. The value of the world's ecosystem services and natural capital. Nature 387: 253-260.

Désaunay Y. & Guérault D : Manuel des protocoles de campagne halieutique. Campagnes Nourriceries Gascogne. Système d'Information Halieutique., DRV/RH/DT/2002-05 - - 2002

Díaz S., and Cabido M. (2001) Vive la différence: plant functional diversity matters to ecosystem processes. Trends in Ecology & Evolution 16: 646-654.

Elliott, M., Dewailly, F. (1995) The structure and components of European estuarine fish assemblages. Netherlands Journal of Aquatic Ecology 29: 397–417.

Garcia SM. et Cochrane KL. 2005. Ecosystem approach to fisheries: a review of implementation guidelines. ICES Journal of Marine Science 62: 311-318.

Gilliers C., Le Pape O., Desaunay Y., Morin J., Guérault D., Amara R. (2006). Are growth and density quantitative indicators of essential fish habitat quality? An application to the common sole Solea solea nursery grounds. Estuarine Coastal And Shelf Science, 69: 96-106.

Laptikhovsky V., Salman A., Onsoy B., Katagan T. (2002). Systematic position and reproduction of squid of the genus Alloteuthis (Cephalopda: Loliginidae) in the eastern Mediterranean. Journal of the Marine Biological Association of the UK 82: 983-985.

Micheli, F. and B.S. Halpern. (2005). Low functional redundancy in coastal marine assemblages. Ecology Letters 8:391-400.

Petchey, O.L. & Gaston, K.J. (2002). Functional diversity (FD), species richness and community composition. Ecology Letters 5: 402-411.

Pihl, L., Modin, J., and Wennhage, H. (2005) Relating plaice (Pleuronectes platessa) recruitment to deteriorating habitat quality: effects of macroalgal blooms in coastal nursery grounds. Canadian Journal of Fisheries and Aquatic Sciences 62: 1184-1193.

Podani, J. and D. Schmera. (2006). On dendrogram-based measures of functional diversity. Oikos 115: 179-185.

Raya C.P., Balguerias E., Fernandez-Nunez M.M., Pierce G.J. (1999). On reproduction and age of the squid Loligo vulgaris from the Saharan Bank (north-west African coast). Journal of the Marine Biological Association of the UK 79: 111-120.

Team, R. D. C. (2005). R: A language and environment for statistical computing. In "R Foundation for Statistical Computing", Vienna, Austria

Tillin, H.M., Hiddink, J.G., Kaiser, M.J. & Jennings, S. (2006) Chronic bottom trawling alters the functional composition of benthic invertebrate communities on a sea basin scale. Marine Ecology Progress Series 318: 31-45.

Relevance of Otolith features for anchovy age classification

Aitor Astoreca*[a] , Jose Antonio Fernandes[a] , Unai Cotano[a], Andres Uriarte[a], Xabier Irigoyen[a]

Introduction

Knowledge of age composition in fish populations is one of the most important issues in stock assessment and management. Otoliths are calcified structures in the inner ear of fish that function as sound detectors. They are employed as indicators of age in the conventional methods of age determination which are based on examination of annual growth increments (annuli) in otoliths. Nevertheless, age determination in otolith is not always easy. The sequence of a single opaque annual growth ring followed by a single hyaline ring is not always clear, so the resulting rings may be difficult to interpret and the cost-benefit of the acquisition of age data readings through otolith interpretation by experienced personnel has to be considered. Age determination through the direct interpretation of growth patterns is complex, and extremely time-consuming.

Short living pelagic fish population, like anchovy (*Engraulis encrasicolus*, L. 1758), mainly consist of a few age classes with highly variable recruitment. At spawning time basically three age classes are usually present (Uriarte et al. 1996). In this case there is the potential that simple measurable features of the otoliths (such as weight, area, shape etc) may allow to directly assign their ages without visual examination of hyaline rings. An example of that was provided by Gonzalez-Salas (2007).

In this study the biological relevance of some features extracted from biological and otolith data sets is analyzed to distinguish between different anchovy age classes, combining otolith morphological features and fish features like its length and weight. In addition, the classification power of directly obtained features is compared with the capacity of automated acquired features (image analysis).

Methods

Sampling

Anchovies were collected during the RAKE scientific survey, conducted by The Spanish General Secretariat of Maritime Fisheries and coordinates by AZTI-Tecnalia with the collaboration of the IEO, during the May of 2007 by 13 purse-seiners from the Bay of Biscay.

The total length of all fish was measured and rounded down to the nearest millimetre, the total weight recorded to the nearest 0.1 g. and had their sex and maturity determined by macroscopic observation of the gonads.

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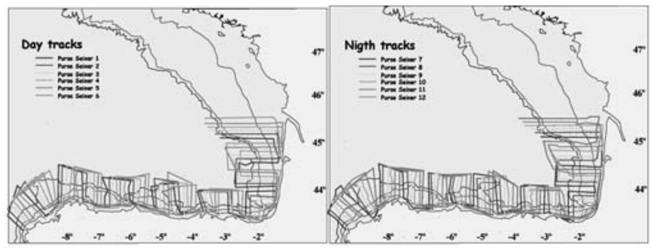

Figure 1. Vessel tracks during the Rake07 survey at day (left) and night (right) conditions

Otolith extraction

The sagittae otolith produced the most easily interpreted annual increment structure.

The right and left sagittal otoliths were removed from each fish, cleaned in distilled water, and stored in dry envelopes for future analysis.

Reading procedures

Age was determined from whole sagittae otoliths by an experienced age reader.

After drying and clearing, whole otoliths were mounted on black slides and were examined in a binocular stereoscope under reflected light, the numbers of annual rings in each otolith were counted to determine their age (in years).

Age determinations were made following the standards established for this species and agree among institutes working in the area (Uriarte et al. 2002). The annulus was defined as the translucent zone or the zone of slower growth that appeared as a dark zone in the otolith. The counts were converted into ages assuming the 1st of January as the designated birthday.

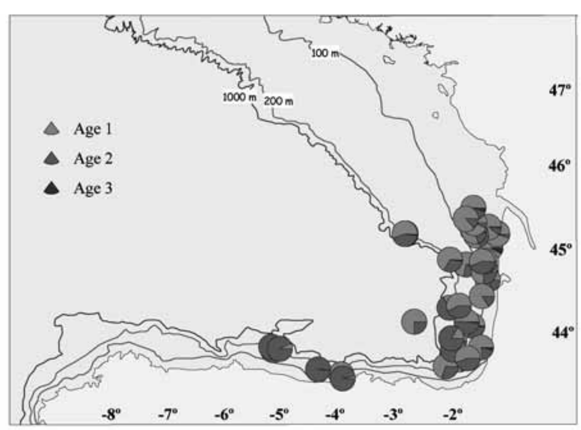

Figure 2. Spatial distribution of anchovy age composition during the Rake07 survey, calculated from otolith analysis.

Otolith weight

The left otolith of each sagittal pair was weighted to the nearest 0.0001 g using a Sartorius M5P electronic microbalance, provided that the otoliths were not damaged.

Otolith morphometric features

The otoliths were scanned (only the left otoliths) with a digital scanner (Epson Perfection 4990 Photo).

The resulting high contrast images were analyzed by ZooImage software, developed by Philippe Grosjean (freely available at http://www.sciviews.org/zooimage/). Subsequently, morphological features were extracted through an automated process from the images, the following measurements were taken for each otolith: area, perimeter, circularity, Feret´s diameter, primary and secondary axis of the best fitting ellipse, height and width of the smallest rectangle enclosing the selection, ECD (equivalent circular diameter of the surface of the otolith digitized image , 2 x (Area / 3.14)$^{1/2}$) and grey scale parameters.

Weka software (machine learning library distributed under the terms of the GNU General Public License, Witten and Frank 2005) has been used to perform the ranking of features, feature selection and classification.

This features were analysed as covariates in a Bayesian network where observations are conventional expert age determination.

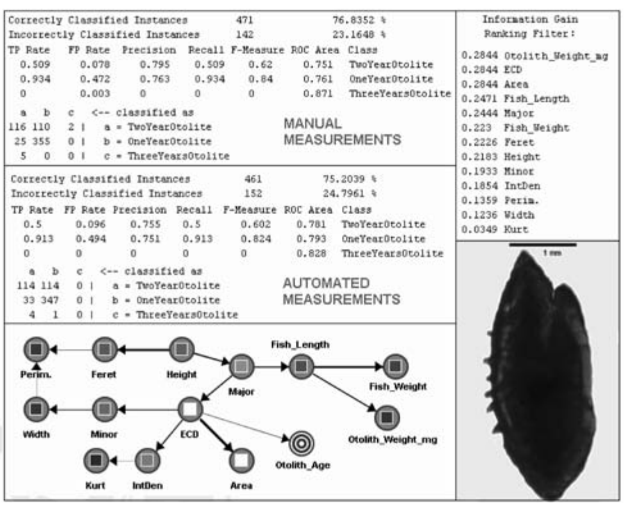

Figure 3. Manual vs. automated measurements and variables classification relevance (Upper right corner). Bayesian network showing feature probabilistic relationships (lower area).

Results

Otolith weight, ECD and otolith area have been found as the most relevant variables. These relevances can be observed in the features ranking (Fig. 3) where the information brought by each feature to the otolith age is evaluated.

Strong relationships between otolith weight, ECD and otolith area have been found, moreover, relationships between other features and the age of fish have been found through ECD variable (Fig. 3. Bayesian network).

Fish length and weight are relevant features that are routinely done.

The primary and secondary axis of the best fitting ellipse (major and minor), and Feret´s diameter are image analysis features that are useful too.

In terms of age classification there is no difference between using the weight of the otolith or the area.

Otolith age supervised classification has been achieved with a 75% accuracy (well classified), both with scanned features and with direct measurements. In automated classification length and weight of the fish has been included because are measures that are routinely taken. Although similar accuracies are obtained without them.

Conclusions

This study presents anchovy age analysis and classification from otolith images, with a morphological analysis supported by scientific studies and an automatic feature-recording method.

We obtained a classification rate of 75.2%. The classification power of manual and automated measurements is similar with minor differences that are not statistically relevant. This level of agreement is still below the average level of agreement achieved between experienced readers (Uriarte et al. 2002).

The present study is a preliminary step towards achieving automated techniques for age classification. Improvements in scanning process and future further research are foreseen to extend the experiments in order to improve the automated procedures accuracy.

In any case the use automated fish aging method techniques implies to provide the system with interpreted data. Consequently, expert readers will still be required to interpret a representative subset of otoliths to update the trained model.

Acknowledgements

We thank the crews of commercial fishing vessels that participated in the cruises.

The processing work was made by AZTI´s technical staff.

References

Borja, A., A. Uriarte, J. Egaña, L. Motos, V. Valencia, 1998. Relationships between anchovy (Engraulis encrasicolus) recruitment and environment in the Bay of Biscay. *Fisheries Oceanography*, 7(3/4):375-380.

ICES, 2006. Report of the Working Group on the Assessment of Mackeral, Horse Mackerel, Sardine and Anchovy (WGMHSA), 5 - 14 September 2006, Galway, Ireland. *ICES CM* 2006\ACFM:36. 1191 pp.

Gonzalez-Salas, C., P. Lefant. 2007. Interaanual variability and intraannual stability of the otolith Shape in European anchovy *Engraulis encrasicolus* (l.) in the Bay of Biscay. *Journal of Fish Biology*,70(1):35-49.

Uriarte, A., P. Prouzet, B. Villamar, 1996. Bay of Biscay and Ibero Atlantic anchovy populations and their fisheries. *Scientia Marina*, 60(Supl. 2): 237-255.

Uriarte, A., M. Blanco, O. Cendrero, P. Grellier, M. Millán, A. Morais, I. Rico, 2002. Report of the Workshop on anchovy otoliths from subarea VIII and division Ixa (Annex to PELASSES report EU study Project -EC DG XIV Contract nº99/010 and Working Document to the ICES Working Group on the assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. Copenhagen, 10-19 September 2002).

Witten, I. H., E. Frank, 2005. Data mining-Practical machine learning tools and techniques, 525pp. Elsevier.

Common octopus commercial landings on Northern Atlantic Spanish slope

Isabel Bruno*[a], Gersom Costas[b] and Antonio Punzón[c]

Common octopus (*Octopus vulgaris* Cuvier, 1797) is the cephalopod specie with the highest landings in Northern Atlantic Spanish waters (it constitutes the 54% of total cephalopod landings), and represents the main marketable cephalopod in this area.

This study is based on the octopus landing records of the Spanish fishery fleet operating in ICES Divisions VIIIc and IXa for the period 1995 to 2006. Data were collected in several of the most important Northern Spanish ports, by the "Instituto Español de Oceanografía" (IEO) Sampling and Information Network.

Spanish artisanal fishery is responsible for main of the total common octopus landings in Northern Iberian Peninsula (about a 98%). This specie is caught by the artisanal fleet using tramps.

Octopus landing data show a seasonal trend with a maximum values in autumn and winter, and minimum in summer.

Introduction

Common octopus (*Octopus vulgaris* Cuvier, 1797) is the cephalopod specie with the highest landings in Northern Atlantic Spanish waters (it constitutes the 54% of total cephalopod landings), and represents a very significant fishing resource in this area.

The present study aims to obtain information on the annual and seasonal changes in common octopus landings.

Methods

This study is based on the octopus landing records of the Spanish fishery fleet operating in ICES Divisions VIIIc and Northern IXa for the period 1995 to 2006. Data were collected in several of the most important Northern Spanish ports, by the "Instituto Español de Oceanografía" (IEO) Sampling and Information Network.

Monthly octopus landing data from the different fishing nets were collected in several ports for different periods. Data from most of Galician ports are available since 1995; and that from Cantabrian coast were taken since 2000.

Moreover, monthly body weights were carried out since 1997 to 2005. A total of 57254 specimens of *Octopus vulgaris* were obtained to the nearest 5g from 1015 samples in Galicia ports. Body weight distributions provides from the artisanal fishery landing in Ribeira, Muros, Fisterra, Burela, Coruña, San Cibrao, Baiona and O Grove ports.

Results

Spanish artisanal fishery is responsible for main of the total common octopus landings in Northern Iberian Peninsula (about a 98%). This specie is caught by the artisanal fleet using tramps.

Ribeira port presented the langest amount of common octopus landed in observed Galicia ports (about a 18% of recorded landings); Bueu presented the 12%; Malpica, the 8%; Fisterra, the 6%; Muros, Coruña, Camariñas and Baiona, about the 5% each one; Porto do Son, Burela and Lira-Carnota, 4% each one; and A Guarda, Cedeira, Cariño, O Grove, Cangas, Cayón, San Cibrao, Portonovo, Laxe and Rivadeo, presented values between (1-3) % each one.

For Cantabrian ports, maximum landing values were observed in Luarca (34%), Tapia de Casarigo (14%), Avilés (13%), Gijón (7%), Puerto de la Vega (7%), Viavélez (6%), Santander (5%), Ribadesella (4%), San Vicente de la Barquera (2%), Santoña (1%), Llanes (1%), and Lastres (1%).

Octopus yearly average landing data from Galicia show a seasonal similar trend to the observed on Cantabrian Sea ports, with high values from January to May and from September to December. However, Cantabrian ports presented its peak of landed octopus on March, and the Galician had its maximum values on November and December.

The highest yearly landing values on Galicia took place in 1997; on Cantabrian ports, landings reached its maximum in 2001.

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Cephalopods in commercial fisheries landings of Northern Atlantic Spanish Waters

Isabel Bruno*[a], Baltasar Patiño[b], Roberto Morlán[c] and Rosa Gancedo[d]

Cephalopods represent a valuable fishing resource for the Spanish fishery fleet in the Northern Atlantic Spanish waters.

Data used in the present study came from the landing records of the Spanish fishery fleet in the North Iberian Peninsula ports since 1994 to 2006 operating in ICES Divisions VIIIc and IXa and were compiled by the "Instituto Español de Oceanografía" Sampling and Information Network.

Cephalopods make up the 6% of landings observed for Spanish fleet that operate in ICES Subdivision IXa-North, although this percentage decreases in ICES Division VIIIc.

Family *Octopodidae* represents the 73% of cephalopod landings (*Octopus vulgaris* 54% and *Eledone cirrhosa* 17%); Fam. *Ommastrephidae* 16%; Fam. *Sepiidae* 8%; and Fam. *Loliginidae* 3%.

For the North Iberian Peninsula, trawler fleet is responsible for about 34% of the total cephalopod Spanish landings, but a 64% of cephalopods landings are made up of the Spanish artisanal fishery.

Moreover, landing monthly data show a marked seasonal trend for different cephalopod species.

Introduction

Cephalopods represent a valuable fishing resource for the Spanish fishery fleet in the Northern Atlantic Spanish waters and make up the 6% of landings observed for Spanish fleet that operate in ICES Subdivision IXa-North, although this percentage decreases in ICES Division VIIIc.

Cephalopods landings in Northern Atlantic Iberian Peninsula are mainly made up of octopus, short-finned squid, cuttlefish and squid.

Each cephalopod species is caught by a different group of fishing nets, but artisanal fishery and trawler fleet are responsible for main of Spanish cephalopod landings.

Methods

Data used in the present study came from the monthly landing records of the Spanish fishery fleet in the North Iberian Peninsula ports since 1994 to 2006 operating in ICES Divisions VIIIc-West (Northern Galicia), and since 2000 to 2006 that operating in IXa-North (Western Galicia) and VIIIc-East (Cantabrian Sea), were compiled by the "Instituto Español de Oceanografía" Sampling and Information Network.

This study was carried out on the cephalopod commercial fisheries landings from Galician and Cantabrian main ports, such as: Santa Uxía de Ribeira, Coruña, Marín, Bueu, Burela, Muros, Gijón, Avilés, Malpica de Bergantiños, Vigo, O Grove, Celeiro or Fisterra.

Results

Trawler fleet is responsible for about 34% of the total cephalopod Spanish landings, but a 64% of cephalopods landings are made up of the Spanish artisanal fishery.

Common octopus (*Octopus vulgaris*) represents the highest cephalopod landing values (54% of total landings weight); horned octopus (*Eledone cirrhosa*) reaches 17%; short-finned squid (Fam. *Ommastrephidae*), the 16%; cuttlefish (Fam. *Sepiidae*), the 8%; and squid (Fam. *Loliginidae*), the 3%.

The most representative cephalopod landings of Galicia took place in: Santa Uxía de Ribeira (it records 20% of landed cephalopod in weight), Coruña (10%), Marín (10%), Bueu (8%), Burela (6%) and Muros (5%) ports. For Cantabrian Sea, Gijón represents the 27% of cephalopod landings, Avilés the 25%, and Santander the 18%.

Data show that 89% of horned octopus, 97% of short-finned squid and 54% of squid landed was caught by trawler fleet; however, 98% of common octopus, 87% of cuttlefish and 37% of squid was caught by artisanal fishery.

Monthly landing data showed a marked seasonal trend for cephalopod several species. Horned octopus reaches its maximum values landing during first half of the year; common octopus has minimum landings in summer; squid landings are highest during the second half of the year; short-finned squid presents picks of landings in spring and autumn; and cuttlefish reach its minimum values landing from June to September.

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L'alimentation des juvéniles de la sole commune (*Solea solea, L.*) dans les pertuis charentais (Golfe de Gascogne, France)

Fanny Lepareur[a] et Jean-pierre Leaute[a]

Introduction

Dans le cadre de l'Observatoire de Recherche sur les pertuis Charentais (ORE REPER), une problématique a été posée sur les conséquences des modifications de la qualité de l'environnement sur le fonctionnement de la nourricerie de la sole commune (*Solea solea*, L.).

Pour répondre à cette problématique, les secteurs préférentiels des juvéniles de la sole dans les Pertuis ont été déterminés à l'aide des données récoltées lors de la campagne SOLPER 2006 (Léauté, 2007) qui suit l'évolution de l'abondance des juvéniles. Ensuite, leur alimentation dans ces zones a été décrite par l'analyse de leurs contenus stomacaux afin de comprendre les relations qui existent entre les juvéniles de la sole et leur environnement.

Matériel et méthodes

Lors de la campagne SOLPER 2006 qui s'est déroulée fin août 2006, des traits de chalut à perche ont été réalisés régulièrement dans les pertuis Charentais (pertuis Breton et pertuis d'Antioche). Les densités de juvéniles pêchés ont été cartographiées par un Système d'Information Géographique pour connaître leur répartition dans les Pertuis.

Les estomacs des soles pêchées ont été prélevées et les proies ont été identifiées. Pour décrire leur régime alimentaire, une méthode quantitative numérique a été utilisée avec des indices tels que la fréquence d'occurrence des proies (%O) et la composition des estomacs (%N) (Castel, 1985). Les proies préférentielles des juvéniles (%O > 50%) sont alors identifiées pour chaque classe de taille de soles (inférieure et supérieure à 90 mm).

Ensuite, un traitement statistique (Analyse Factorielle des Correspondances Multiples et Classification Ascendante Hiérarchique) a été nécessaire pour identifier des zones où le comportement alimentaire des soles et l'écologie (nature du sédiment et profondeur) sont homogènes.

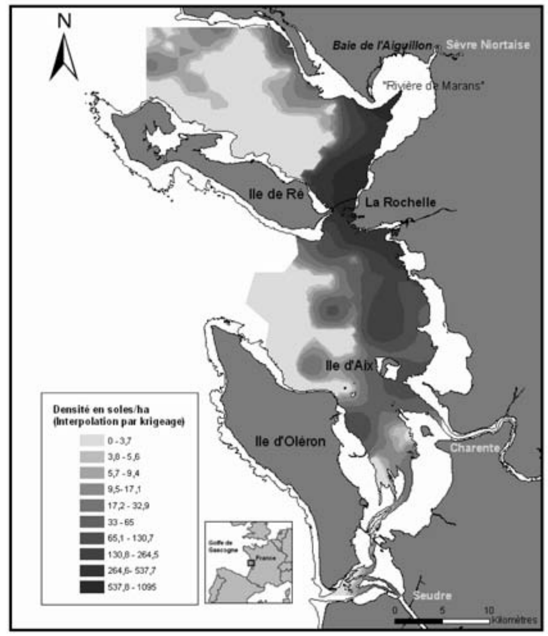

Figure 1. La répartition des juvéniles de soles (en soles/ha) dans les pertuis charentais.

Résultats et Discussion

Les juvéniles de soles se localisent préférentiellement sur le grand plateau vaseux de faible profondeur situé entre la baie de l'Aiguillon et l'Embouchure de la Charente (figure 1).

Au cours de leur croissance, les soles des deux pertuis remplacent une alimentation basée majoritairement sur des petits crustacés, et notamment des copépodes harpacticoïdes, par des polychètes (*Diopatra neapolitana*, *Sternaspis scutata...*) et des bivalves (*Phaxas pellucidus*, *Abra nitida...*) (table 1).

L'analyse statistique a révélé une disparité entre le pertuis Breton et le pertuis d'Antioche avec des comportements alimentaires différents. Six secteurs homogènes ont été discriminés et les espèces-proies consommées sont caractéristiques des paramètres écologiques des secteurs d'alimentation et notamment de la nature du fond (figure 2).

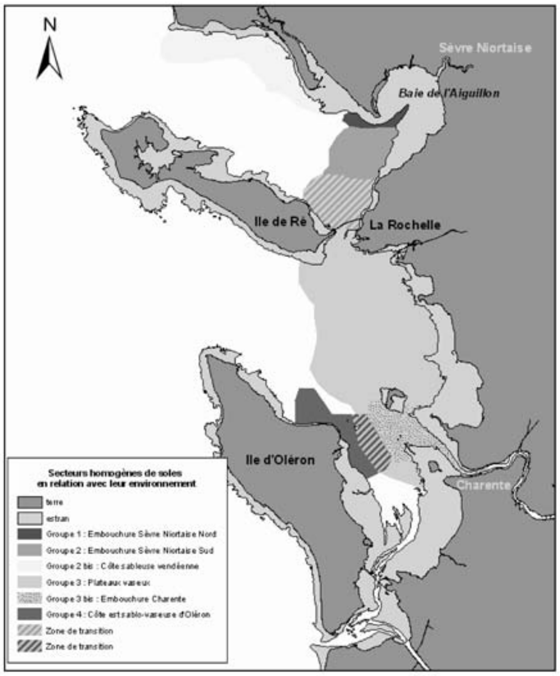

Figure 2. Répartition des juvéniles en relation avec leur environnement et leur proies selon six secteurs homogènes

References

Castel J., 1985. Importance of the meiobenthic copepods in the diet of juvenile euryhaline fish. *Bull. Ecol.*, 16 (2), p. 169-176.

Léauté J-P., 2007. Rapport de la campagne SOLPER 2 (28 août-2 septembre 2006). *Rapport IFREMER* DRV/RH/DT/07-002.

A review of laboratory experiments with european anchovy *Engraulis encrasicolus* at the Aquarium of San Sebastián 1999- 2007.

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Introduction

Anchovy is a fragile species which rarely is seen is aquaria, nevertheless since 1998 anchovy has been successfully displayed at the Aquarium. Once the adult and juvenile anchovies were successfully maintained at the Aquarium, new experiments were planned. In 1999 the Aquarium and AZTI started the first experimental trials with anchovies captured in the Bay of Biscay. The initial objective of this collaboration was to validate some biological parameters which are relevant in the process of stock evaluation.

Early life stages of anchovy through eggs incubation and larval culture as well as daily growth under different environmental conditions of temperature have being studied, among other aspects. A brief description of the experiments and some results are shown.

Methods

Juvenile anchovy captured in the Bay of Biscay were kept in the quarantine tanks at the Aquarium (Figure 1). Different kinds of experiments were run:

OTOLITH INCREMENT FORMATION experiments to validate method of ageing in anchovy. The otoliths were marked by immersion in oxytetracycline hydrochloride (OTC) at concentrations between 350 and 410 mgl-1 for 12 hours to induce fluorescent bands in the otolith microstructure.

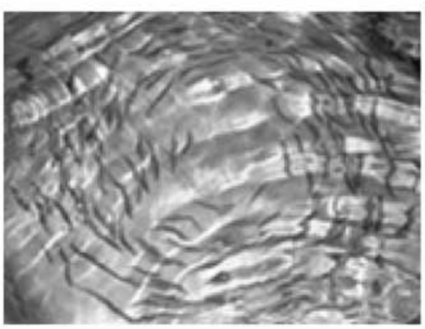

Figure 1. School of anchovy at a quarantine tank of the Aquarium.

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TAGGING experiments with external tags (fingerlings) to study the rate of survival of fish tagged and internal tags (inyection of

OTC with a dose of 0.01 – 0.04 ml of OTC) to examine the continuance of oxitetracycline in the fish tagged edible tissues (muscle).

Studies on reproductive biology were also undertaken: First monitoring of the DEGENERATION OF THE POST OVULATORY FOLLICLES (POFs) in the ovaries of recently caught spawning anchovies was performed and compared with those in wild conditions. Second, induced spawning to run EGG INCUBATION AND LARVAL CULTURE experiments were also conducted to study the development of the early life stages of anchovy under laboratory conditions and check the influence of the environmental factors on larval growth and survival.

Results and Discussion

OTOLITH INCREMENT FORMATION: Counting of micro increments in otoliths between the induced OTC bands (Figure 2) validated the daily otolith increment formation in the European anchovy short after juveniles and adults were laid in the aquarium and this served to stablish a consistent daily age reading methodology for the otoliths of juveniles (Cermeño et al. 2003, Cermeño 2007).

TAGGING:

External tagging: a survival rate of 35.7 % was obtained 4 months after tagging.

Internal tagging: oxitetracycline practically disappears from the fish edible tissues (muscle) at 4 weeks after tagging.

DEGENERATION OF POSTOVULATORY FOLLICLES:

The captive females displayed similar degeneration rates of post ovulatory follicles (POFs) as the females in the wild at the open sea. Overall the degeneration rates of POFs for this anchovy were assessed and are being used to review the estimation of the spawning frequency (Alday *et al*. 2005 and submitted).

EGG INCUBATION AND LARVAL CULTURE:

Spawning was obtained through control of temperature and photoperiod. Incubation of eggs, embryonic development and estimation of mortality was obtained for 5 temperatures (12, 15, 18, 21, 24ºC). Data is under process.

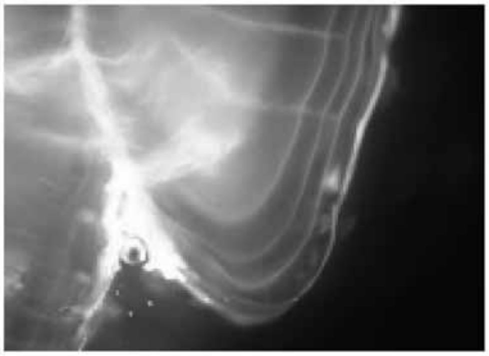

Figure 2. Otholith of juvenile anchovy with OTC rings..

Conclusions

Those experiments can be used as a tool for the validation of some biological parameters of high relevance for the ecological studies and direct assessment of this population, improving ultimately the fishery stock assessment of the population.

Marine Research Centres without quarantine facilities can have an important support in Aquaria for development of research projects in species conservation.

References

ALDAY, A., A. URIARTE, M. SANTOS, I. MARTÍN, A. MARTINEZ DE MURGUIA, L. MOTOS (2005). Staging and ageing the degeneration of postovulatory follicles for the Bay of Biscay anchovy (*Engraulis encrasicolus*). *ICES CM* 2005/Q:25 (Submitted to Scientia Marina).

CERMEÑO, P., A. URIARTE, A. M. DE MURGUÍA AND B MORALES-NIN (2003). Validation of daily increment formation in otoliths of juvenile and adult European anchovy. *Journal of Fish Biology*, 62: 679-691.

CERMEÑO, P., (2007). *Analysis of the microstructure of the Otoliths for growing and recruitment. Application to the European anchovy (Engraulis encrasicolus) in the Bay of Biscay.* Tesis Doctoral Departamento de Zoología y Biología Celular Animal. Universidad del País Vasco (UPV-EHU).

FUKUHARA, O. (1983). Development and growth of laboratory reared Engraulis japonica (Houttuyn) larvae. *Journal of Fish Biology*, 23: 641-652.

HUNTER, J., (1972). Swimming and feeding behaviour of larval anchovy *Engraulis mordax*. *Fishery Bulletin*. *U.S.* 70: 821-838.

HUNTER, J., (1976). Culture and growth of northern anchovy*, Engraulis mordax* larvae*. Fishery Bulletin. U.S*. 74(1): 81-88.

LEONG, R. (1971). Induced Spawning of the Northern Anchovy, *Engraulis mordax* Girad. *Fishery Bulletin. U.S.* 69(No. 2): 357-360.

O' CONNELL, C.P. AND RAYMOND, L.P. (1980). The effect of food density on survival and growth of early post yolk-sac larvae of the northern anchovy (*Engraulis mordax*) in the laboratory. *Journal Experimental Marine Biology and Ecology*, 5, 187-197.

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