REGIONE DEL VENETO

Definition of the Adriatic ecosystem quality as basis for Maritime Spatial planning

Contribution to the initial assessment of marine Adriatic waters according to Directive 2008/56/CE

Action 4.2 Final Report

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REGIONE DEL VENETO

List of Acronyms

ACCOBAMS = Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area

APAT = Agenzia per la Protezione dell'Ambiente e per i servizi Tecnici (Italian Agency for the Protection of the Environment and Technical Services; currently included in ISPRA)

ARPA = Agenzia Regionale per la Prevenzione e la Protezione Ambientale (Italian regional environmental authority)

ARSO = Slovenia Environment Agency

BD = Biological Diversity

C = Carbon

CFP = Common Fishery Policy

COP = Conference of the Parties

COR-GEST = Correspondence Group on GES and Targets

CPUE = Catch Per Unit of Effort

DIN = Dissolved Inorganic Nitrogen

DIP = Dissolved Inorganic Phosphorus

DM = Decreto Ministeriale (Italian Ministerial Decree)

DOC = Dissolved Organic Carbon

DOM = Dissolved Organic Matter

DPNM = Directorate for Nature Protection and Sea (of Italy)

E-SAd = Eastern South Adriatic current

EAC = Eastern Adriatic Current

EC = European Commission

ECAP = Ecological Approach

EcAp CG = Ecological Approach Coordination Group

EEA = European Environment Agency

EMEP = European Monitoring and Evaluation Programme

EO = Ecological Objective

ERSEM = European Regional Seas Ecosystem Model

ESA = European Space Agency

EU = European Union

ECMWF = European Centre for Medium-Range Weather Forecasts

FAO = Food and Agriculture Organization

GEF = Global Environmental Facility

GES = Good Environmental Status

GFCM = General Fishery Commission for the Mediterranean

GIS = Geographic Information System

GMES = Global Monitoring for Environment and Security

GNOO = Gruppo Nazionale di Ocenografia Operativa (Italian National Group of Operative Oceanography)

HAB = Harmful Algal Bloom

Hs = Significant Wave High

IBA = Important Bird Area

ICES = International Council for the Exploration of the Sea

ICRAM = Istituto Centrale per la Ricerca Scientifica e Tecnologica applicata al Mare (Central Institute for the Scientific and Applied Technological research for the Sea; currently included in ISPRA)

ICZM = Integrated Coastal Zone Management

IGI = Interconnection Greece Italy

IMP = Integrated Maritime Policy

INGV = Istituto Nazionale di Geofisica e Vulcanologia (Italian National Institute of Geophysics and Volcanology)

IREPA = Istituto di Ricerche Economiche per la Pesca e l'Acquacolutura (Institute for the Economic Research for Fishery and Aquaculture)

IOC = Intergovernmental Oceanographic Commission

ISPRA = Istituto Superiore per la Protezione dell'Ambiente (Higher Institute for Environmental Protection and Research)

ITGI = Interconnection Turkey Greece Italy

IUCN = International Union for Conservation of Nature

JANAF = JANAF, Plc JAdranski NAFtovod Joint Stock Company

JRC = Joint Research Centre of European Commission

LBS = Land-Based Sources

LIPU = Lega Italiana Protezione Uccelli (Italian National Association for the Protection of Birdlife)

MARCOAST = Marine and Coastal Environment Information Service

MATTM = Italian Ministry of the Environment, Land and Sea

MEDPOL = Programme for the assessment and control of pollution of the Mediterranean

Mipaaf = Ministero delle Politiche Agricole Alimentari e Forestali (Italian Ministry of Agriculture, Food and Forest Policy)

MSFD = Marine strategy Framework Directive

MSP = Maritime Spatial Planning

NAd = North Adriatic current

NIS = Non Indigenous Species

NOOA = National Oceanic and Atmospheric Administration

OBIS = Ocean Biogeographic Information System

OECD = Organisation for Economic Cooperation and Development

OG = Official Gazzette

OSPAR = Oslo and Paris Convention

PAH = Polycyclic Aromatic Hydrocarbon

PAP/RAC = Priority Action Programme/Regional Activity Centre

PCB = Polychlorinated Biphenyl

PISCES = Partnerships Involving Stakeholders in the Celtic Sea Ecosystem

POM = Particulate Organic Matter

PRC = Policy Research Corporation

PSU = Practical Salinity Unit

RAC = UNEP/MAP Regional Activity Centre

RAC/SPA = Regional Activity Centre for Specially Protected Areas

RMN = Rete Mareografica Nazionale (Italian National Mareographic Network)

SAA = Stabilization and Association Agreement

SAC = Special Area of Coservation

SCI = Site of Community Importance

SIBM = Società Italiana di Biologia Marina (Italian Society of Marine Biology)

SIDIMAR = banca dati del Sistema Difesa del Mare (database of the System for the Protection of the Sea)

SIN = Sito di Interesse Nazionale (Site of National Interest)

SINTAI = Sistema Informativo Nazionale per la Tutela delle Acque Italiane (National Information System for the Protection of Italian Waters)

SPA = Special Protection Area

SSM = Solid Suspended Matter

SST = Sea Surface Temperature

STD = Standard Deviation

TEU = Twenty foot Equivalent Unit

TN = Total Nitrogen

TOC = Total Organic Carbon

TP = Total Phosphorus

TRIX = Trophic Index for marine systems

TSS = Total Suspended Sediment

UNEP MAP = United Nation Environmental Programme Mediterranean Action Programme

UNESCO = United Nations Educational, Scientific and Cultural Organization

WAM = Wave Modelling

W-MAd = Western Middle Adriatic current

W-SAd = Southern Middle Adriatic current

WACC = Western Adriatic Coastal Current

WFD = Water Framework Directive

WHO = World Health Organisation

WP = Work Package

ZEPZ = Zone of Ecological Protection and Fishery

1 Introduction

The Shape project is structured in 5 Work Packages (Figure 1-1). Apart the horizontal ones, namely WP1 – Project management and Coordination and WP2 – Communication and Dissemination, three WPs have been defined to embrace all the technical activities at the core of the project: WP3 - Integrated Coastal Zone Management and WP4 - Shipping towards Maritime Spatial Planning, and WP5 Within Land and Sea.

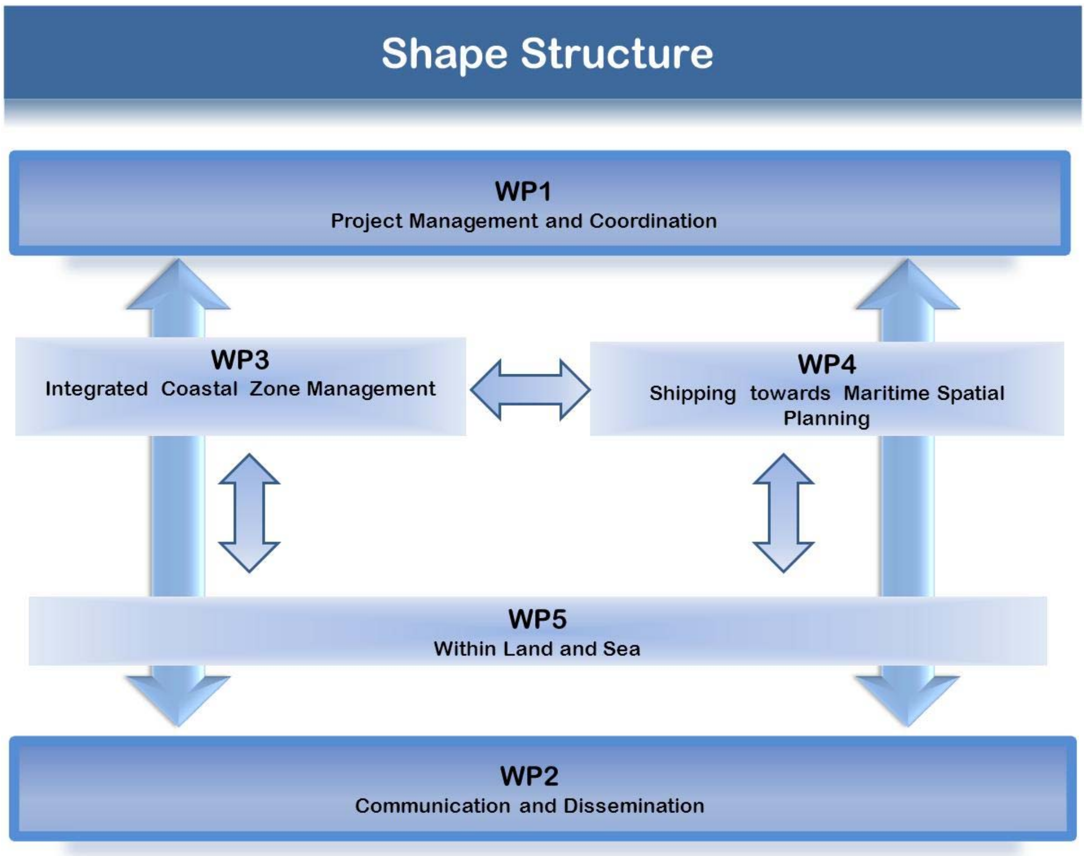

Figure 1-1 The Shape Project Structure.

Due to the fact the project has itself an integrated methodology approach, it naturally goes with an integrated methodology of participation: it starts from the management, coordination and dissemination (WP1 and WP2) towards the real integrated coastal zone management with the effective implementation of the ICZM Protocol (WP3) strengthening its role in the Adriatic Region and preparing the ground for National and local strategies.

This approach goes towards the activities of the WP4 for a future Maritime Spatial Planning to reach a high level of coherence between planning in coastal areas and planning in maritime spaces, binding ICZM and MSP and it ends within the WP5 with the definition of a common base of knowledge that develops a coherent picture of the Adriatic sea.

WP3, WP4 and WP5 have been implemented contemporaneously, by a continuous exchange of outputs and results from one to another, ensuring in this way the real coherence among single activities. Work Package 4 aims at addressing MSP in the Adriatic sub-region, creating an *ad hoc* methodology for maritime planning and to test MSP at local scale by common data processing, mapping and developing pilot actions. To reach this objective WP4 in articulated in 5 actions addressing the following issues:

- Action 4.1 an holistic approach for a common Maritime Spatial Planning;
- Action 4.2 ecosystem assessment as the basis for MSP;
- Action 4.3 major issues analysis and maps creation for MSP;
- Action 4.4 Pilot Project for ICZM/MSP integration;
- Action 4.5 Development of a common methodology for MSP.

The present report is the final deliverable of Action 4.2. The action focuses on the definition of main characteristics of the Adriatic basin ecosystem and the development of common recommendations at the basin scale to: (i) determine the current environmental status of the waters, (ii) define quality objectives, (iii) establish programmes of measures to achieve a good environmental status. To this regard, the action and the report are directly related to Directive 2008/56/EC (Marine MSFD) provisions. Beside this introduction the report is structured in other 3 chapters:

- Chapter 2 illustrates the EU legislative context (i.e. the MSFD) and the related status of implementation in the Adriatic Sea, as resulted from the analysis performed by Shape partners involved in Action 4.1.
- Chapter 3 provides a first contribution to the initial assessment of Adriatic waters according to requirements defined by art. 8 of MSFD. This contribution was elaborated on the basis of available literature and other information sources, mainly provided by international bodies (as for example UNEP-MAP, European Environmental Agency, Joint Research Centre (JRC) of the European Commission) and national agencies, as for example ISPRA, the Italian Higher Institute for Environmental Protection and Research. The analysis is structured according to Annex III of the MSFD “Indicative lists of characteristics, pressures and impacts”; art. 8 expressly refers to Tables 1 and 2 of this Annex when invites Member States to develop the initial assessment of their marine water. Based on the elaborated initial assessment chapter 3 finally identifies main knowledge gaps. Draft contents of chapter 3 were circulated among Shape partners, in particular those involved in Action 4.2: Emilia Romagna Region (Italy), Regional Development Centre Koper (Slovenia), Public Enterprise for Coastal Zone Management (Montenegro), Abruzzo Region (Italy), and Puglia Region (Italy). Partners’ feedbacks were than integrated in the report.
- Chapter 4 illustrates a set of recommendations for the implementation of MSFD at the Adriatic Sea level. Preliminary recommendations were identified on the basis of the results of the analysis performed for the previous two chapters and the results of Action 4.1; this action enabled to depict the legal, policy and planning framework supporting MSP and MSFD implementation in the Adriatic Sea. Preliminary recommendations were discussed among Shape partners in particular during the Shape meeting held in Pescara (Italy) in April 2013. The discussion led to the definition of the recommendations illustrated in this report.

2 Legislative context

This chapter is focused on the analysis of MSFD implementation at the level of European Union and single Adriatic countries. In the latter case, information was provided by Shape partners (in particular: Veneto Region for Italy, Regional Development Centre Koper for Slovenia, Institute of physical planning region of Istria for Croatia, Public Enterprise for Coastal Zone Management for Montenegro and ECAT Tirana for Albania)[1]. Differences among countries are related to the different country status in relation to the European Union: Italy and Slovenia are EU members, Croatia became an EU member very recently (July 2013), Montenegro is a candidate country, Albania is a potential candidate[2]. No information on MSFD implementation was available for Bosnia and Herzegovina, that is a potential candidate, too.

2.1 The Marine Strategy Framework Directive (MSFD)

The Marine Strategy Framework Directive (MSFD) (2008/56/EC) is the environmental pillar of the Integrated Maritime Policy (IMP) of the European Union. It aims to protect more effectively the marine environment. Its objective is to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend.

The MSFD from a normative perspective provides a solid legal basis for the application of an ecosystems based approach to the management of human activities affecting the marine environment and ecological systems, all with a view to ensuring that they are not irreversibly damaged by the cumulative effects of natural and anthropogenic pressures (Long, 2011).

The MSFD is a clear articulation of the obligation enshrined in the art. 174 of Treaty on the Functioning of the EU (preamble 44) and the Charter of Fundamental Rights that environmental protection requirements must be integrated into the definition and implementation of the EU's policies and activities with a view to promoting sustainable development (preamble 45).

The MSFD goes much further than simply requiring the integration of environmental principles into EU policies in so far as "*it establishes a science-driven and iterative process for environmental management which acknowledges that the status of marine ecosystems may evolve over time with the different patterns of human activities and in response to different impacts including those attributed to climate change".* For this reason, *the normative framework established by the Directive is designed to take into account scientific and technological development, and remains flexible enough to respond to the various threats and pressures posed by human activities to marine ecosystems in the future."*

The provisions of this legal binding instruments are organized into five chapters, the first of which sets out the subject matter, scope, definitions, marine regions and sub-regions, marine strategies, rules for coordination and cooperation between Member States and competent authorities. The second chapter deals with the preparation of marine strategies and has provi-

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[1] The analysis of the MSFD implementation level, as of any other directive and policy related to the marine environment (including MSP), was carried out within Action 4.1 of the Shape project. Main results were than used in this report.

[2] http://europa.eu/about-eu/countries/index_en.htm; last access 17 June 2013.

sions on assessment, determination of good environmental status, establishment of environmental targets, monitoring programmes, notification and assessment. The third chapter deals with programmes of measures, exceptions, recommendations for Community action, notification and Commission's assessment. The fourth chapter addresses the important issues of updating, interim reports, public areas, Community financing and the future review of the Directive. The final chapter provides for technical adaptations, regulatory committee, transposition, entry into force and addressees. Throughout the text of the Directive, there are many references to the six technical Annexes which address the following issues: qualitative descriptors for determining good environmental status; competent authorities in the Member States; indicative lists of characteristics, pressures and impacts; monitoring programmes and programme of measures.

One of the most notable changes brought about by the MSFD to the regulation of the marine environment is the introduction of the new concepts of "marine region" and "marine subregion" into EU law for the first time. European marine regions are identified on the basis of geographical and environmental criteria (Art. 4). More specifically, the Directive requires Member States to cooperate and coordinate their actions with other Member States in designing and implementing marine strategies within the following marine regions: the Baltic Sea, the North-east Atlantic Ocean, the Mediterranean Sea, and the Black Sea; these regions are illustrated in Figure 2-1. Provision is also made for the establishment of sub-regions in the North-east Atlantic and the Mediterranean Sea for the purpose of applying the Directive and with a view to taking specific management actions in a particular area. In the case of the Mediterranean Sea, they are: (i) the Western Mediterranean Sea; (ii) the Adriatic Sea; (iii) the Ionian Sea and the Central Mediterranean Sea; (iv) the Aegean-Levantine Sea.

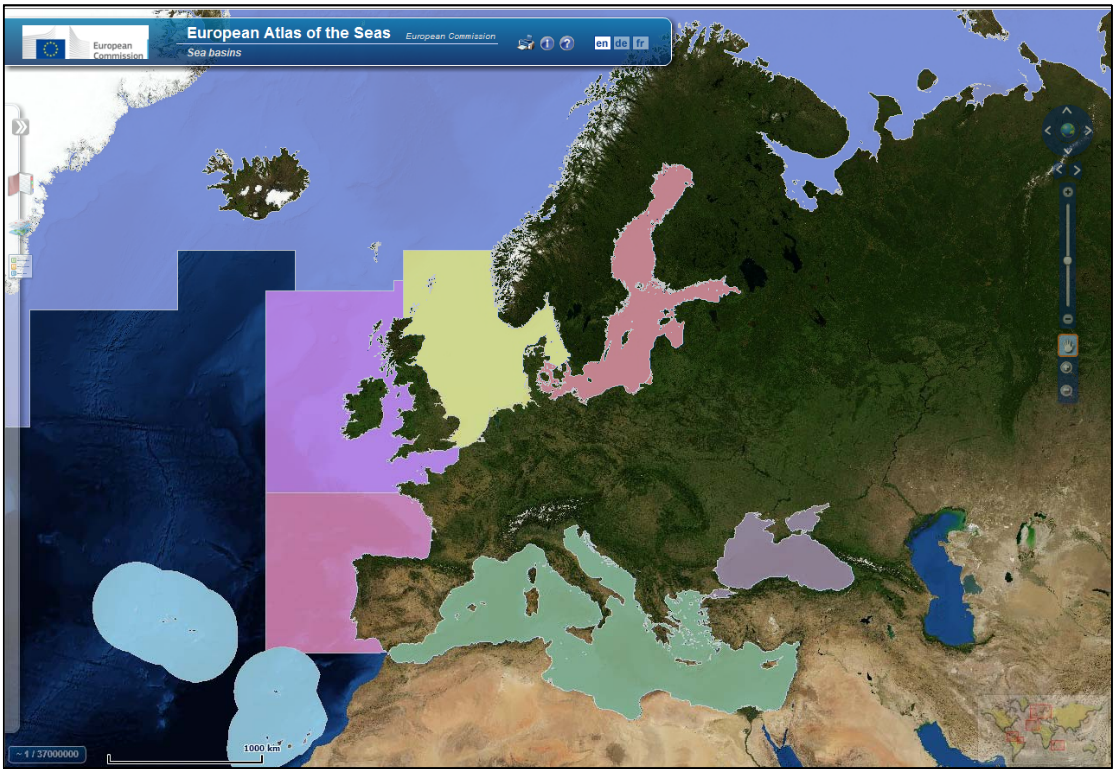

Figure 2-1 European Sea Basins, according to the European Atlas of the Sea subdivision (source: http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/, last access 17.06.2013).

Each Member State - cooperating with other Member States and non-EU countries within a marine region – is required to develop strategies which must contain a detailed assessment of the state of the environment, a definition of "Good Environmental Status[3]" at regional level and the establishment of clear targets and monitoring programmes. In respect to these regions and sub-regions Member States are required to develop marine strategies (art. 5), accordingly with a plan of action for which they are requested to follow a common approach with important milestones (Figure 2-2):

a) Preparatory phase (Chapter II):

- By 15 July 2012: description of the current environmental status of the waters concerned and the environmental impact of human activities thereon; determination of good environmental status; and establishment of environmental targets and associated indicators;
- By 2013: report on progress in the establishment of marine protected areas (MPAs)
- By 15 July 2014: establishment and implementation of a monitoring programme for on-going assessment and regular updating of targets.

b) Programme of measures (Chapter III):

- By 2015: development of a programme of measures designed to achieve or maintain good environmental status;
- By 2016 at the latest: entry into operation of the program and full implementation to achieve good environmental status by 2020.

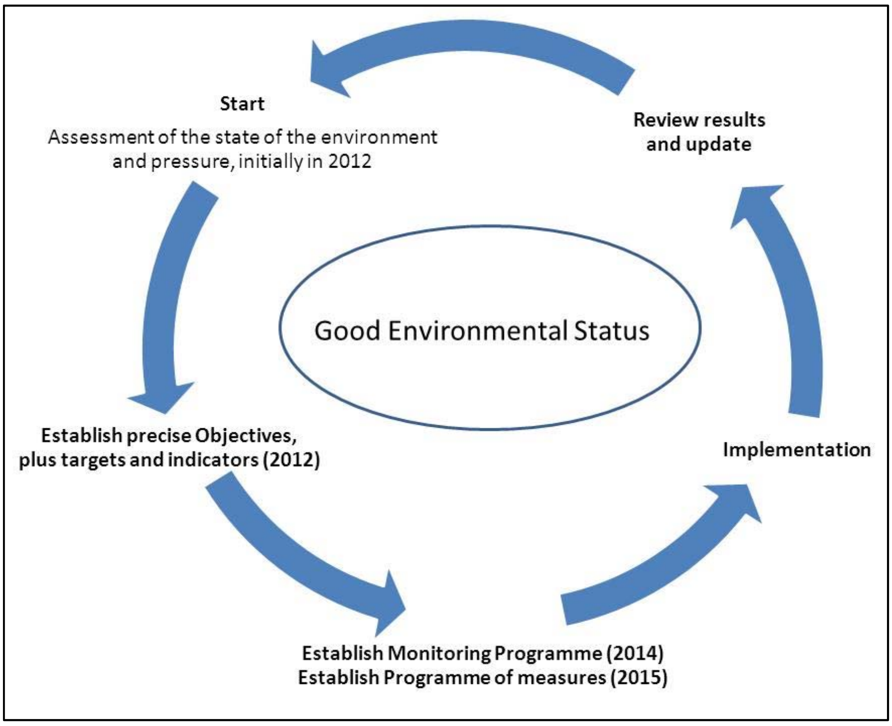

Figure 2-2 Process of attaining GES under the MSFD (Long, 2011).

[3] Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (2010/477/EU).

The goal of the Marine Strategy Framework Directive is in line with the objectives of the Water Framework Directive which requires surface freshwater and ground water bodies - such as lakes, streams, rivers, estuaries, and in particular coastal waters - to be ecologically sound by 2015.

In determining their good environmental status as requested by art. 9 of the Directive, Member States shall determine a set of qualitative descriptors (Annex I of the Directive):

- Descriptor 1: Biological diversity;
- Descriptor 2: Non-indigenous species;
- Descriptor 3: Population of commercial fish / shell fish;
- Descriptor 4: Elements of marine food webs;
- Descriptor 5: Eutrophication;
- Descriptor 6: Sea floor integrity;
- Descriptor 7: Alteration of hydrographical conditions;
- Descriptor 8: Contaminants;
- Descriptor 9: Contaminants in fish and seafood for human consumption;
- Descriptor 10: Marine litter;
- Descriptor 11: Introduction of energy, including underwater noise.

Member States shall take into account also an indicative list of elements concerning physical and chemical features, habitat types, biological features and hydro-morphology, as well as identify pressure and impacts of human activities (Annex III).

On the basis of the assessment Member States are required to establish environmental targets and associated indicators in order to guide progress toward the GES (art.10), as well as design and implement coordinated monitoring programmes of the status of marine waters (art.11). For each descriptor the criteria and indicators for good environmental status of marine waters are the object of a specific Commission Decision published in 2010 (2010/477/EU).

After the preparatory phase, a programme of measure shall be identified which need to be taken into account to achieve and maintain the GES (art. 13), taking into account other relevant Directives, as well as international agreements. Member States shall give due consideration to sustainable development and, in particular, to the social and economic impacts of the measures envisaged. To assist the competent authority or authorities referred to in Article 7 to pursue their objectives in an integrated manner, Member States may identify or establish administrative frameworks in order to benefit from such interaction. In drawing the programmes "*Member States shall ensure that measures are cost-effective and technically feasible, and shall carry out impact assessments, including cost-benefit analyses, prior to the introduction of any new measure. Programmes of measures established pursuant to this Article shall include spatial protection measures, contributing to coherent and representative networks of marine protected areas, adequately covering the diversity of the constituent ecosystems, such as special areas of conservation pursuant to the Habitats Directive, special protection areas pursuant to the Birds Directive, and marine protected areas as agreed by the Community or Member States concerned in the framework of international or regional agreements to which they are parties".*

Every six years member states are obliged to review the process, in particular the initial assessment, the environmental targets, monitoring programmes and programmes of measures.

2.2 Implementation of the Marine Strategy Framework Directive in the Adriatic States

2.2.1 Italy

The Directive 2008/56/EC of the European Parliament and the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy (Framework Directive on the Strategy for the Marine Environment) was transposed into Italian legislation on the 13 October 2010, with the legislative decree n. 190. The decree establishes a framework to develop strategies directed to the marine environment and the adoption of measures necessary to achieve and maintain good environmental status by 2020 (Art. 1).

The MSFD identify four marine regions: the Baltic Sea, the North-east Atlantic Ocean, the Mediterranean Sea and the Black Sea. The Mediterranean Sea is sub-divided in for marine sub-regions, as the North-east Atlantic Ocean. Italy, for its geographical position, assumes a relevant role in the implementation of the MSFD in the Mediterranean Sea; actually three sub-regions are relevant for Italy: the Western Mediterranean Sea, the Adriatic Sea, the Ionian Sea and the Central Mediterranean Sea.

The Ministry of the Environment, Land and Sea (MATTM) is the Reference/Competent Authority in Italy for the coordination of activities under the decree. For a coordination purpose MATTM appointed a Technical Committee, established within the Ministry itself by a special decree (Article 4). The Committee is composed of (Art. 5):

- Three representatives of the Ministry of the Environment, one of whom shall be the appointed chairman;
- Two representatives of the Ministry of Agriculture and Forestry;
- One representative from each of the following Ministries: Ministry of Infrastructure and Transport, Ministry of Health, Ministry of Defence, Ministry of Foreign Affairs, Ministry of Education, University and Research, Ministry of National Heritage and Culture, Ministry of Economic Development and the Department for Regional Affairs;
- One representative from each region and autonomous province;
- One member representing the Union of Italian provinces;
- A representative of the National Association of Italian Municipalities.

The Technical Committee concurs with the definition of acts pertaining to the Marine Strategy, identified by article 7. With the purposes of carrying out scientific and technical duties the Committee may consult experts appointed by members of the Committee. Representatives of research institutions, environmental associations and other associations can be invited to participate to the Technical Committee meetings.

The Higher Institute for Environmental Protection and Research (ISPRA - Istituto Superiore per la Protezione dell'Ambiente) provides its scientific-technical support to MATTM coordination activities.

In accordance with MSFD art. 5, art. 7 of the Italian decree identifies actions to be implemented:

- The initial assessment of the current environmental status of marine waters;
- Determination of characteristics of good environmental status of waters;
- Establishment of environmental targets;
- Definition of a monitoring programme;
- Definition of a programme of measures designed to achieve or maintain a good environmental status of marine waters.

The Ministry of Environment promotes and coordinates the initial assessment of the current environmental status and the impact of human activities on the marine environment, based on existing data and information, including those arising from the implementation of part three of the legislative decree of 3 April 2006, no. 152 as amended, that transpose the WFD. All national administrations, public and private bodies that produce or hold data and information relevant to the assessment shall, at the request of the Ministry of Environment, make them available.

Following the approval of the Decree, Directorate for Nature Protection and Sea (DPNM), the competent direction of MATTM, with note no. DPN-2010-27030 of 16.12.2010, entrusted ISPRA to elaborate a feasibility study for the initial assessment of the current environmental status of Italian marine waters, in accordance with art. 8 of D.Lgs. 190/2010. Main goals of the document were: survey of relevant data and information (according to tables 1 and 2 of MSFD Annex III), analysis of data quality, identification of main gaps, identification of main data sources and related responsible bodies. Moreover, a matrix identifying the correspondence between Annex III tables and Qualitative descriptors for determining good environmental status (MSFD Annex I) was elaborated.

Following the above preparatory work, MATTM and ISPRA elaborated an articulated document responding to the first three actions defined by the MSFD and included in the Italian transposing decree (art. 7), i.e.: initial assessment of the current environmental status of marine waters, determination of good environmental status, establishment of environmental targets. The report is structured in reporting sheets, according to the list and the template provided by the European Commission; major themes (each theme can be divided in several subthemes according to specific requirements) are:

- Geographic areas;
- Analysis of characteristics included in Annex III – Table 1 of MSFD;
- Analysis of pressures and impacts according to Annex III – Table 2 of MSFD;
- Analysis of socio-economic aspects;
- Determination of good environmental status;
- Establishment of environmental targets.

The initial assessment was produced at the sub-regional level (Western Mediterranean Sea, Adriatic Sea, Ionian Sea and Central Mediterranean Sea), while good environmental status and environmental targets were defined referring to the whole Mediterranean Region. The document was elaborated by ISPRA and shared and agreed with the competent Ministries and regional and local authorities within the Technical Committee established according to art. 5 of D.Lgs. 190/2010.

In compliance with art. 16 of D.Lgs. 190/2010 (and art. 19 of EC MSFD), MATTM and ISPRA have activated a series of initiative aiming to provide opportunities for public information and consultation. All information on the MSFD implementation process in Italy is available at the http://www.strategiamarina.isprambiente.it/ web-site. Moreover, the public consultation included an on-line questionnaire on the initial assessment, determination of the good environmental status and establishment of environmental targets; to this regards the above described document elaborated by ISPRA was made available on the web-site, where it can be still consulted. After the consultation and before the 15.10.2012 deadline, MSFD reporting sheets were notified to the European Commission, as requested. The Italian institutions involved in MSFD implementation are continuing their work on the environmental assessment, GES determination and targets identification, thus refining the work done until now and providing full support to the whole process; e.g. MATTM, ISPRA and Italian Regions are focusing on information gaps identified by the initial assessment.

2.2.2 Slovenia

Between 2005 and 2008, Slovenia, together with other EU Member States, participated in the process of drafting a common EC marine environment policy. On this basis, the Marine Strategy Framework Directive of the European Parliament and of the Council was adopted on 11 December 2007, establishing a framework for Community action in the field of marine environment policy (hereinafter referred to as the Directive 2008/56/EC). The Directive 2008/56/EC provides the framework for action by the Community in the field of marine environment policy in conjunction with the maritime and fisheries policies.

In Slovenia, the authority responsible for the implementation of the Directive 2008/56/EC is the Ministry of Agriculture and the Environment (hereinafter referred to as the Ministry), including its constituent bodies.

According to the provisions of the Water Act, the authority responsible for the implementation of the Directive 2008/56/EC is the Ministry responsible for waters, entrusted with the tasks of transposing the Directive into national law, preparing the marine strategy, inter-sectoral coordination and harmonisation of its content with neighbouring countries and the countries in the region. The platform for transposition of the Directive into the Slovenian national law is Article 59a of the Water Act, specifying that a marine environment management plan has to be prepared to achieve the strategic goals in the field of water management. The tasks are shared by the Ministry (Environment Directorate – Water Division) and its affiliated body – the Slovenian Environment Agency (ARSO) with its offices by river basins (Adriatic and Danube) and sub-basins (Soča River, which flows into the Adriatic Sea). Another body within the Ministry is the Inspectorate of the Republic of Slovenia for the Environment and Spatial Planning.

The Ministry is responsible to draw up a programme of measures designed to achieve or maintain good environmental status, which requires a comprehensive environmental impact assessment, socio-economic assessment, justification of exceptions and feasibility of implementation by 2016 at the latest.

To ensure the implementation of the Directive 2008/56/EC, the Ministry prepared a framework plan of action for the first planning period 2008-2015, which is summarised below. The plan was prepared on the basis of the provisions of Directive 2008/56/EC, which, in addition to principles, objectives and instruments for the attainment of goals, specifies the individual steps to be carried out by the Member States for the preparation of marine strategies and timelines. The Directive also specifies the method of preparation of individual steps where coordination of marine strategy content is needed amongst the Member States as well as the non-member countries in the region or sub-region.

In accordance with Article 5 of the Directive 2008/56/EC, the plan of action consists of:

- an initial assessment of the environmental status (Article 8);
- determination of good environmental status (Article 9(1));
- establishment of environmental targets (Article 10);
- a monitoring programme (Article 11);
- notifications and Commission's assessment (Articles 12, 16);
- programmes of measures (Article 13);
- exceptions (Article 14);
- public consultation and information (Article 19);
- notifications and Commission's assessment (Articles 9,10,11 and 15);
- regional cooperation (Articles 5 and 6).

Organisation of the implementation of tasks at the national level: the Ministry of Agriculture and the Environment is responsible for preparing and reporting to the Commission on the implementation of Marine Strategy. It also notifies the Government and the National Assembly of the Republic of Slovenia, as well as the general and professional public. The Ministry is also responsible for the harmonisation of particular contents of the Directive at the regional level and the Adriatic sub-region.

The key professional tasks in relation to the implementation of the Directive 2008/56/EC are carried out by the Institute for Water of the Republic of Slovenia, Marine Biology Station Piran and Institute of the Republic of Slovenia for Nature Conservation with the participation of Fisheries Research Institute of Slovenia, Slovenian Environment Agency and other specialised professional institutions.

Due to the diversity of content and cooperation of the professional public it is appropriate to also involve other bodies within the Ministry through working groups (sectoral task force) and other ministries (intersectoral task force).

2.2.3 Croatia

On its way to become an EU member state, Croatia has started a process of harmonisation with the EU legal acquis, including the adoption of approaches and policies relevant for the coastal and marine environment protection and management. In particular, in 2011 Croatia adopted a "Regulation establishing a framework for action in the field of marine environmental protection" (OG 136/11), that sets the basis for the development, implementation and monitoring of the national marine strategy according to MSFD requirements. As foreseen by MSFD, the marine strategy is applied to water under jurisdiction of Croatian law. In September 2012, the Croatian Ministry of the Environment and Nature Protection published the initial assessment of the marine environment (Croatian portion of the Adriatic Sea), as requested by MSFD[4]. The assessment includes:

- The analysis of the basic characteristics and features of the current state of Croatian marine environment, as required by 2008/56/EC Annex III table 1;
- The analysis of main pressures and impacts on the marine environment, as required by 2008/56/EC Annex III Table 2.

Furthermore, it is important to highlight that Croatia has adopted its Water Management Strategy in 2008 and drafted the related Water Management Plan 2012-2015, both in accordance with the EU WFD. WFD-MSFD links and overlaps are well known, assuming particular relevance in Croatia, where, due the great number of islands, a large part of territorial sea (more than 40%) corresponds to coastal waters according to WFD.

In the next future Croatia intends to develop the Croatian Coastal and Marine Strategy according to ICZM and MSP principles and MSFD requirements. The strategy will aim to provide an innovative integrated policy solution for both the marine and the coastal space. Moreover, the strategy will take into account climate variability and climate change into coastal and marine planning and will harmonise with the national water strategy defined accordingly to the EU Water Framework Directive (2000/60/EC). The proposed new national strategy will hence introduce consideration of the marine side, following the ECAP approach, MSFD provisions and contents of the recently draft Directive on MSP and ICM. Therefore, it is expected that improved coordination and coherence of actions in the management of coastal and marine areas will be achieved.

The MSFD Marine Strategy shall set out and direct long term goals for the management of the marine environment based on the principles of sustainable development in accordance with overall economic, social and cultural development on the territory of the State. The Marine Strategy shall contains the fundamental basis for directing and harmonising economic, technical, scientific, educational, organisational and other measures as well as measures for implementing international obligations, with the aim of protecting the marine environment and shall contain in particular:

- an assessment of the current status of the marine environment and of the effect of human activities on the environment;
- the criteria and requirements for determining good marine status;
- the goals of marine environmental protection and the indicators;
- short-term and long-term measures for achieving good environmental status;
- programme for monitoring marine status;
- integrated coastal management.

The Marine Strategy shall be drawn up by the Croatian Ministry of Environment and Nature Protection in cooperation with central state administration bodies competent for: the sea, tourism, transport and development, the economy, agriculture, forestry, water management, nature science and health. The Marine Strategy shall be adopted by the Croatian Parliament,

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[4] http://www.mzoip.hr/doc/More/Pocetna_procjena_morski_okolis.pdf; last access 15 May 2013.

upon the proposal of the Government. It shall be adopted for a ten year period, on the basis of the analysis of the efficiency of measures undertaken and of the environmental status from the Environmental Status Report.

2.2.4 Montenegro

Marine Framework Strategy Directive in Montenegro is currently not implemented. Within Regional Environmental Network for Accession (RENA) financed by EU and managed by the European Commission, to assists the beneficiary countries in exchange of information and experience related to preparation for accession, the Ministry of sustainable development and tourism reported that currently only 6% of MFSD is transposed in national legislation which relates the few definition already set in national legislation.

In December 2010, Montenegro was assigned the candidate status for EU membership, and the Decision on the opening of accession negotiations, was adopted by the EU Council in June 2012. So far in Montenegro negotiation structures have been formed in order to participate in the screening and assessment of compliance of Montenegrin legislation with the EU legislation (screening), to prepare draft of the negotiating positions, with the support of the state government and other agencies and institutions.

Among these, during 2013 working Group for Chapter 27 held bilateral and explanatory screenings, and the preparation of the Report of the defining initial screening criteria for opening negotiations on Chapter 27 is in progress. As proposed by in the screening process during 2013, the Marine Strategy Framework Directive will be transposed through the adoption of the Law on the Protection of the marine and coastal ecosystems by 2017. In accordance with this Law, the competent authorities will be designated (Art. 7.1 of the MSFD). After the adoption of the Law, the Initial assessment of the current environmental status of the waters (Art. 8), determination of the Good Environmental Status (Art. 9.1), establishment of environmental targets and associated indicators. (Art. 10.1), establishment of monitoring programs for on-going assessment of marine waters status (Art. 11.1) and establishment of programs of measures for each concerned region/sub-region (Art. 13) will be carried out.

However, the implementation of some MSFD requirements is carried out through several other initiatives and activities that Montenegro participates. The most important is the implementation of Barcelona Convention and its Protocols such as regular reporting on the implementation of the Barcelona Convention and Protocols, annual monitoring sea waters and coastal area parameters in accordance with MEDPOL Programme requirements, numerous activities and documents developed toward the implementation of the LBS and SPA Protocol. Montenegro is very active in transboundary and regional cooperation on marine protection, especially in the scope of the Joint Commission for Protection of Adriatic Sea which recognized the importance of national and regional efforts for the transposition of MSFD with purpose to create Marine Strategy for the Adriatic.

Finally, Monitoring program of the state of coastal sea ecosystem of Montenegro, carried out by Environmental Protection Agency in Montenegro is composed of the following complementary programs: (i) monitoring program of the quality of coastal, transition (brackish) and sea water, (ii) monitoring program of eutrophication, (iii) monitoring program of biological indicators and ecological indicators including defining bio-indicators and ecological indicators, (iv) defining biomarkers of environmental pollution, (v) monitoring program of the quality of waters for mariculture and ecotoxicology of seashells including water quality testing and ecotoxicological testing of seashells pollution, (vi) program of testing the quality of waters in hotspots, (vii) and monitoring program of river inputs. Responsible bodies for implementation methods of assessment and monitoring of the quality of marine waters are Environmental Protection Agency, Institute of Hydrometeorology and Seismology, Centre for Ecotoxicology research and University of Montenegro - Institute for Marine Biology.

2.2.5 Albania

Albania has not yet transposed to its national legislation the Maritime Strategy Framework Directive, nor it is planned to do it in the short time future. This is possible, considering that Albania is a potential candidate country for EU membership and the EU legislation is not obligatory as for the member states. According to the Stabilization and Association Agreement (SAA), Albania has the obligation to approximate the national legislation with the EU *acquis* within a period of 10 years after the entry into force of the SAA, which entered into force on April, 1, 2009. After a careful review of the national legislation and of the requirements of the MSFD, will be elaborated the plan on transposing this legal act in compliance with the specificities of the country.

3 Contribution to the initial assessment of the Adriatic Sea

Coasts have long been focal points for a wide range of uses. The sea, too, has been used in various ways for centuries. The concept of sustainable resource management was developed to respond to increasing pressure on coastal and marine resources, with particular attention to the viability and wise use of ecosystems. Also the Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP) approaches have been designed to ensure the sustainable management of coasts and marine areas. Pressure on marine space is also growing on account of new forms and new types of use. Some of these have challenged existing concepts of how we use the sea, in particular marine space. Wind and wave power, mariculture and also marine nature reserves are examples of uses that are static as well as spatially intense. Once established, static uses are difficult to re-locate, either because they depend on a key resource (e.g. a particular habitat) or because they require infrastructure investment (e.g. an oil platform). Some assurance is therefore needed that they will be able to occupy these spaces without any disruption for long periods of time. Environmental change represents a third reason for spatial pressure on coasts. Climate change is a particular concern. Threats of rising sea levels, for example, could lead to an increased “coastal squeeze”: since re-location of existing uses may become necessary, additional pressure on densely used coastal land or areas further inland could result.

In relation to above concepts this chapter presents an overview, at the Adriatic basin scale, of the state of the current environmental marine region, thus representing a contribution to the initial assessment required by the MSFD for this basin. As specified by the Directive 2008/56/CE the initial assessment should consider an indicative list of characteristics, pressures and impacts listed in Annex III. To this regards, following an initial paragraph dealing with general feature of the Adriatic Sea, the overview described in the present chapter is structured according to Annex III (Tables 1 and 2) contents:

- Physical and chemical features:
  - Topography and bathymetry;
  - Annual and seasonal temperature regime;
  - Mixing characteristics and current velocity;
  - Upwelling phenomenon;
  - Wave exposure;
  - Turbidity;
  - Residence time;
  - Spatial and temporal distribution of salinity;
  - pH profile;
- Habitat types:
  - Predominant seabed and water column habitat types;
  - Identification and mapping of special habitat types;

- Biological features:
  - Biological communities associated with the predominant seabed and water column habitats, macro-algae and invertebrate bottom fauna;
  - Population dynamics, natural and actual range and status of species of fishes;
  - Population dynamics, natural and actual range and status of species of marine mammals and reptiles;
  - Population dynamics, natural and actual range and status of seabirds;
  - Population dynamics, natural and actual range and status of non-indigenous, exotic species;
  - Population dynamics, natural and actual range and status of other species occurring in the marine region or subregion which are the subject of Community legislation or international agreements;
- Other characteristics;
- Pressure and impacts:
  - Physical loss;
  - Physical damage;
  - Other physical disturbance;
  - Interferences with hydrological processes;
  - Contamination by hazardous substances;
  - Systematic and/or intentional substances emission;
  - Nutrient enrichment and eutrophication;
  - Biological disturbance.

The overview of the Adriatic Sea characteristics was elaborated considering documents and reports provided (mainly on-line) by various agencies, institutions and organizations as well as the principal scientific literature. Among consulted sources, particular relevance was given to the: United Nation Environmental Programme Mediterranean Action Programme (UNEP-MAP), European Environmental Agency (EEA) and Joint Research Centre (JRC) of the European Commission. For the western part of the Adriatic Sea most relevant information was acquired from: the Italian Higher Institute for Environmental Protection and Research (ISPRA), the Italian National Environmental Ministry (MATTM) and Italian local environmental authorities (ARPA). Particular useful was the on-line available initial assessment of Italian marine regions, elaborated by ISPRA and MATTM[5].

Draft version of chapter 3 was circulated among Shape partners, in particular those involved in Action 4.2: Emilia Romagna Region (Italy), Regional Development Centre Koper (Slovenia), Public Enterprise for Coastal Zone Management (Montenegro), Abruzzo Region (Italy), and Puglia Region (Italy). Partners' feedbacks were than integrated in the report.

5 http://www.strategiamarina.isprambiente.it/consultazione/documenti-per-la-consultazione; last access 17 June 2013.

In relation to Actin 4.2 Work Plan, Shape project (in particular Action 4.2) could not take in consideration the highly relevant information included in the Croatian-language document "Initial assessment of the state of and pressure on the marine environment of the Croatian portion the Adriatic Sea" issued by the Croatian Ministry of the Environment and Nature Protection in September 2012[6]. This information can be surely used in a future step to evolve and improve the present first contribution to the initial assessment of Adriatic waters according to requirements defined by art. 8 of MSFD.

Finally, activities performed under action 4.2 included a survey on MSFD (according to Annex III – Indicative list of characteristics, pressures and impacts) data and information available at Shape partners involved in this specific action. The survey was conducted through five structured tables (four referring to Table 1 of Annex III and 1 to Table 2 of Annex III), in particular: (i) Table 1. Characteristics - Physical and chemical features; (ii) Table 1. Characteristics - Habitat types; (iii) Table 1. Characteristics - Biological features; (iv) Table 1. Characteristics - Other features; (v) Table 2. Pressures and impacts. For each MSFD data typology the tables describe the following information:

- Data availability;
- Data owner; i.e. agency, department, office, etc., that can provide data;
- Most recent available data, with the indication of the related year;
- Data format (table, map, checklist, etc.);
- Any other useful information.

Annex 1 of the present document includes tables provided by the following partners: Veneto Region, Emilia Romagna Region, Marche Region, Abruzzo Region, Puglia Region, Regional Development Centre Koper (for Slovenia), Public Enterprise for Coastal Zone Management (for Montenegro).

3.1 General features

The Mediterranean is a semi-enclosed sea, connected to the Atlantic Ocean through the narrow Strait of Gibraltar, to the Red Sea by the man-made Suez Canal and to the smaller enclosed Black Sea via the narrow Bosporus Strait. In the Mediterranean Sea, two basins of almost equal size can be identified: the western basin and the eastern basin. The Adriatic Sea is part of the eastern basin and extends northward between Italy and the Balkans, communicating with the eastern Mediterranean basin through the Strait of Otranto.

The Adriatic Sea has a surface area of 138,600 km^2, a volume of 33,000 km^3 and its shape can be approximated as a rectangle extending north-northwest, about 800km long and 200 km wide. The Adriatic receives a large amount of freshwater from numerous rivers, with total annual average reaching about 5,700 m^3/s. Of this amount, about 28% (1,585 m^3/s) comes from the Po river in the north-western corner and shallowest part of the basin. The second most important freshwater inflow is the set of Albanian rivers and surrounding drainage bringing in average 923÷1,244 m^3/s. The connection with the rest of the Mediterranean is given by the Strait

[6] http://www.mzoip.hr/doc/More/Pocetna_procjena_morski_okolis.pdf; last access 15 May 2013.

of Otranto, which connects the Adriatic to the Ionian sea and is the narrowest part of the Adriatic Sea; the area is characterized by a wide and deep inlet (72 km wide and 780 m deep), which has an important role in determining the circulation pattern and the water properties between the Ionian and the Adriatic Seas.

The Adriatic sea has its own typical features, both at land and sea. Although part of the wider Mediterranean Sea, it is a semi-enclosed, narrow sea area solely connected to the rest of the Mediterranean through the Strait of Otranto. The northern and north-western coastlines are characterized by shallow waters and sandy beaches. The eastern part of the sea is deeper, rocky and contains many islands and islets. The deepest parts of the Adriatic are located in the south.

The Adriatic sea can be divided into three main basins (Figure 3-1):

- Northern basin;
- Central basin;
- Southern basin.

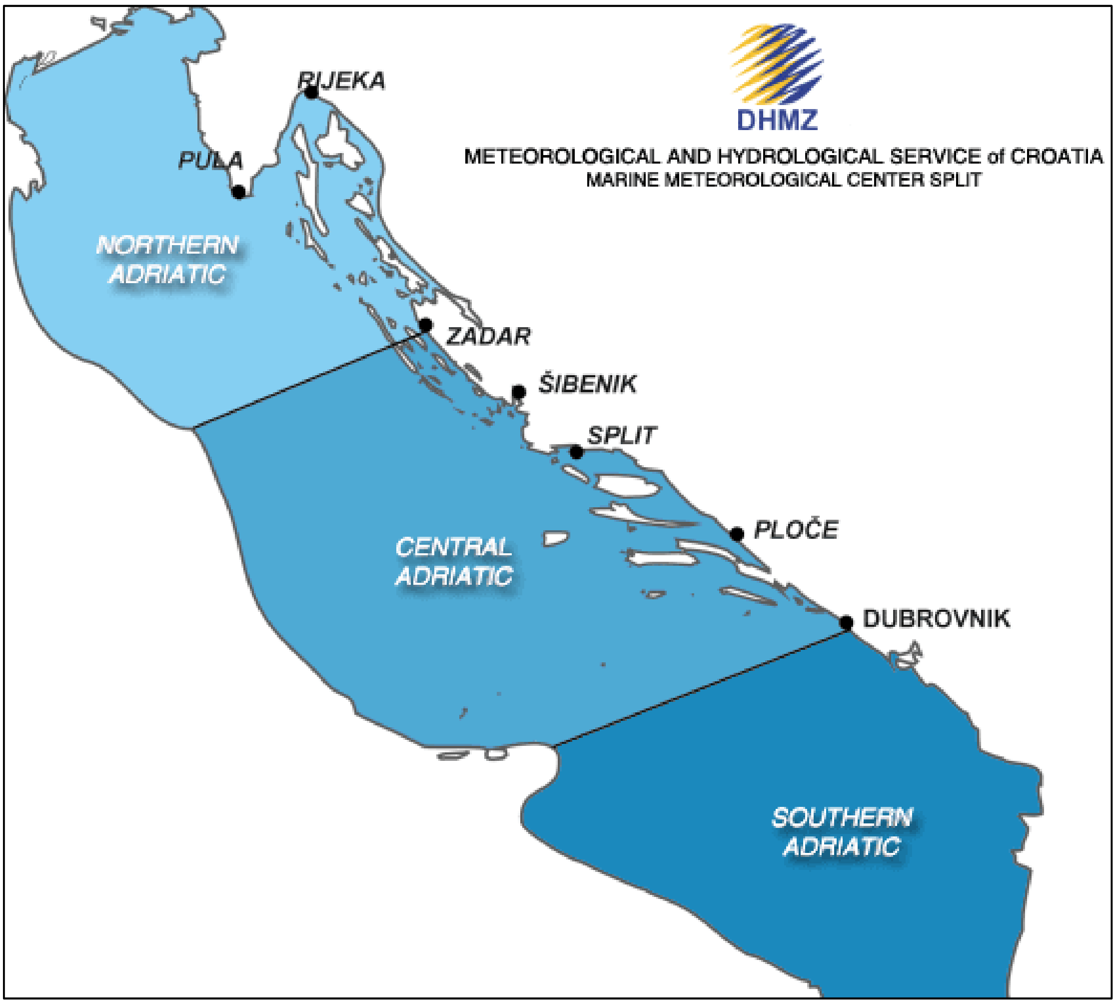


Figure 3-1 Adriatic sea basins (Source: Croatian Meteorological and hydrological Service, http://www.dhmz.htnet.hr/index_en.php, last access 22 November 2012).

The northern Adriatic basin spans from the Gulf of Venice and Trieste to the line joining Ancona and Zara. It includes the Gulf of Quarnaro, in which there are many islands. The seabed slope of the northern basin with an average depth of 35 m has truly coastal characteristics and gently goes down to a depth of 70-75 m. This basin has many peculiarities that make it one of the most studied seas in the world. The chemical and physical properties of its waters are strongly influenced by the water supply of Po (the largest Italian river), and by many other important rivers in the Alps and Apennines. Furthermore, its low depth stimulates a strong heating of the water column in summer.

The central Adriatic basin extends from the ideal line joining Ancona and Zadar to the line joining the Gargano Peninsula and Lastovo. The most important morphological characteristic of this section of the basin is the presence of a very deep area, called Jabuka trench, or Pomo trench. Despite this important morphological element, the central Adriatic is not too different from the northern Adriatic basin.

The Southern Adriatic basin extends from the Gargano - Lastovo alignment to the parallel of Otranto. The basin has an elongated shape in the northwest-southeast direction, sub-parallel to the coast of Puglia and to the Dalmatian - Albanian coast. The basin is characterized morphologically by the depression of the basin of Otranto.

The Adriatic Sea is bordered by six coastal states in total (Figure 3-2): Albania, Montenegro, Bosnia and Herzegovina, Croatia, Slovenia, and Italy. The share of Adriatic Sea coastline belonging to each country differs greatly. Croatia has by far the longest coastline of the six Adriatic countries. Including more than 1,000 islands, the Croatian coastline amounts to almost 6,000 km (30.5% mainland and 69.5% islands), which is approximately 75% of the total length of the Adriatic coastline. The Italian coastline accounts for 15% of the total Adriatic coastline length, while the remaining countries of the Adriatic are characterized by shorter coastlines. Slovenia and Bosnia and Herzegovina have the shortest coastlines in the Adriatic Sea basin, respectively 47 and 23 km. Apart from large differences in terms of coastline length, there are considerable imbalances in terms of share in maritime activities. Table 3-1 summarizes the coastline length of the Adriatic countries, number and surface of islands and islets and maritime zones characteristics.

Figure 3-2 The Adriatic Sea basin and its coastal states (Source: Policy Research Corporation, 2011; based on Vidas, D., 2008).

Table 3-1 Coastline length and maritime zones in the Adriatic Sea basin (modified by Policy Research Corporation, 2011[7]).

	Albania	Bosnia Herzegovina	Croatia	Italy	Montenegro	Slovenia
Adriatic coastline length (km)	362	23	5,835	1,300	294	47
Islands and islets (km^2)	n/a	n/a	3,300	n/a	5.65	n/a
Territorial sea (width) (nm)	12	Treaty signed; not ratified	12	12	12	Established, but no agreement
Territorial sea (km^2)	6,210		31,710	n/a	2172	n/a
Continental shelf (width) (nm)	North: 25 South: 2-4	n/a	Extends outside of Croatia's territorial waters to the median line	Extends outside of Italy's territorial waters to the median line	NW: rt Oštro (9,5nm) SE: mouth of river Bojana (34nm)	n/a
Continental shelf (km^2)	n/a	2.4	44,850	n/a	3,079	n/a
Ecological and fishery protection zone	-	-	In force, but does not apply to EU Member States	-	-	-
Ecological protection zone	-	-	-	Framework legislation was passed in 2006; up until today, no EPZ established	-	Established in 2005 (no agreement)

7 Data on Montenegro provided by Montenegro Shape partner (Montenegro Public Enterprise for Coastal Zone Management) based on Republic of Montenegro (2007).

3.2 Physical and chemical features in the Adriatic Sea

3.2.1 Topography and bathymetry of the seabed

Depth and topography of the seabed directly and indirectly influence most ocean environmental conditions, including sedimentation, current movements and stratification, and thus temperature and oxygen gradients, light penetration and photosynthesis. These parameters influence species distribution patterns and productivity in the oceans. They may be considered the foundation for any standardized classification of ocean ecosystems and important correlates of metrics of biodiversity.

The Adriatic Sea bathymetry is characterized by transversal and longitudinal asymmetries. The eastern coast is generally high and rocky, whereas the western coast is low and mostly sandy (Artegiani et al. 1996). The north-western part of the basin is very shallow, starting with a depth of about 15 m along the Venice –Trieste coastline, increasing slowly southward and then sharply reaching about 270 m in the Middle Adriatic Pit (MAP). To the South of this pit depth rises to the 170 m – deep Palagruza Silla, separating the MAP from the much deeper and round shaped South Adriatic Pit (SAP). This abyssal depression reaching a depth slightly over 1200 m marks the deepest part of the Adriatic. Further South, the bottom rises again, forming the Otranto Sill (780 m), which separates the Adriatic from the Ionian Sea. The transversal asymmetry of the Adriatic consists in a different morphology of the coastal areas: the western coastline is relatively smooth and regular with no islands and a gentle shelf, while the eastern coastal area is characterized by many Dalmatian islands and a very irregular bottom increasingly steeply in the offshore direction. The following bathymetry map (Figure 3-3) shows the water depth of the Adriatic Sea in meters.

Along the Italian coasts of the northern sector (Figure 3-4), the -10 m isobath is very far from the shoreline, and this distance increases along the coasts of the Emilia Romagna region, where it lies at a distance of 6 km from the coastline. The -50 m isobath stops south of the parallel of Cape Promontore that marks the southernmost point of Istria. The depth of the Adriatic, near the islands of the Gulf of Kvarner is higher, although the maximum depth rarely exceeds 100 m. Instead there is a substantial difference in the morphology of the seabed and in the protruding geological formations. Regarding the coastline of the north-western Adriatic, going towards the open sea, perpendicular to the shore, the seabed has a break of gradient in correspondence with the isobaths between the -20 m and -25 m, which is particularly relevant in front of the Po river delta. From Rimini to the Gargano (Puglia Region) this feature is still present and the seabed in front of the coast is almost flat (Van Straten, 1970). From Trieste (Friuli Venezia Giulia region) to San Benedetto del Tronto (Marche region) the seabed has roughly a depth of -20 m.

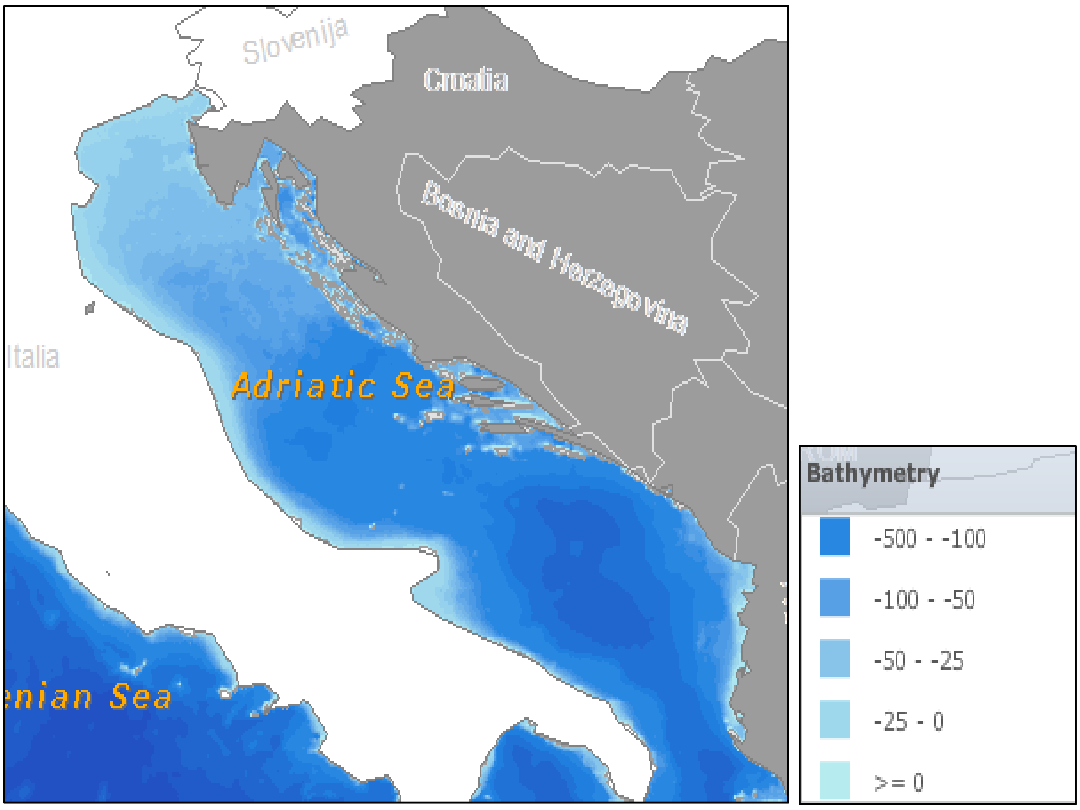


Figure 3-3 Adriatic bathymetry (Source: European Atlas of the Sea; http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/, last access 22 November 2012).

Of particular relevance in the north western part of the basin are some elevations from the seabed called "tegnue" (rocky outcrops) of different dimensions and heights, which can be found until approximately 29 m depth and 20 km from the coast. They play a relevant role from the biodiversity point of view and can derive from (Regione Marche and Zara County, 2008):

- Sedimentary deposits with chemical origin (beach rock);
- Destruction of coral reef due to marine undertow (cracks of reef);
- Sandstone.

The central Adriatic basin is on average 140 m deep, the most important morphological characteristic of this section of the basin is the presence of a very deep area, called Jabuka trench, or Pomo trench which includes three small basins with a maximum depth of just over 250 m and is oriented northeast-southwest. The Southern Adriatic has an elongated shape in the northwest-southeast direction, sub-parallel to the coast of Puglia and to the Dalmatian-Albanian coast. The basin is characterized morphologically by the depression of the basin of Otranto. In this area the depth is about -1200 m and rises up to -800 m at the Strait of Otranto. Figure 3-5 resumes Adriatic bottom profile along the NW - SE axis.

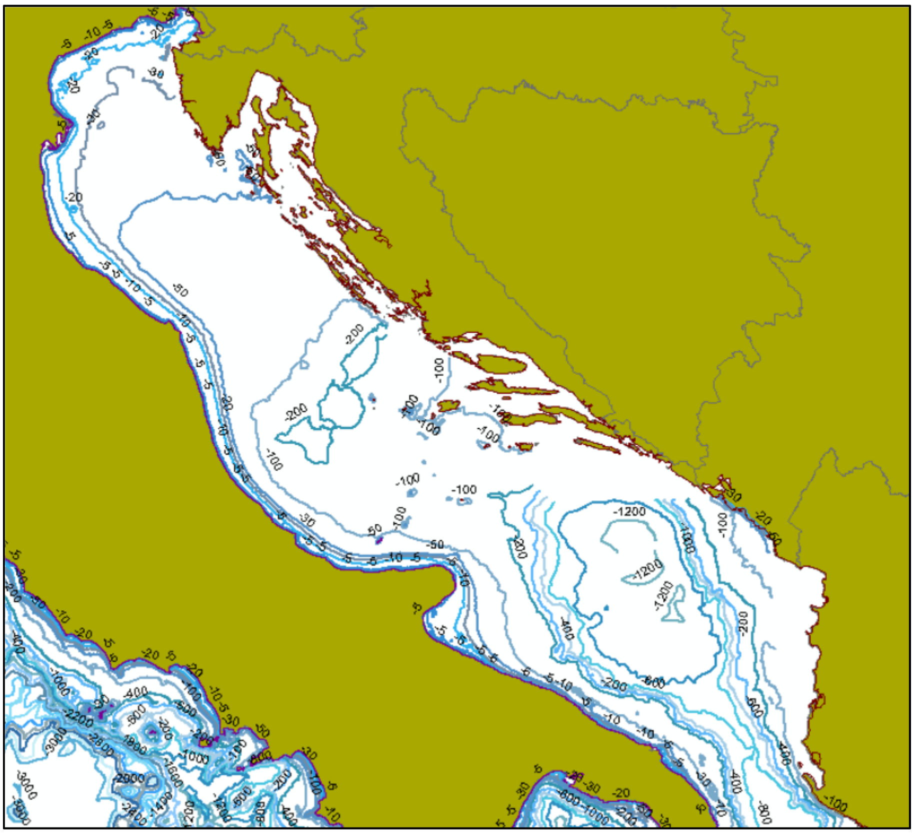


Figure 3-4 Adriatic Sea bathymetry (Source: ISPRA, 2012).

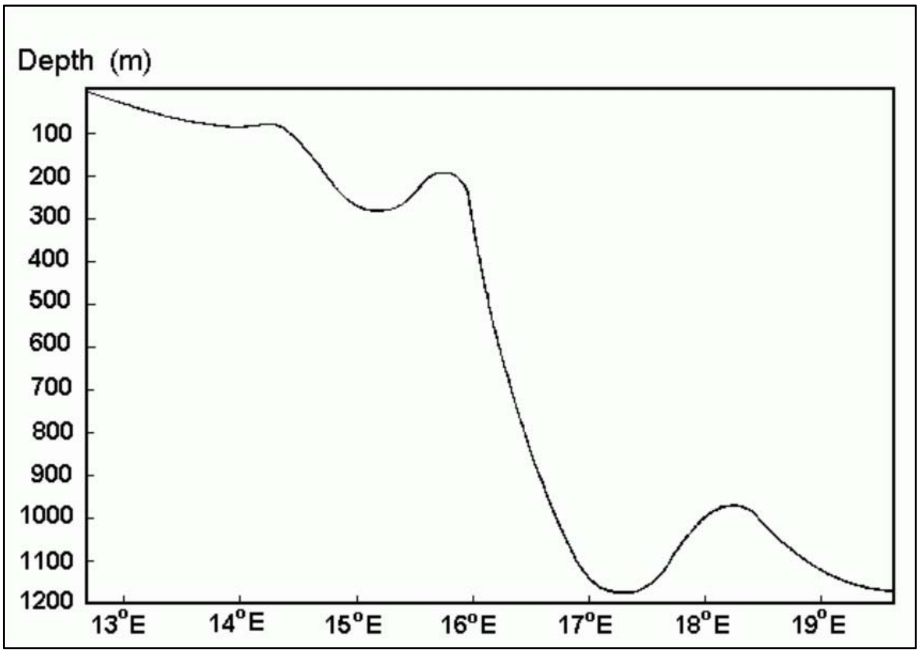


Figure 3-5 bottom depth of the Adriatic Sea along the NW - SE axis (Source: Franic, 2004).

3.2.2 Annual and seasonal temperature regime

The sea surface temperature (SST) is one of the most important characteristics of the sea surface and one of the most widely observed oceanographic parameters. The sea surface is characterized by a remarkable temporal and spatial homogeneity of temperature, primarily due to the large heat capacity and efficient mixing processes. The meteorological factors affecting the SST are the net radiation to or from the sea surface, evaporation and precipitation processes and the heat exchange with the atmosphere. The increase in the SST can greatly impact the marine ecosystems and is important also for climate studies. The map showed in Figure 3-6 shows the annual average sea surface temperature, based on satellite observations made by the European Commission Joint research centre using the EOS MODIS-A (NASA GSFC) sensors for year 2009.

Going deeper into seasonal details, information derived by the study provided by ISPRA (2012) within the process of MSFD implementation in Italy and based on satellite data collected during MARCOAST project (Marine and Coastal Environment Information Services)[8] realized within the GMES Service Elements program coordinated by European Space Agency ESA-2011 and a study elaborated by Regione Marche and Zara County (2008), show that (Figure 3-8 and Figure 3-8):

- During winter north Adriatic coastal waters are colder than others of the basin; lower temperatures are associated with fresh waters derived from Po river (BÖhm et al., 2003). In the southern part of the basin it is instead visible the Adriatic western cold current and, on the opposite coast, the entrance of the Ionian sea into the south Adriatic eddy (gyre). Ionian waters are visible because they have a higher temperature and they continue their course northward along the coastline until Istria peninsula. A thermal gradient exists both along the transversal and longitudinal axis of the basin, with average temperatures lower than 7 °C in the north (also caused by heat losses derived from Bora wind) and higher than 13 °C in the south eastern regions;
- During spring the situation is very changeable reflecting the transition between winter and summer season; it's difficult to discern water mass circulation in the north Adriatic with the exception of warmer waters near Po river delta;
- During summer the lowest thermal variability is observed. Coastal upwelling in the middle Adriatic causes lower temperatures offshore Dalmatian coastlines. These waters expand in the middle of the central Adriatic generating a wide cooler water area in the sea surface temperature (SST). In the south Adriatic, water coming from Ionian sea is visible as cold water. The entrance of Ionian waters continue northward along the coastline until Istria peninsula;
- During autumn in the north Adriatic is visible a colder coastal water flux. The western Adriatic current is clearly visible in the SST maps from November to March. In the south Adriatic the cold western current and opposite the entrance of the Ionian sea into the south Adriatic eddy (gyre) can also be seen. Ionian waters are warmer during autumn and winter and they continue their course northward along the coastline until Istria peninsula (BÖhm et al., 2003).

[8] http://www.marcoast.eu/; last access 17 June 2013

In the whole basin seasonal temperature excursions exceed 10°C, clearly due to the heat flux exchanged with the atmosphere (Artegiani et al., 1996).

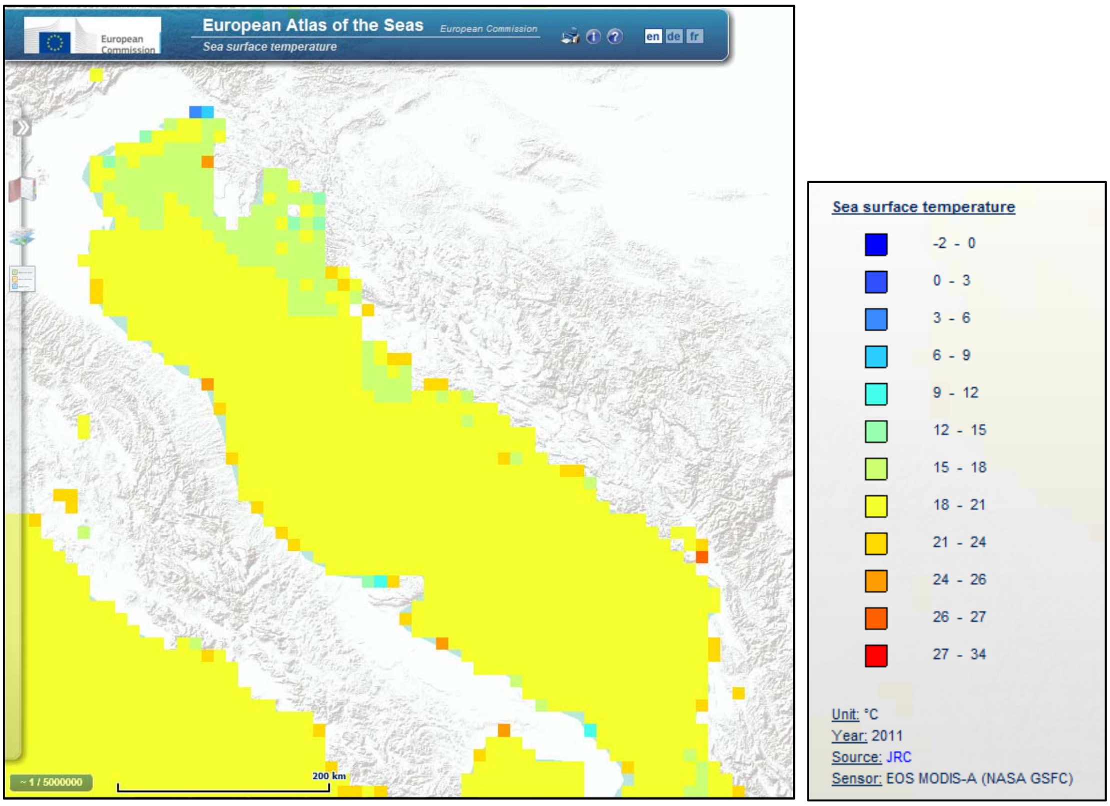


Figure 3-6 Annual average Adriatic sea surface temperature (Source: European Atlas of the Sea; http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/, last access 17 June 2013).

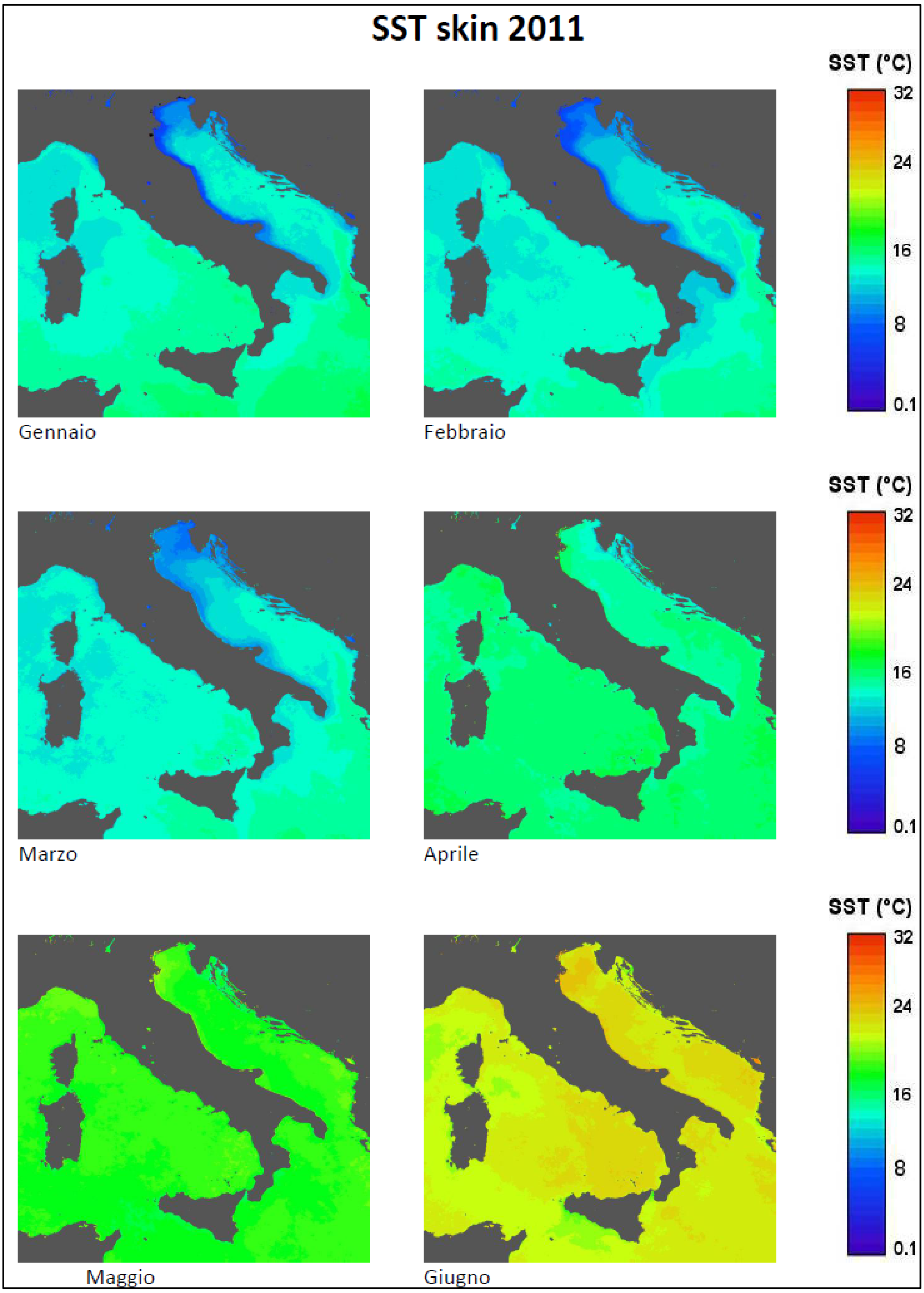


Figure 3-7 Adriatic year 2011 sea surface temperature (SST) January – June 2011 (Source: ISPRA, 2012).

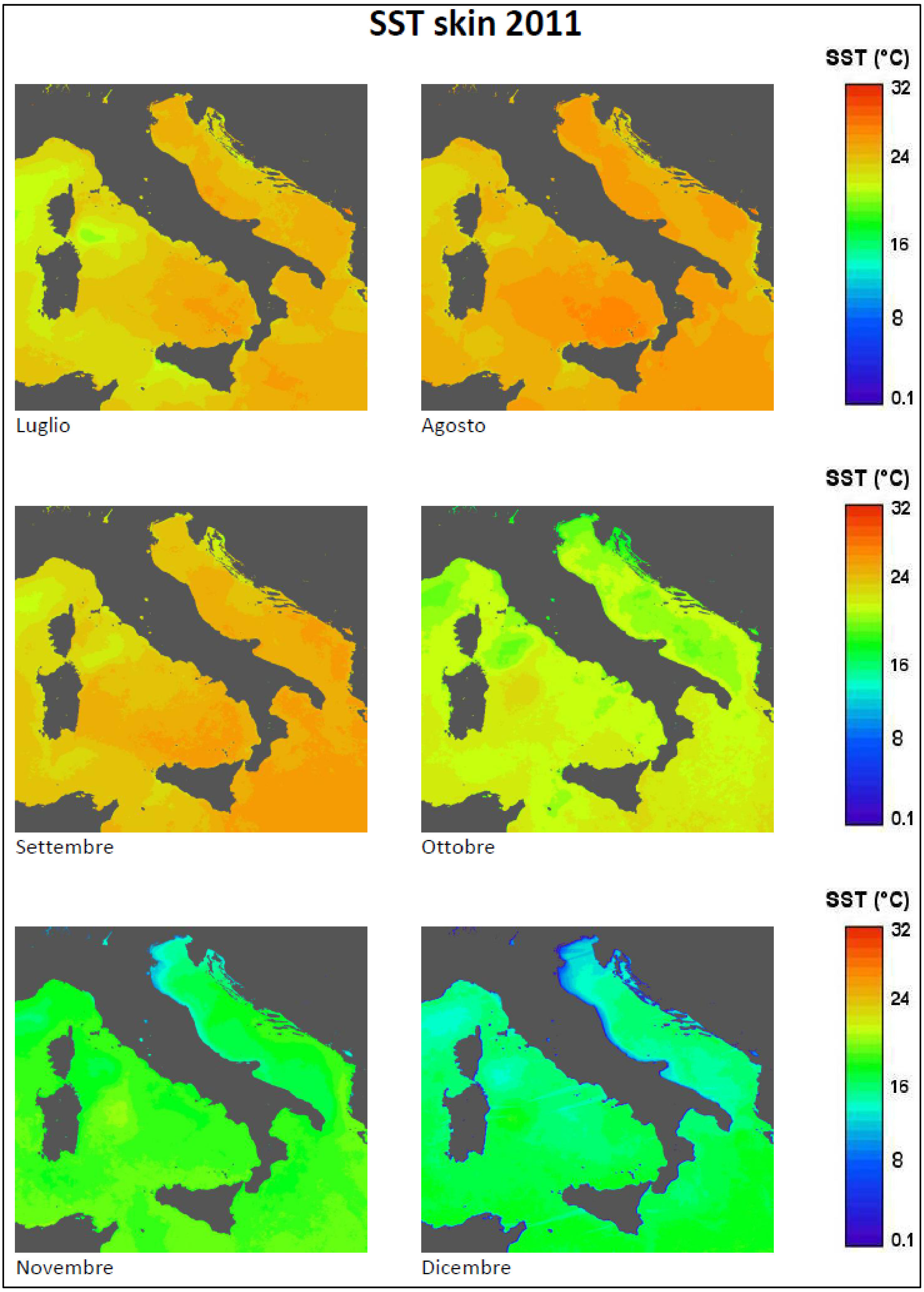


Figure 3-8 Adriatic year 2011 sea surface temperature (SST) July – December, 2011 (Source: ISPRA, 2012).

Concerning the temperature along the water column in the three Adriatic regions, results derived from Artegiani et al (1996), based on a dataset which includes measurements of temperature in the periods 1911-14 and 1947-83 are shown in Figure 3-9. Three regions with homogeneous physical water properties have been defined: the northern Adriatic extending up to the 100-m isobath in the south, the middle Adriatic characterized by the Pomo Depressions up to the Vieste transect, and the southern Adriatic up to the Otranto Channel.

Focusing on the north and middle Adriatic, seasonally average temperature values measured at different depths (at the surface, at 10, 20 50 m and at the bottom) are provided by Table 3-2 (data derived from a specific study of Regione Marche and Zara county, 2008).

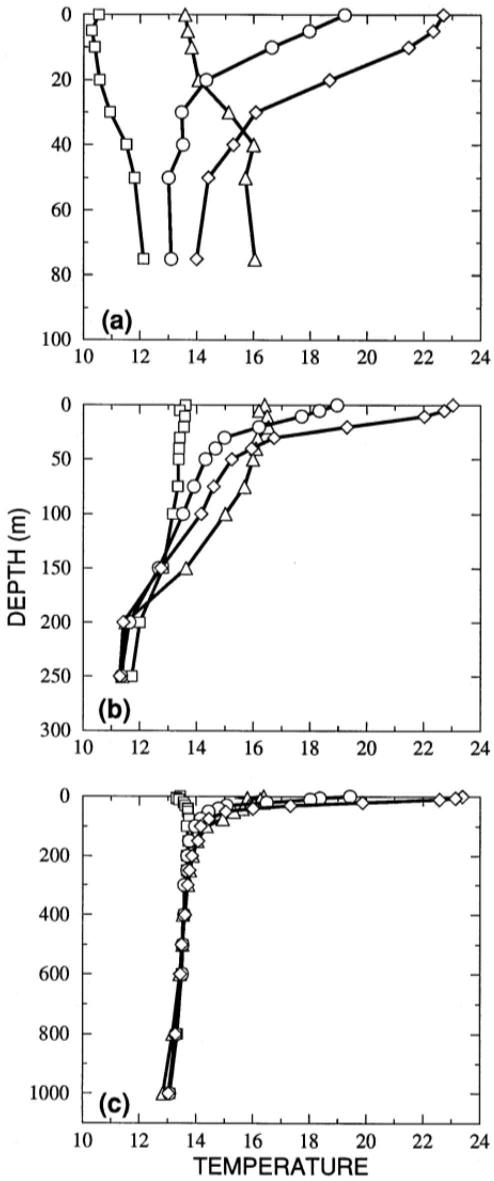


Figure 3-9 Seasonal climatological profiles of temperature (°C) for (a) northern, (b) middle, and (c) southern Adriatic for winter (□), spring (o), summer (◊), and autumn (Δ) (Source: Artegiani et al., 1996).

Table 3-2 average seasonal temperature for north and middle Adriatic at different depths (values in °C) (Source: Regione Marche and Contea di Zara, 2008).

Season	T at the surface	T at 10 m	T at 20 m	T at 50 m	T at the bottom
Winter	11.56	-	-	12.69	12.25
Spring	17.30	16.07	14.71	13.35	12.73
Summer	24.47	23.25	19.29	14.29	15.52
Autumn	18.14	-	-	15.57	-

In the northern Adriatic the entire water column exhibits an evident seasonal thermal cycle. A well-developed thermocline is present in spring and summer down to 30-m depth, whereas a significant cooling begins close to the surface in autumn when the bottom temperature reaches its maximum value, probably due to increased vertical mixing and intrusion of middle Adriatic waters. Only in winter the cooling of the whole water column occurs; in this season temperature generally increases down to the bottom.

In the middle Adriatic the spring–summer thermocline is formed down to a depth of 50 m. In the layer from 50 to 150 m the seasonal temperature changes are still observed. The middle Adriatic deep water has relatively low average temperature and from spring to autumn it has the coldest bottom water mass in the entire Adriatic basin.

In the north and middle Adriatic it can be noted that temperature changes at 10 and 20 m depth are quite similar to variations at the surface, especially during winter and autumn due to mixing processes, while differences are found during spring and summer; at 50 m depth seasonal thermal variability is reduced with values ranging between 10 and 18 °C. At the bottom instead an increased thermal variability is observed due to bathymetry; in particular where seabed is lower (western coast) during winter colder waters are observed while during summer high values are registered.

In the southern Adriatic the seasonal thermocline extends down to approximately 75 m. The southern Adriatic deep water again has different average characteristics from the other water masses of the basin. It has warmer and saltier waters compared to north and central Adriatic.

3.2.3 Mixing characteristics and current velocity

Mediterranean sea is a semi-closed basin connected with the Atlantic ocean through Gibraltar strait and with Black sea through Dardanelli strait (Figure 3-10). It is an evaporative basin where surface evaporation is not balanced with rainfall; the balance is consequently obtained with water entrance from the Gibraltar strait. Atlantic waters, with lower salinity values, enter in the Mediterranean surface water and span along Algerian coastline (Carillo et al 2011). Mediterranean circulation is consequently forced by water exchanges through the Gibraltar and Dardanelles Straits, by wind stress and by large freshwater fluxes and intense winter heat fluxes. In a very schematic way, the Mediterranean Sea thermohaline circulation can be described as a large scale anti-estuarine buoyancy-driven circulation with fresher surface waters inflow and subsurface saline waters outflow at Gibraltar (Oddo et al. 2009).

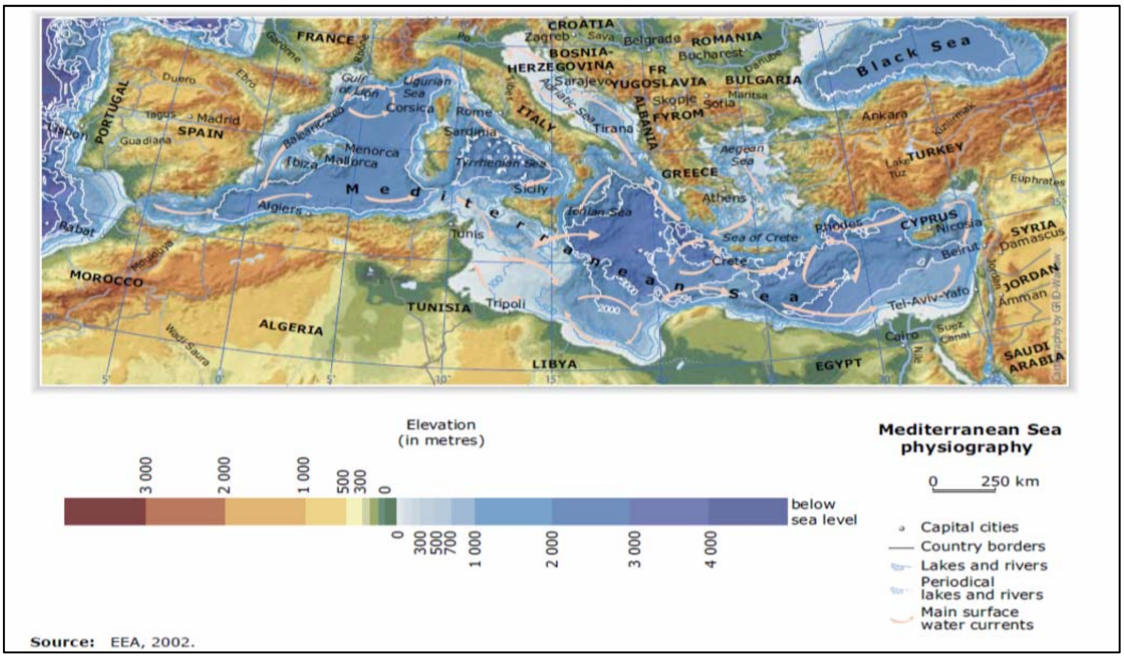


Figure 3-10 Depth and distribution of the main currents in the Mediterranean (EEA, 2005).

Concerning the Adriatic Sea, its hydrodynamic characteristics are extremely complex; in many ways, it can be considered as a small scale model of ocean circulation. During its annual hydrological cycle, the basin changes its own hydrodynamic characteristics from those of a vertically homogeneous system to those specific of a stratified basin. In general, the Adriatic Sea is characterized by the sinking of cold and heavier water in winter (and therefore there is a complete mixing), by a significant surface heating in summer, and by the presence of heavy rainfall and high runoff from the rivers, especially Po, in spring and autumn.

The general circulation of the Adriatic Sea and its seasonal and inter-annual variations depict a general cyclonic circulation with three cyclonic gyres in the northern, central and southern sub-basins, an intensified WACC (Western Adriatic Coastal Current) flowing along the Italian shoreline exiting the Adriatic through the Otranto Straight and counterbalanced by a northwestward flow of warm and salty water along the eastern side, named EAC (Eastern Adriatic Current) (Simoncelli et al, 2010).

Figure 3-11 illustrates current and gyres at the surface and in the upper thermocline. The circulation regime varies seasonally and inter-annually in response to changes in the heating and wind regimes. In particular at the surface winter general circulation is composed only of segments of currents: North Adriatic current (NAd) and Eastern South Adriatic current (E-Sad). During spring and summer Western Middle Adriatic (W-MAd), Southern Middle Adriatic (W-SAd) currents and two main gyres (MAd and SAd gyres) appear; lastly autumn is characterized by the maximum coherence in the general circulation structure. In fact, there are three cyclonic gyres, a continuous western Adriatic boundary current, connected between the three sub-basins, and an intense SAd current (Artegiani et al, 1996).

Figure 3-12 shows a summary scheme of Adriatic circulation including also bottom current, which transports southwards cold and thick waters generated during winter in the north Adriatic.

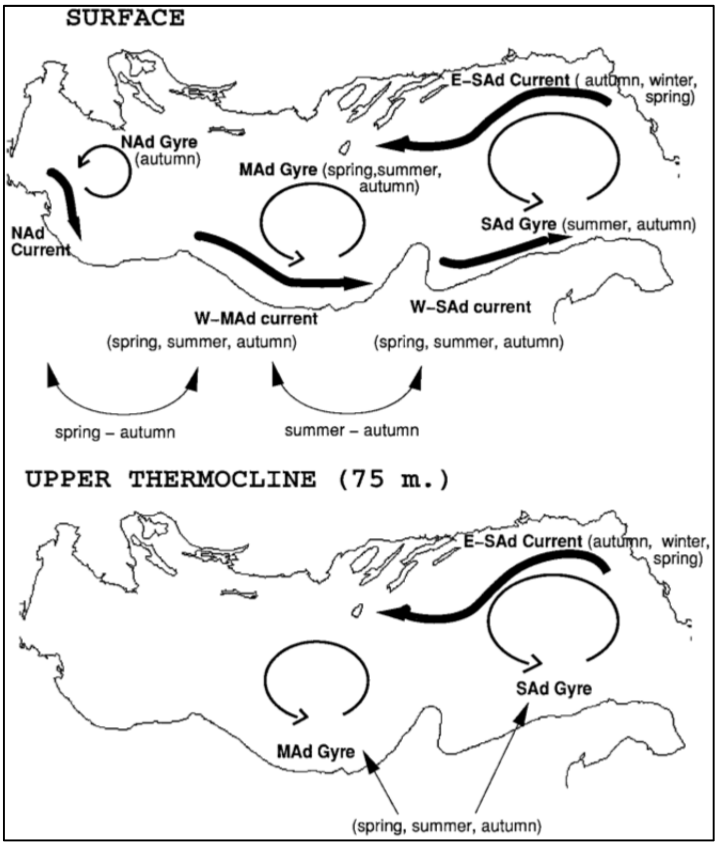


Figure 3-11 Schematic of the Adriatic Sea baroclinic circulation (Source: Artegiani, et al., 1996).

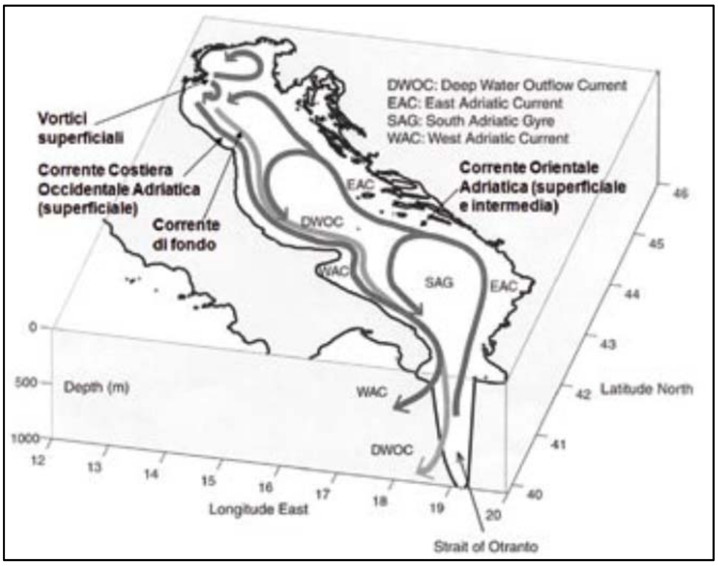


Figure 3-12 summary scheme of the Adriatic circulation (Source: Regione Marche and Contea di Zara, 2008).

This circulation derives from temperature and salinity differences which generates diverse densities and has three major components, perhaps equally important for the overall Adriatic dynamical engine:

- River runoff, characterized by low salinity waters derived mainly from the Po and Albanian Rivers. The Po forcing produces compensation of temperature and salinity gradients horizontally and is an important component of the buoyancy budget in the overall basin. In fact, we have an overall heat loss together with a water gain, in contrast to the overall Mediterranean, which exhibits a water loss;
- Wind and heat forcing at the surface, which produce deep-water masses in the northern and southern Adriatic and forces the circulation to be seasonal;
- The Otranto Channel forcing, which provides heat and salt in the circulation as a restoring mechanism for the northern heat losses and water gains.

Regarding current velocity, the following figures, derived from ISPRA (2012), based on results emerged from European Projects MyOcean and MyOcean2 (validated by GNOO Gruppo Nazionale di Oceonografia Operativa – INGV), show the fluid dynamics in the free surface for a period of ten years (2001-2010). Current velocity data consist of monthly average velocities at 72 depth levels. Figure 3-13 shows the average velocity during the decade, while the other figures illustrate seasonal average velocity during the decade.

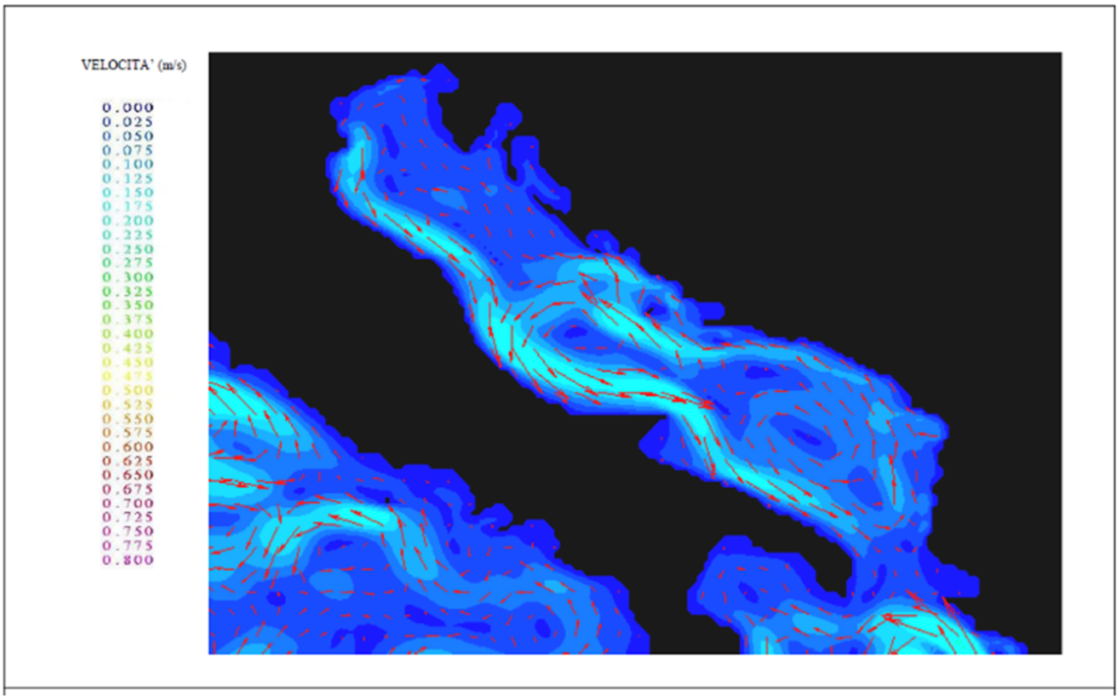


Figure 3-13 Average velocity in the free surface during the period 2001-2010 (Source: ISPRA, 2012).

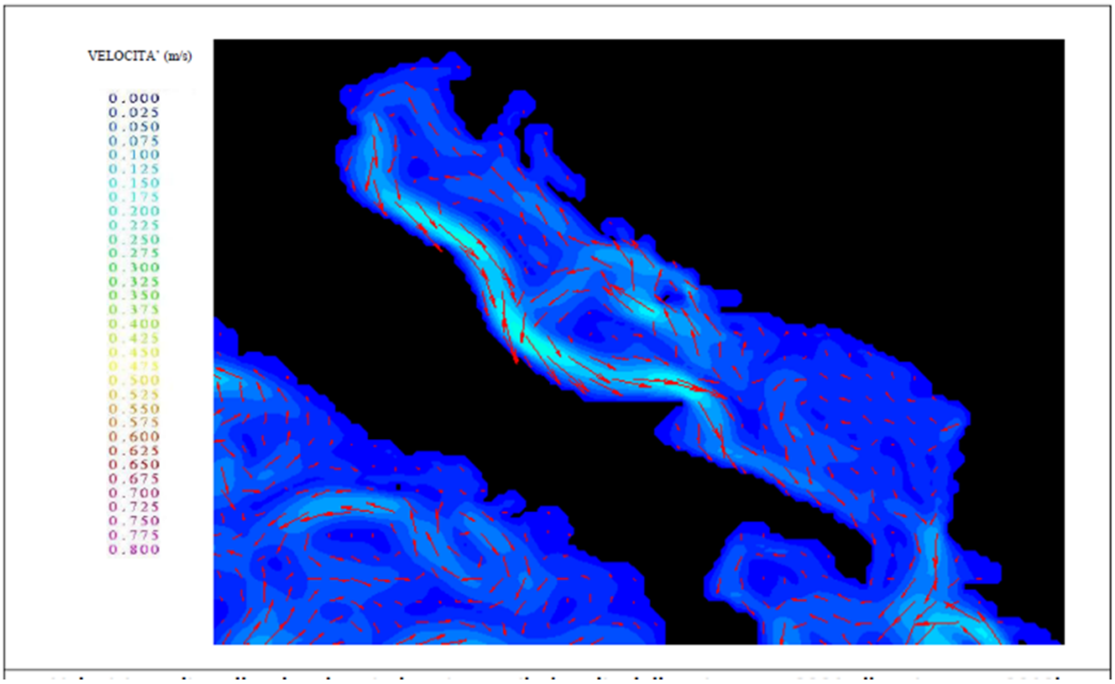


Figure 3-14 Average velocity in spring in the free surface during the period 2001-2010 (Source: ISPRA, 2012).

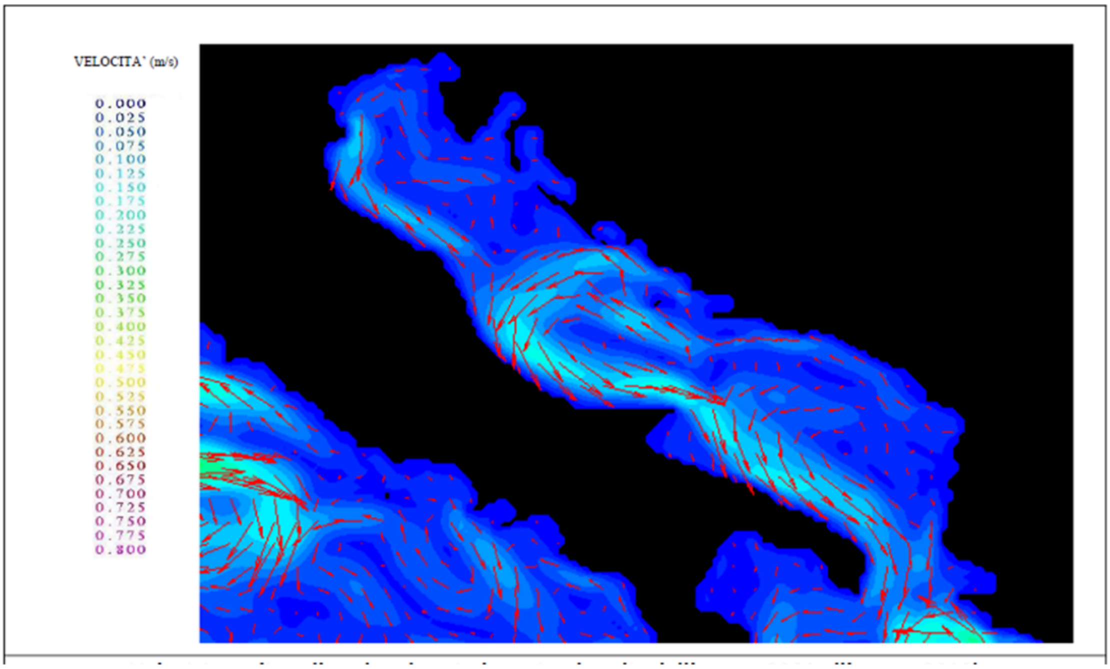


Figure 3-15 Average velocity in summer in the free surface during the period 2001-2010 (Source: ISPRA, 2012).

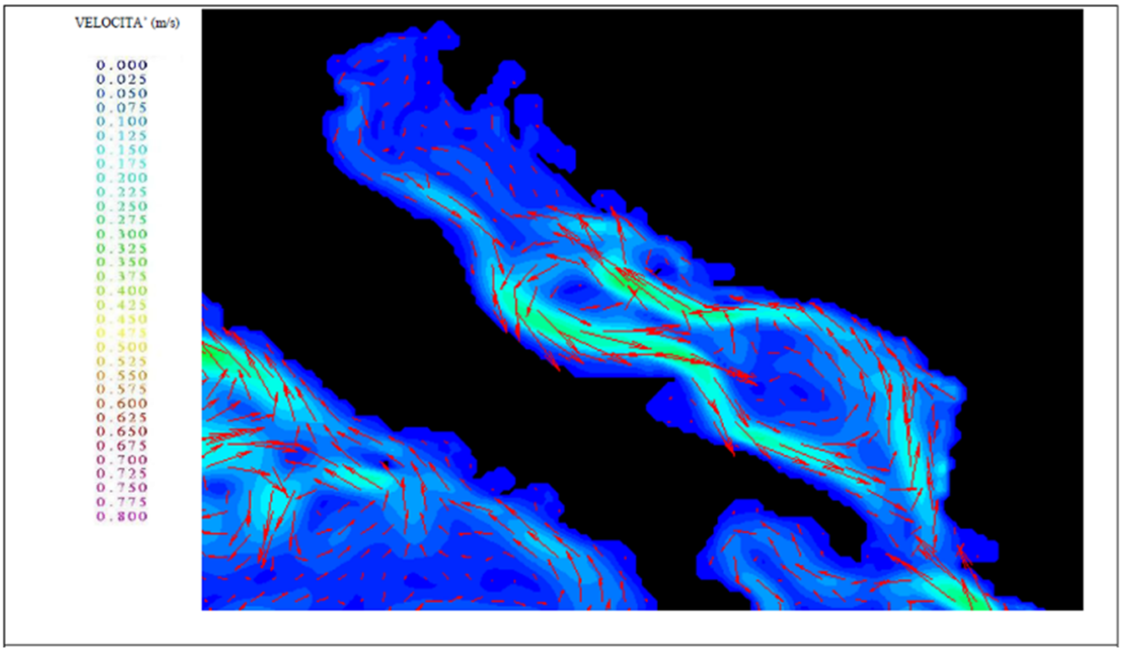


Figure 3-16 Average velocity in autumn in the free surface during the period 2001-2010 (Source: ISPRA, 2012).

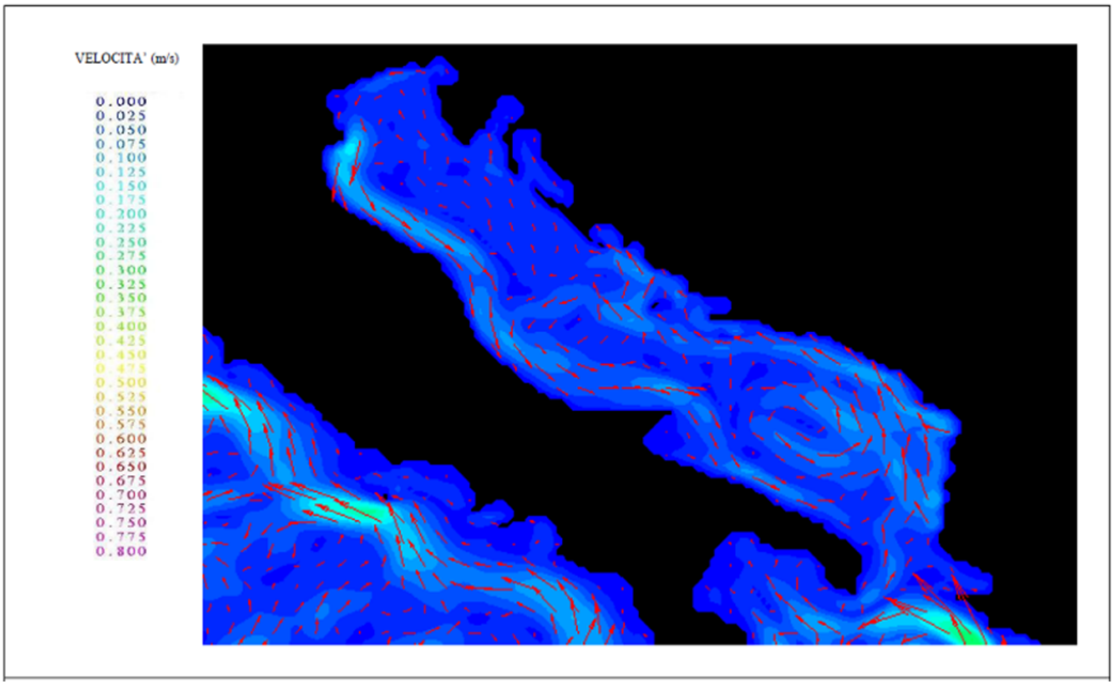
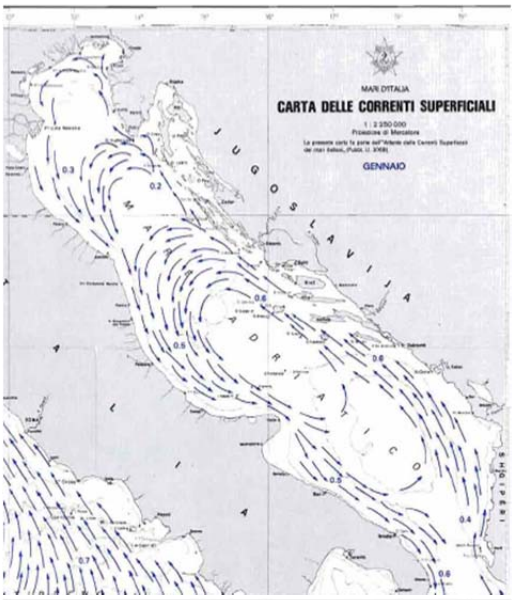


Figure 3-17 average velocity in winter in the free surface during the period 2001-2010 (Source: ISPRA, 2012).

As emerged from previous figures, the strongest currents are distributed in the central Adriatic, mainly during autumn and summer, along the whole Italian coastline and in the Otranto strait with velocities that in the central basin can be of 0.30-0.35 m/s. Monthly current maps are provided in the following figures, based on detection made by the Italian Navy Hydrographic Institute in 1982.


MARI D'ITALIA
CARTA DELLE CORRENTI SUPERFICIALI
1 : 2 250 000
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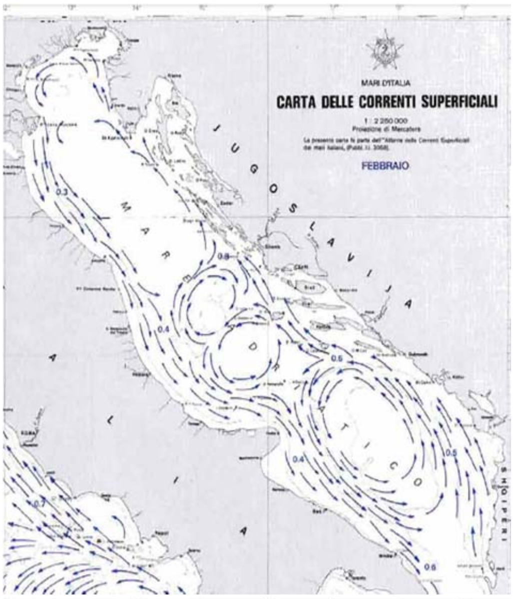
GENNAIO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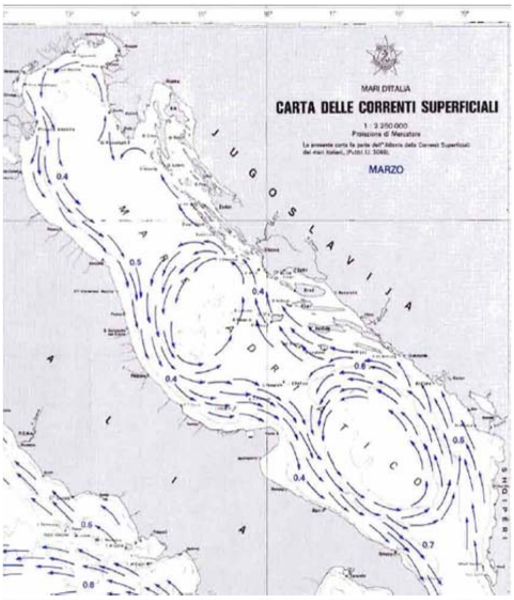
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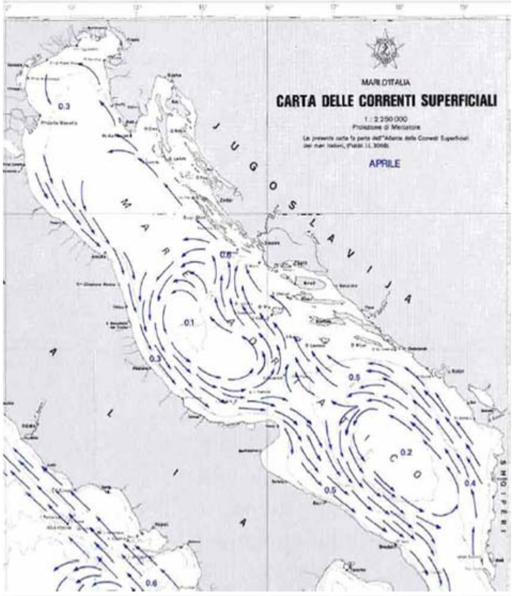
Proiezione di Mercatore
MARZO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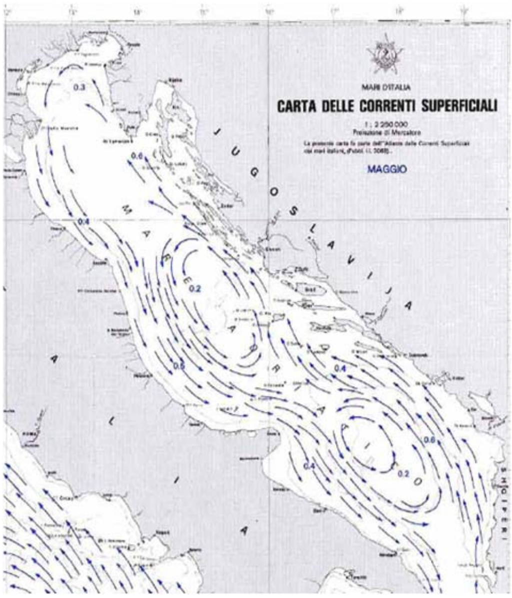
APRILE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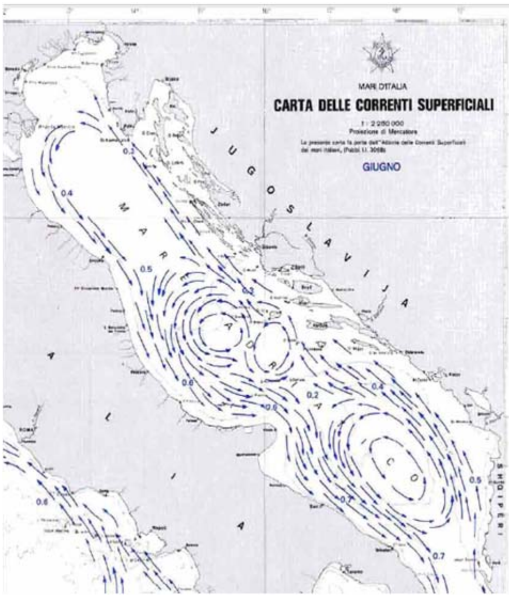
Proiezione di Mercatore
MAGGIO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Proiezione di Mercatore
GIUGNO

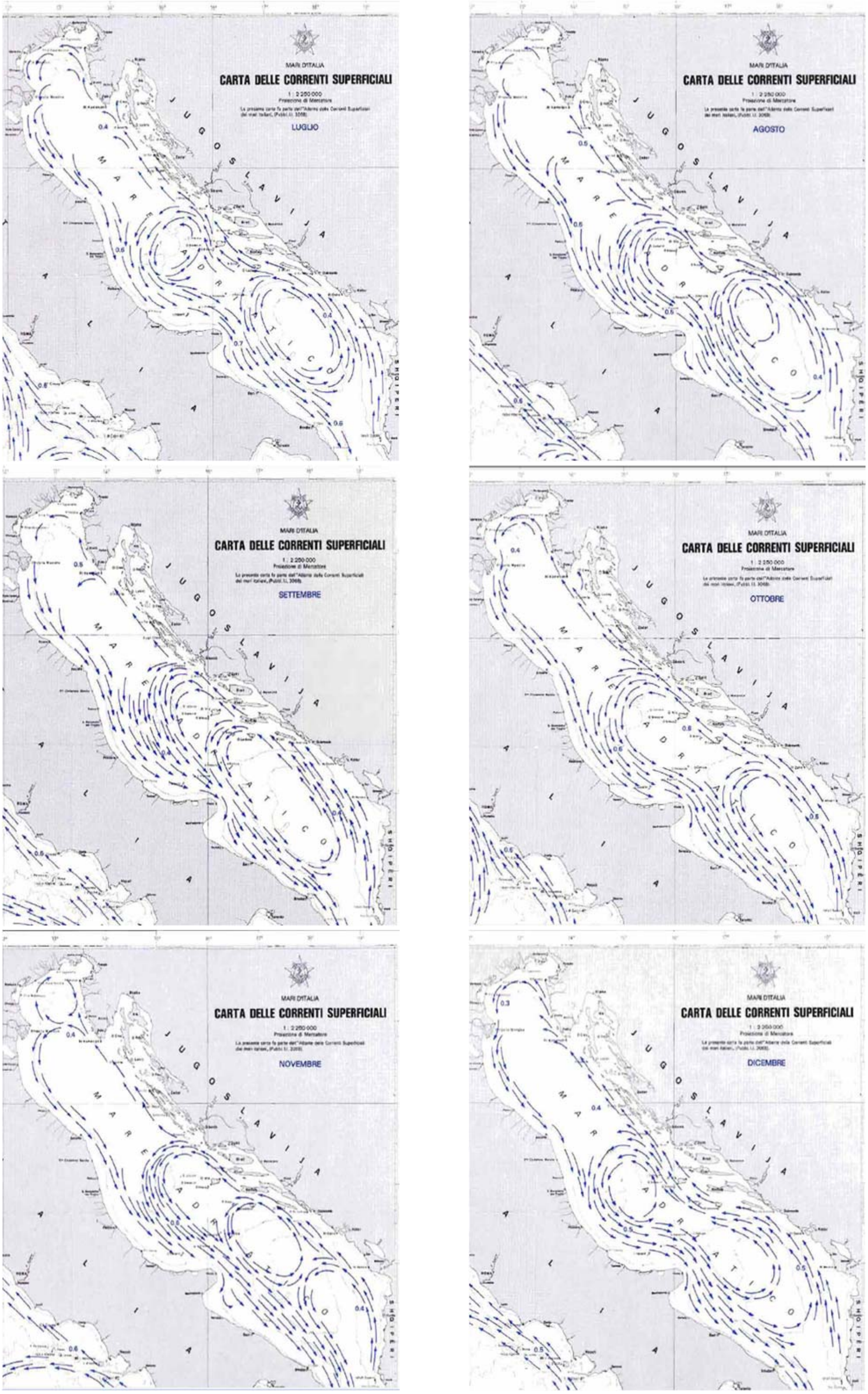


Figure 3-18 Map of monthly superficial currents, year 1982 (Source: Italian Navy Hydrographic Institute, 1982).

For more punctual and in real time data the "Mediterranean Ocean Forecasting System Bulletin" web site (GNOO Gruppo Nazionale di Oceonografia Operativa – INGV) releases each week an analysis of the current velocities for the entire Mediterranean, for different depths. In addition to this, every day a new 9 day forecast is released (see example in Figure 3-19).

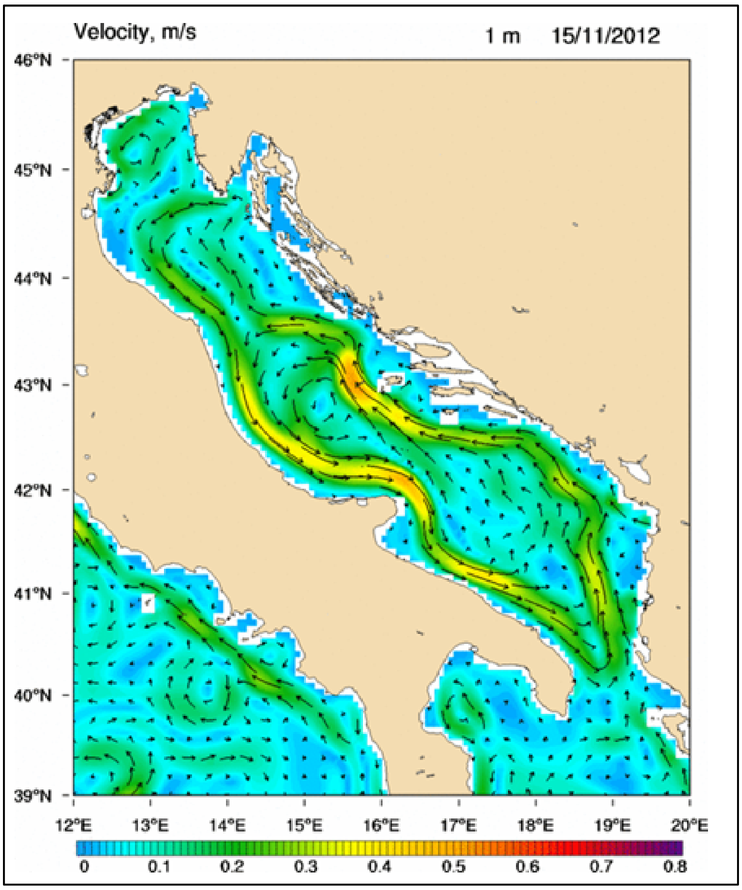


Figure 3-19 Adriatic current velocities at 1 m depth at 15/11/2012 (Source: GNOO, http://gnoo.bo.ingv.it/mfs/Forecast/velocity_A6.htm?link=H, last access 22 November 2012).

3.2.4 Upwelling

Upwelling can be defined as an "ascending motion, of some minimum duration and extent, by which water from subsurface layers is brought into the surface layer and is removed from the area of upwelling by horizontal flow" (Smith 1968). The phenomenon occurs seasonally in response to favourable wind conditions and current flows and is the combination of wind flux direction and Coriolis force. Coriolis force in the north hemisphere causes a deviation of water current of 90° in the right direction and consequently the net current movement takes a direction of 90° with respect to wind direction (Ekman effect) (Figure 3-20). In the boreal hemisphere coastal upwelling happens along coastline where winds blow along the coast direction with the sea on the right of the wind direction (Massetti, 2004).

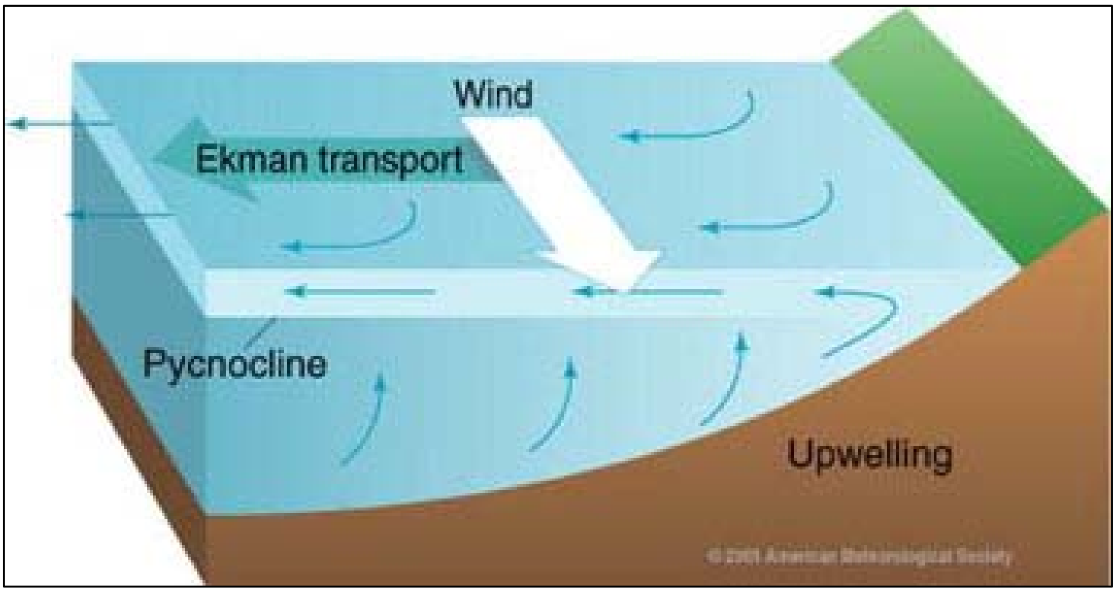
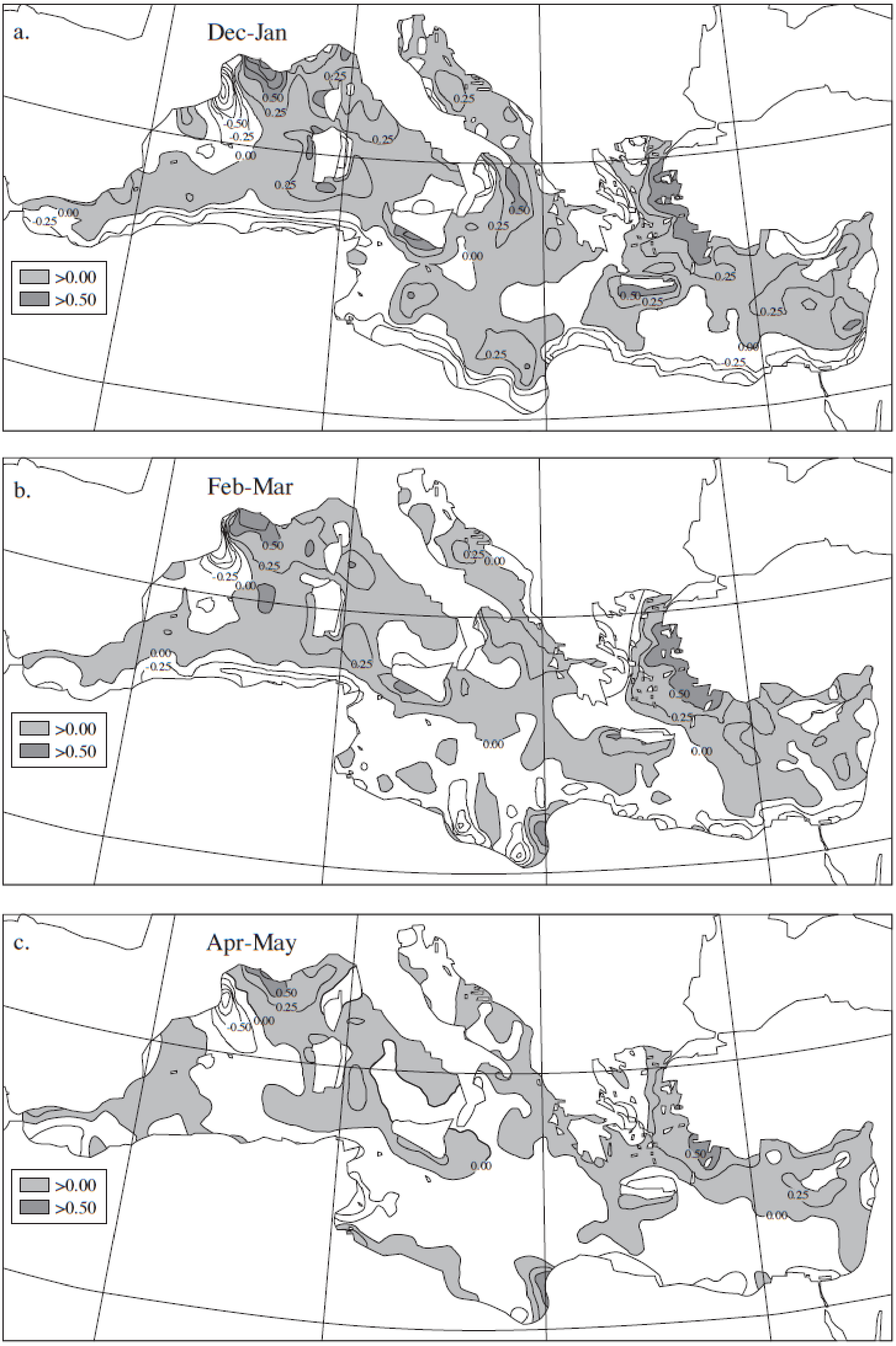


Figure 3-20 Coastal upwelling in the northern hemisphere (Source: Ocean Motion, http://oceanmotion.org/html/background/upwelling-and-downwelling.htm, last access 17 June 2013).

The effect of upwelling phenomenon is the upstream of cold water from higher depths, characterized by high nutrient concentration, which creates ideal condition for primary production growth. Circulation of the Mediterranean Sea is very complex and its interaction with processes of biological nature defines a variety of marine habitats. Offshore waters are typically considered as oligotrophic, nevertheless the enrichment of surface layers is assured by upwelling and water mixing. Upwelling and downwelling maps for the whole Mediterranean have been provided by Bakun and Agostini from the Comprehensive Ocean – Atmosphere Data Set database (Bakun and Agostini, 2001).

The following figures report the seasonal variation of wind-driven upwelling zones (shaded areas) and downwelling (un-shaded areas); darker shading indicates greater upward velocities.


a.
Dec-Jan
>0.00
>0.50
b.
Feb-Mar
>0.00
>0.50
c.
Apr-May
>0.00
>0.50

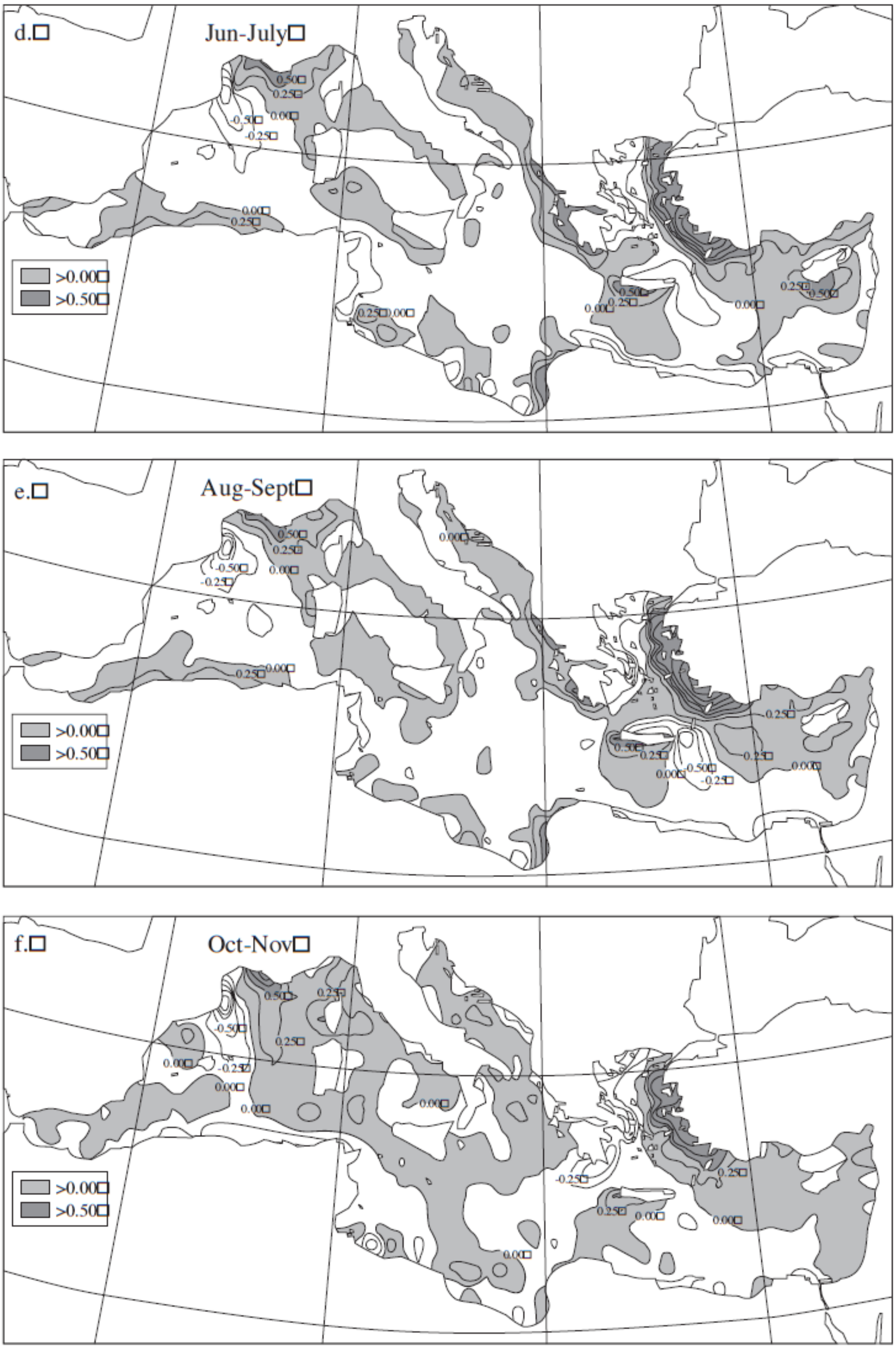


Figure 3-21 Seasonal variation of computed vertical velocities at the bottom of the surface Ekman layer. Units are meters per day. Contour interval is 0.25. Shaded areas indicate zones of upwelling. Darker shading indicates upward velocities greater than 0.5 m/day. Un-shaded areas indicate zones of downwelling; (a) Dec-Jan, (b) Feb-Mar, (c) Apr-May, (d) Jun-Jul, (e) Aug-Sep, (f) Oct-Nov (Source: Bakun and Agostini, 2001).

The Adriatic sea appears to be an area of rather weak average net wind stress, which tends to have a degree of clockwise tendency resulting in weak coastal upwelling on the Balkan side, weak to moderately strong coastal downwelling on the Italian side, and zones of moderate upward Ekman pumping in the interior (Bakun and Agostini, 2001).

Focusing on Italian Adriatic coastline, the study redacted by ISPRA (2012) within the process of MFSD implementation in Italy and based on 2009-2011 data on wind intensity and direction, has detected the following areas as potentially involved by the upwelling phenomenon:

- North Adriatic: Trieste, Venezia, Ravenna and Ortona. When wind blows from the south these areas can be subjected to upwelling. In particular higher probabilities are registered for Trieste and Ravenna;
- South Adriatic: stations in Vieste, Bari and Otranto confirm that the main wind direction which can generate upwelling is SE (Scirocco wind which typically blows from spring to autumn, is less severe than Bora but warmer and wetter and can generate opposite effects on currents with respect to Bora).

3.2.5 Wave exposure

Hydrodynamic factors profoundly impact the environment of coastal areas. Understanding the hydrodynamics of the coast is essential to manage the fragile coastal environment. Relevant processes that regulate hydrodynamic sea evolution are for example wind, energy dissipation, refraction and dissipation near coasts, energy exchange between different waves; these factors are all described by the wave motion model.

In particular the estimate of the wave parameters in coastal and estuarine environments is very important since hydrodynamic factors can profoundly impact the environment in coastal areas.

Map in Figure 3-22 shows the significant wave height in all directions in the Adriatic in nine monitoring stations for year 2005. The whole basin is characterized on average by low wave heights, which don't exceed 1 m.

Going deeper into single wave heights mean, with relative directions, measured in every station, the situation is summarized in Table 3-3 (values are expressed in meters). Numbers in Figure 3-22 corresponds to the stations reported in the table. The situation emerged underlines that:

- In the northern Adriatic main wave heights are generated by Scirocco and Bora winds (SE and NE);
- In the central Adriatic main wave heights are generated by SE. NW and N winds;
- In the south Adriatic main wave heights are generated by S and SE winds.

These results are also confirmed by ISPRA (2012) using data from WAM model of European Centre for Medium-Range Weather Forecasts (ECMWF), which evidences that yearly wave height mean is approximately 0.5 m, with minimum values in the north and maximum values in the southern Adriatic (0.7-0.8 m) (Figure 3-23).

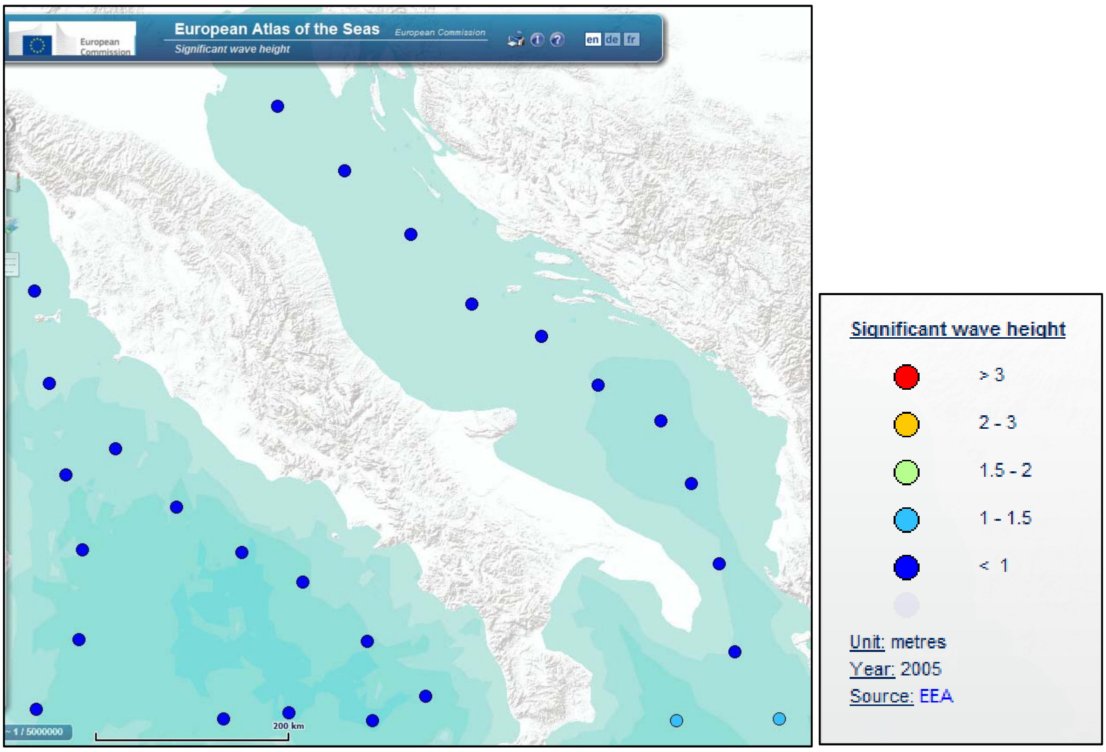


Figure 3-22 Significant wave height in the Adriatic (Source: Source: Source: European Atlas of the Sea; http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/, last access 17 June 2013).

Table 3-3 Significant wave height mean and direction for the Adriatic (Source: data elaborated on information derived from the European Atlas of the Seas; http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/).

Station	N	NE	E	SE	S	SW	W	NW	Omnidirectional average
1	0.41	0.74	0.52	0.85	0.52	0.29	0.41	0.26	0.52
2	0.48	0.67	0.49	0.93	0.45	0.21	0.36	0.37	0.52
3	0.62	0.63	0.53	0.98	0.46	0.19	0.38	0.50	0.58
4	0.70	0.55	0.57	1.04	0.52	0.25	0.42	0.62	0.64
5	0.75	0.48	0.56	1.15	0.68	0.44	0.53	0.77	0.73
6	0.71	0.42	0.54	1.06	0.75	0.43	0.55	0.82	0.71
7	0.64	0.47	0.47	0.91	0.90	0.39	0.52	0.74	0.67
8	0.62	0.44	0.43	0.82	0.96	0.32	0.47	0.67	0.63
9	0.85	0.43	0.36	0.97	1.12	0.45	0.47	0.73	0.75

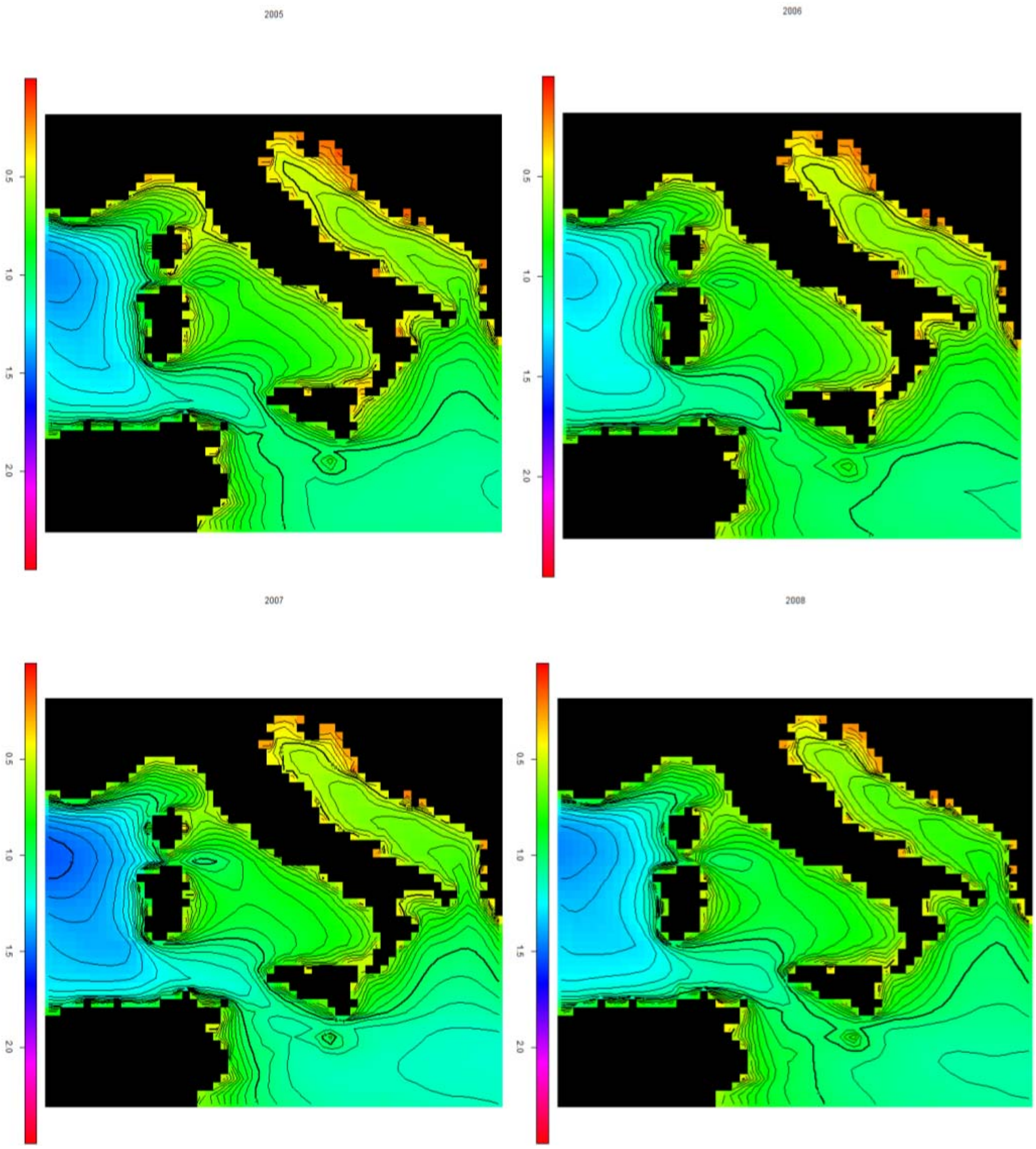


Figure 3-23 Yearly significant wave height mean during years 2005-2008 (Source: ISPRA, 2012).

Wave heights however are strictly seasonal and linked to atmospheric conditions. Data derived from Medatlas (2006) confirm that period with bigger wave heights are mainly autumn and winter (Figure 3-24 - Figure 3-27) and appear in middle south Adriatic. Each contour of the figures depicts the seasonal average value, expressed in meters, of mean wave heights.

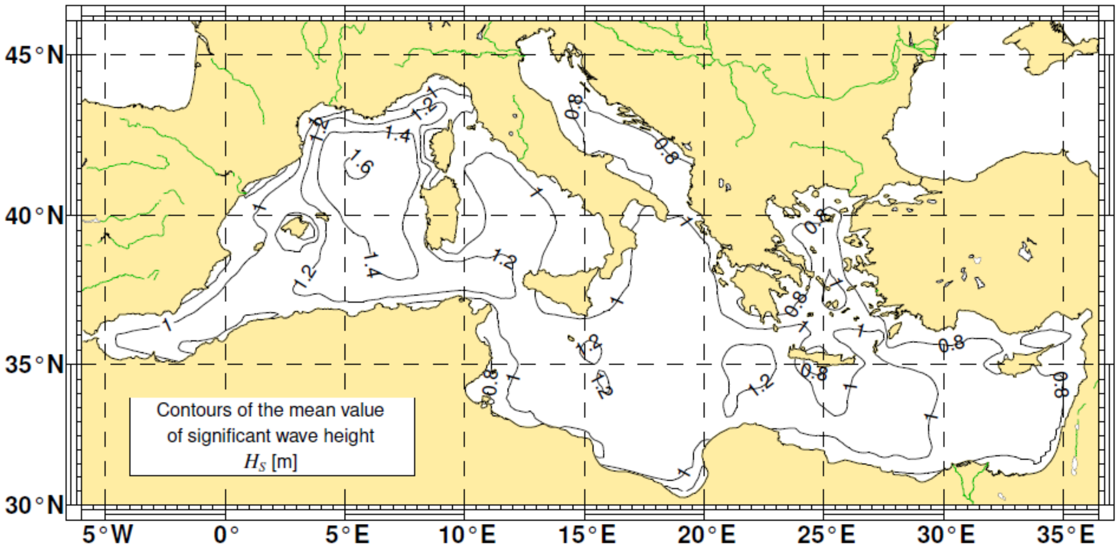


Figure 3-24 Spatial distribution of mean values of significant wave height during autumn (Source: Medatlas, 2006).

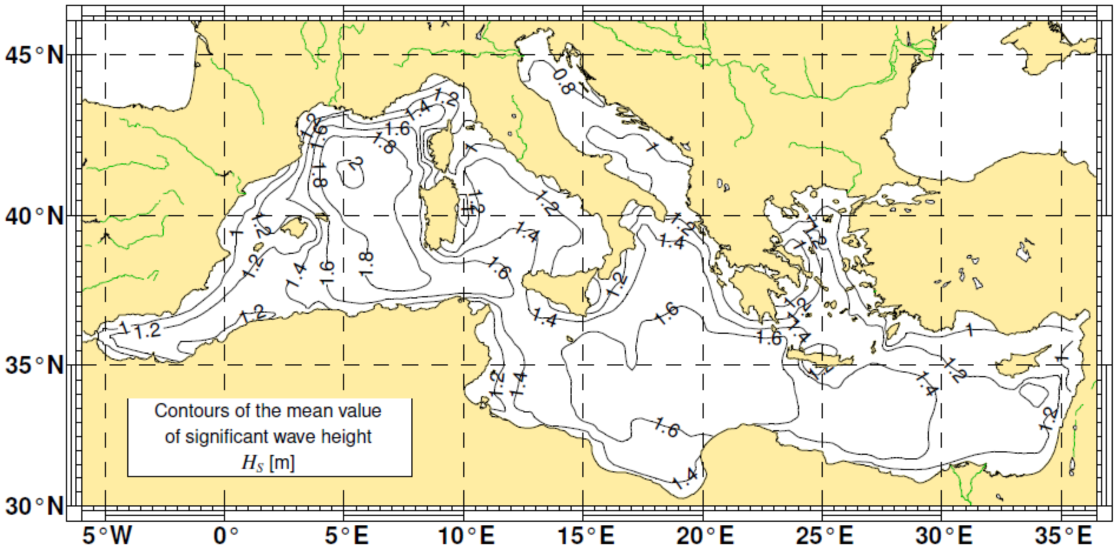


Figure 3-25 Spatial distribution of mean values of significant wave height during winter (Source: Medatlas, 2006).

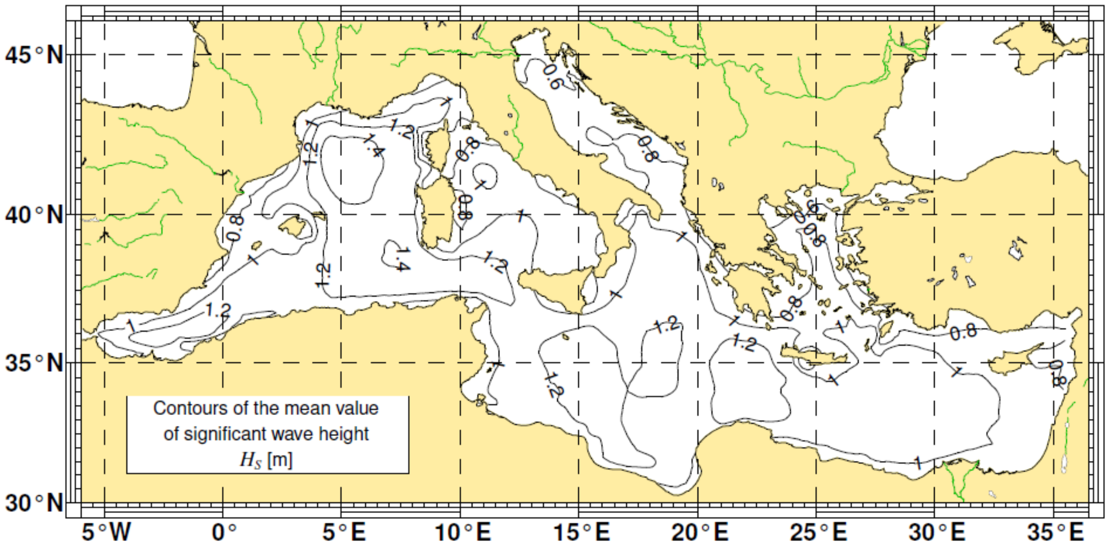


Figure 3-26 Spatial distribution of mean values of significant wave height during spring (Source: Medatlas, 2006).

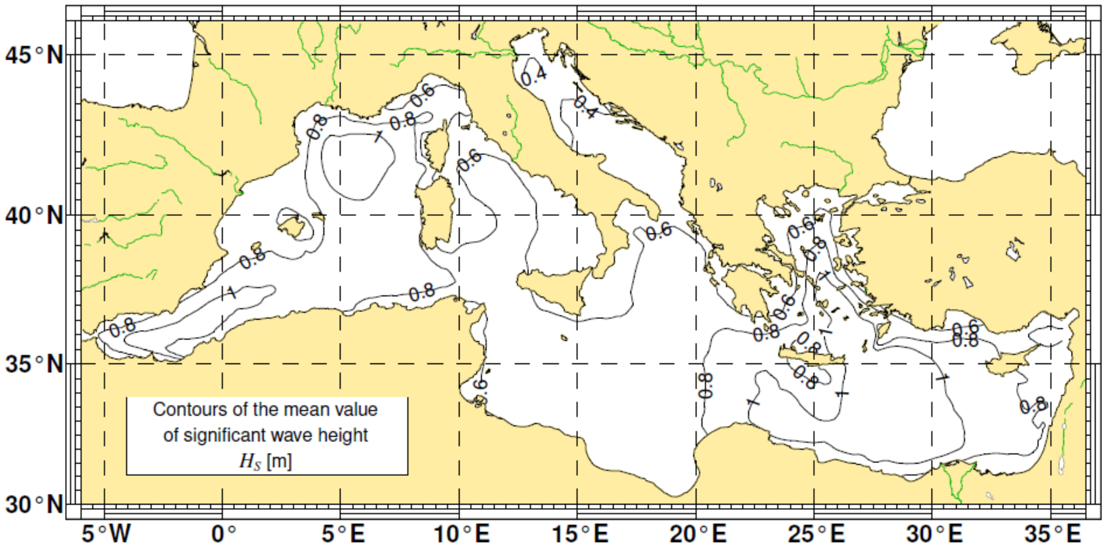


Figure 3-27 Spatial distribution of mean values of significant wave height during summer (Source: Medatlas, 2006).

Average yearly probabilities associated to different wave heights are summarized in the following figures. Curves represent isopleths, which are the locus of sites where the frequency of occurrence of the event ($H_S < H_{S;threshold}$ or $H_S > H_{S;threshold}$) has a constant value. This constant value (in %) is depicted on each isopleth. Wave heights considered are below 0.5 m, below 1.25 m, higher than 2.50 m, higher than 4.00 m.

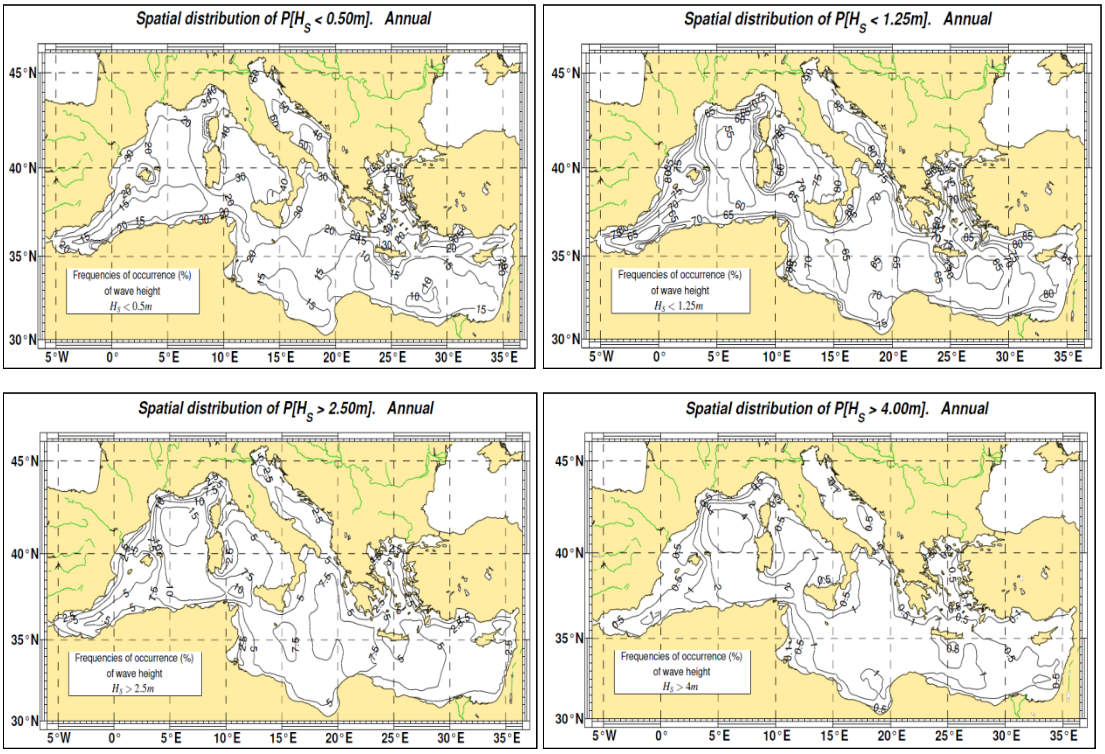


Figure 3-28 average yearly probabilities associated to different wave heights (Source: Medatlas, 2006).

Concerning wave directions, 2005 results for yearly mean and modal values in the Adriatic are quite different because in the basin there are more than one wave motion origin, generated by different winds (Scirocco and Bora in particular) (Figure 3-29 and Figure 3-30).

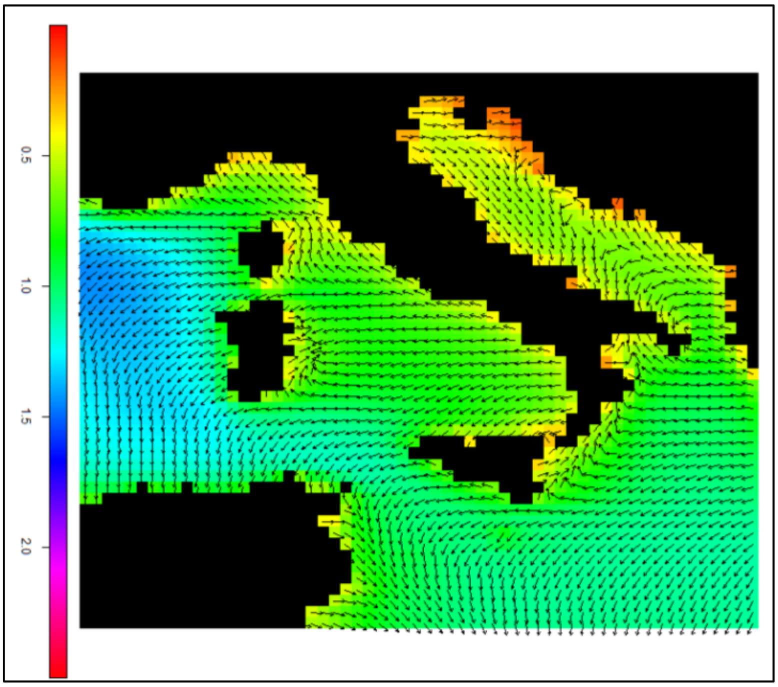


Figure 3-29 yearly wave direction mean year 2005 (Source: ISPRA, 2012).

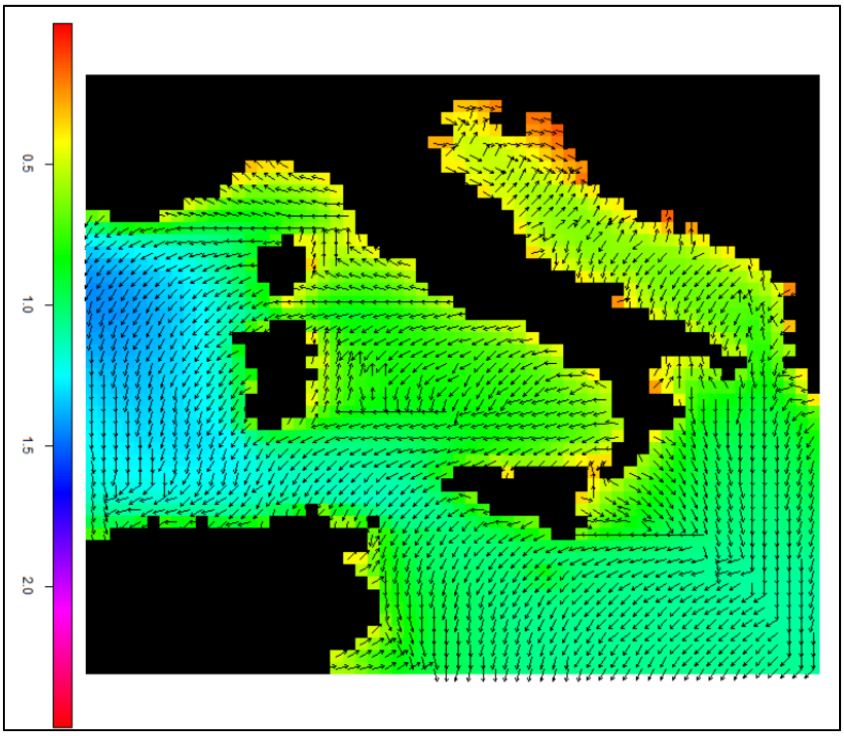


Figure 3-30 yearly wave direction mode year 2005 (Source: ISPRA, 2012).

For seasonal wave direction, data provided by Medatlas (2006) are showed in the following figures. Arrows show the direction from which waves come. The length of the arrows corresponds to the frequency of occurrence (%) of waves coming from the corresponding direction. Twenty four directions are considered. Only waves with significant wave height greater than 1 m are considered and wave directions with frequency of occurrence less than 10% are not drawn. As results in the Adriatic main wave directionality reflects SE and NE winds.

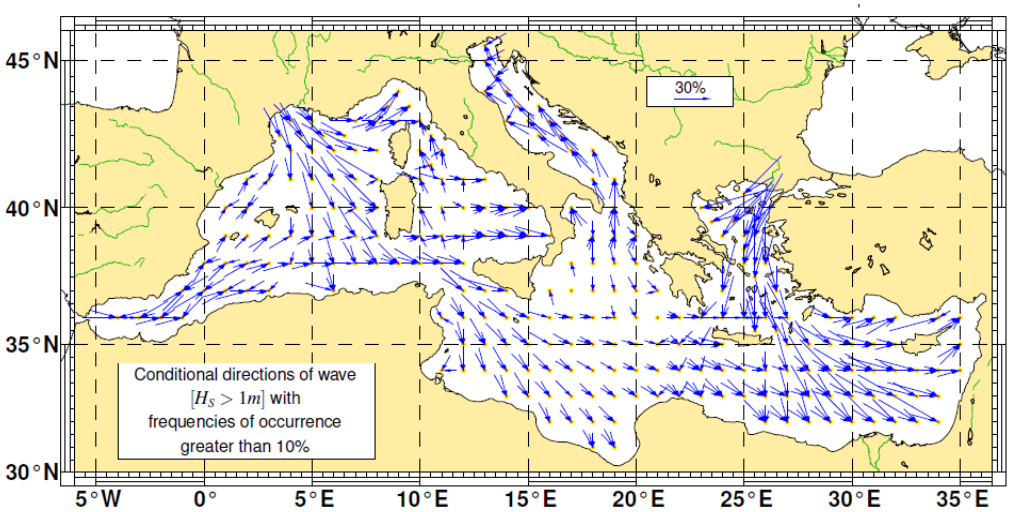


Figure 3-31 Spatial distribution of wave direction during autumn (Source: Medatlas, 2006).

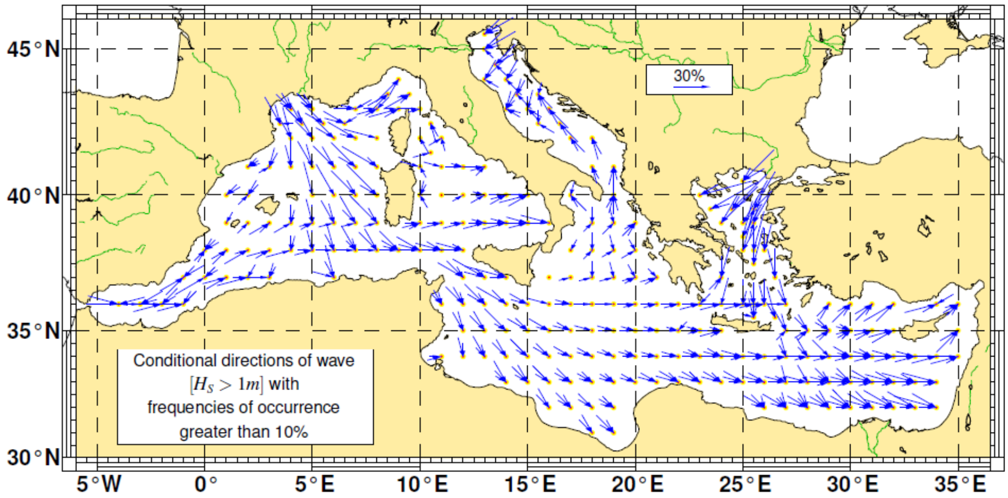


Figure 3-32 Spatial distribution of wave direction during winter (Medatlas, 2006).

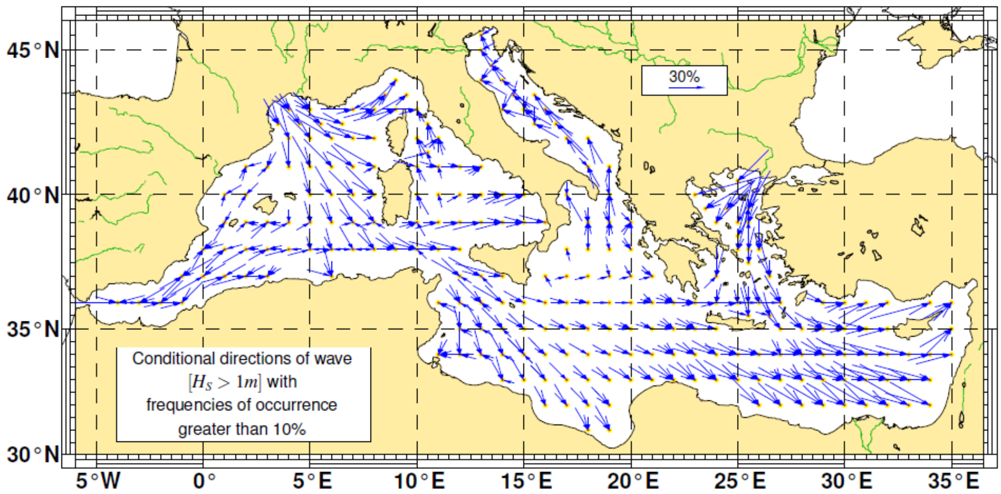


Figure 3-33 Spatial distribution of wave direction during spring (Medatlas, 2006).

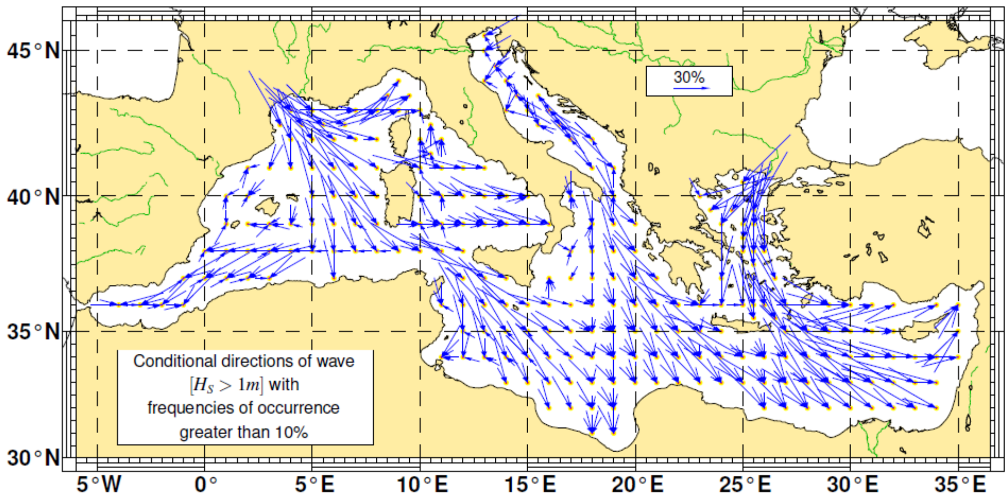


Figure 3-34 Spatial distribution of wave direction during summer (Medatlas, 2006).

3.2.6 Turbidity

Water turbidity derives both from natural and anthropic causes and indicates the presence of organic/inorganic matter suspension in the water column. Turbidity influences chemical and physical water properties mainly in terms of light penetration, which can affect primary production.

In the Adriatic this parameter is mainly influenced by freshwater river contribution, particularly the Po (in the northern Adriatic it is the main freshwater input and accounts approximately for 50% of the total riverine discharge into the basin (Boldrin et al., 2005)) and smaller Albanian and Bosnian rivers. These discharges include suspended sediments, nutrients and pollutants, which interact and mix with coastal waters and cause modification of the existing physical. chemical and biological environment on the adjacent continental shelf.

Focusing on the northern Adriatic, which is the most relevant area where turbidity, with Po river contribution, plays an important role, two main classes of sediments can be identified (Brambati et al., 1973):

- First class consists of coarser sediments of sand with grain size between 50–2000 mm;
- Second class is of finer materials of silt with grain size between 2–50 mm.

The finest class of clay sediment (<2 mm) can also be observed. but is not considered to be a major contribution in the fine sediment distribution of the North Adriatic Sea.

Since the general circulation of the Northern Adriatic Sea is dominated by the Western Adriatic Coastal Current (WACC) along the Italian coast, solid suspended matters (SSM) from the northern rivers are transported southward by the coastal current. During this process. SSM are mechanically sorted out by their grain sizes through the sediment deposition. The sorting mechanism is such that the sediment grain size decreases as the distance increases southward from the river sources (Wang and Pinardi, 2002). Generally in summer the river plume is dispersed towards the centre of the basin, while in winter it remains more confined to the coast where it flows south (Boldrin et al., 2005).

Preliminary data derived from ISPRA (2012) and referred to MARCOAST project[9], are shown, for February and March 2012, in the following figures. Data set are referred to the scattered mitigation coefficient (Kd), collected by the optic sensor MERIS of the European Space Agency (ESA) at 300 m spatial resolution.

[9] http://www.marcoast.eu/; last access 17 June 2013

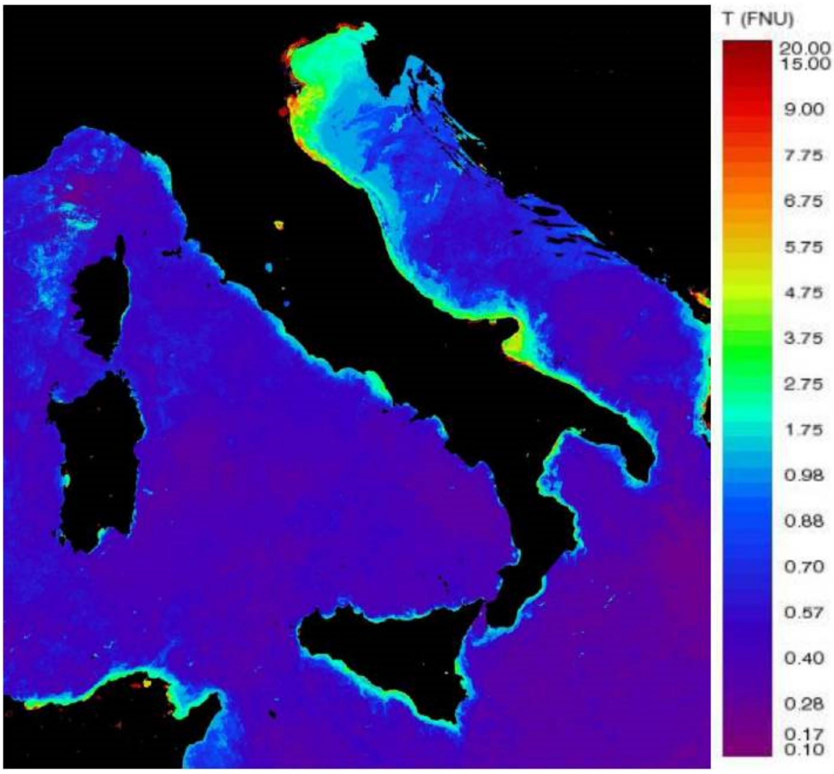


Figure 3-35 February 2012 average Kd values (Source: ISPRA, 2012).

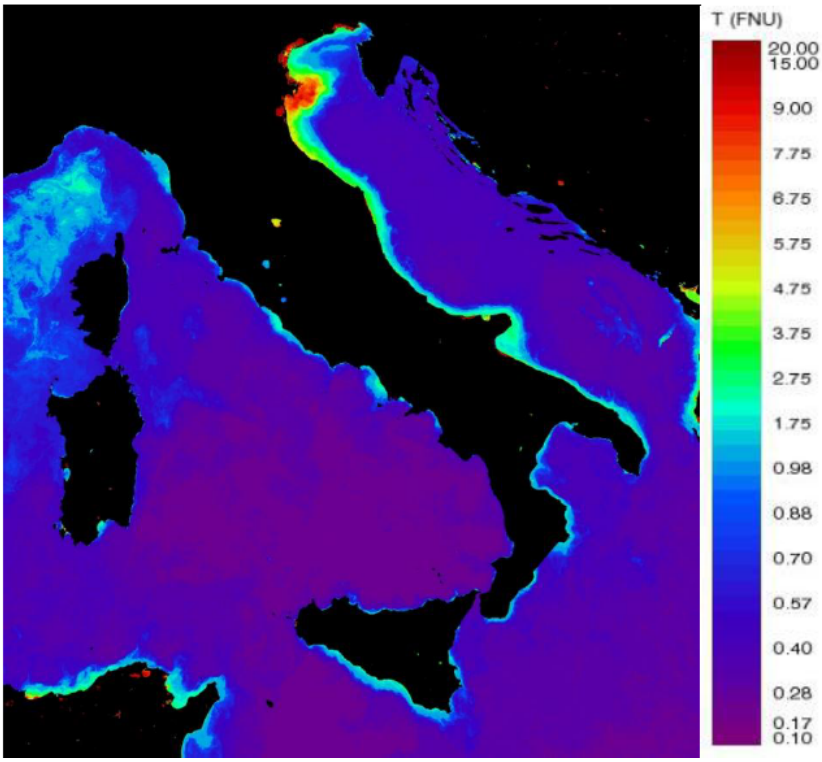


Figure 3-36 March 2012 average Kd values (Source: ISPRA, 2012).

These preliminary results confirm that:

- In winter during February turbidity shows high values in the north Adriatic nearby Po mouth. The discharge of suspended sediment (TSS) and dissolved organic matter (DOM) follows western Adriatic anti-cyclonic current and generates a turbidity increase along Italian coastline until south of Italy with high values also nearby Gargano headland;
- in spring a decrease of turbidity values in the north Adriatic is observed while a significant increase in turbidity is detected near Po mouth (7-13 m^{-1}) with a visible plume in the north east direction. The discharge of suspended sediment and dissolved organic matter follows the western anti-cyclonic Adriatic current and leads to high turbidity along the Adriatic coast as far as the southern Adriatic;
- turbidity along Croatian coastline is significantly lower than turbidity observed along Italian coastline due to river output lacking; higher values are instead found nearby Albania coasts.

3.2.7 Residence time

Residence time can be defined as the average amount of time that a particle spends in a particular system. Water residence time of the Mediterranean is estimated to be on average 75-100 years (UNEP 2002).

In the Adriatic Sea. the communication with the Mediterranean sea is possible only through the Otranto Strait at its southern end. Water flows both northward and southward through the strait. but given that the Adriatic is a net exporter of water. more water flows south into the Mediterranean than enters through the strait. The net gain of fresh water over evaporation causes water to be exported into the Mediterranean through the Otranto Strait. There is also a counter flow of Mediterranean water from the Ionian Sea into the Adriatic. In the basin residence time is associated to sub regional currents. persistent eddies and morphology.

Using strontium sea water and fallout data. assuming that the mean residence time of ^{90}Sr in the Adriatic sea also reflects the turnover time of the Adriatic sea water. the mean residence time of Sr in the Adriatic sea water was estimated to be approximately 3.3 ± 0.4 years; this value is in agreement with the value which was estimated by studying water flows through the Strait of Otranto, to be on the order of 1 year and also with other literature data which estimates a range from 0.7-5 years, obtained by studying water flows of the Adriatic sea water through the Strait of Otranto (Franic, 2004).

Focusing on a smaller scale, ISPRA (2012) is developing a bi-dimensional model which simulates the turbulent contribution using a “random walk” process associated with horizontal turbulence diffusivity. The model estimates residence time as the time that a single particle spends inside a circle of 50 km radius and with centre in the particle release point, considering current velocities as modified by random perturbation. In this case considering a small scale process, residence time is consequently lower and is expressed in days. Figure 3-37 resumes preliminary results for January 2011.

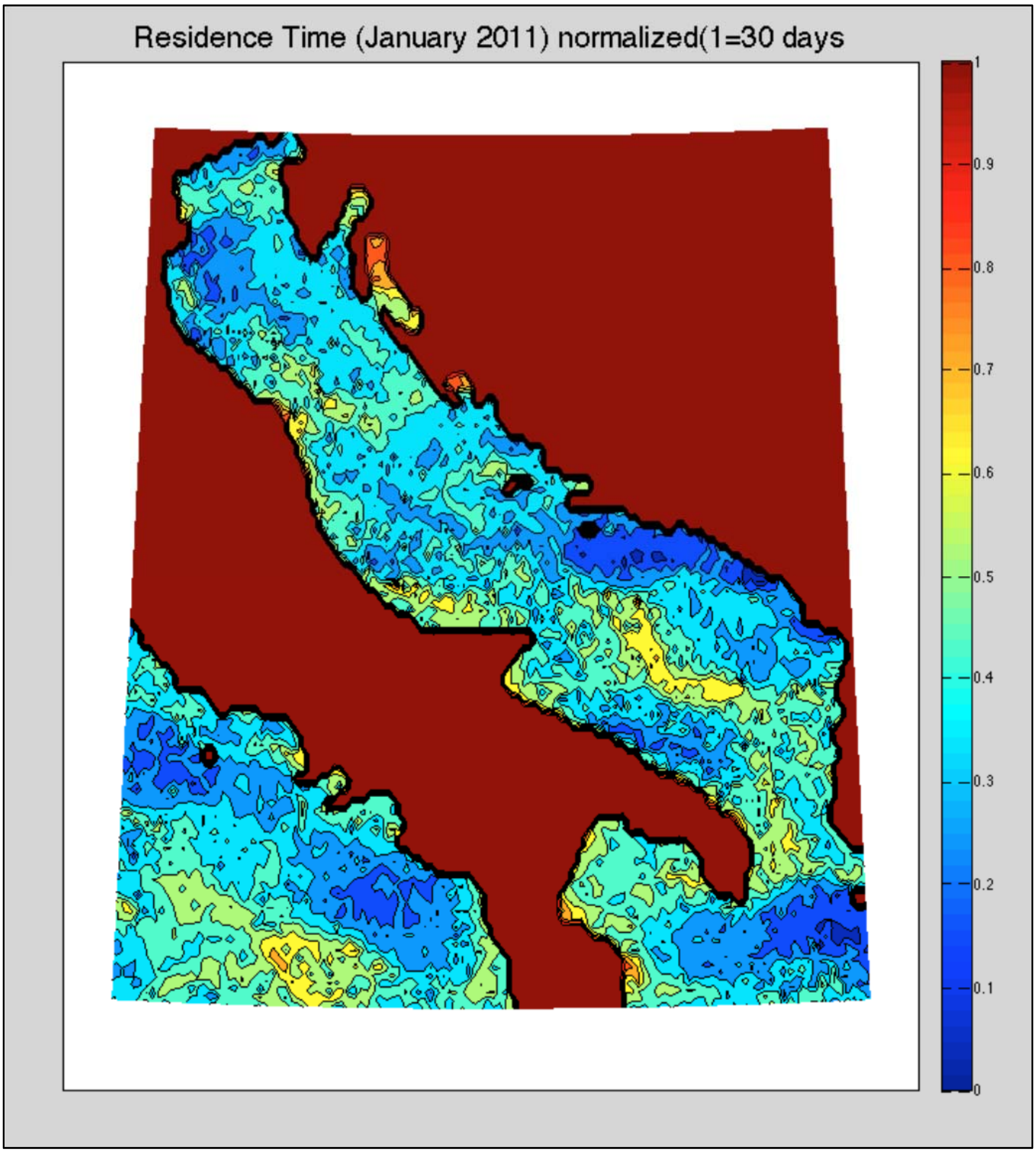


Figure 3-37 Adriatic waters residence time January 2011 (Source: ISPRA, 2012).

Lower values (blue areas) are registered where average currents are stronger (for example in the north Adriatic. Apulia coasts and south Dalmatian coasts) while higher values (15-20 days) are registered where there are weaker average currents and persistent eddies, like in the central Adriatic. Along coasts instead a large spatial variability is generally observed.

3.2.8 Spatial and temporal distribution of salinity

The Adriatic belongs to those parts of the Mediterranean Sea that have a positive difference between precipitation (including river runoff) and evaporation and is characterized by important salinity differences between the north (less salty) and the south.

Results emerged from the study redacted by ISPRA (2012) within the process of MSFD implementation in Italy and using data derived from MyOcean project, show average salinity distribution at the free surface during a period of ten years (2001-2010). The salinity data is expressed in practical salinity units (psu) and referred to the whole period considered (Figure 3-38) and to seasonal fluctuations (Figure 3-39-Figure 3-42).

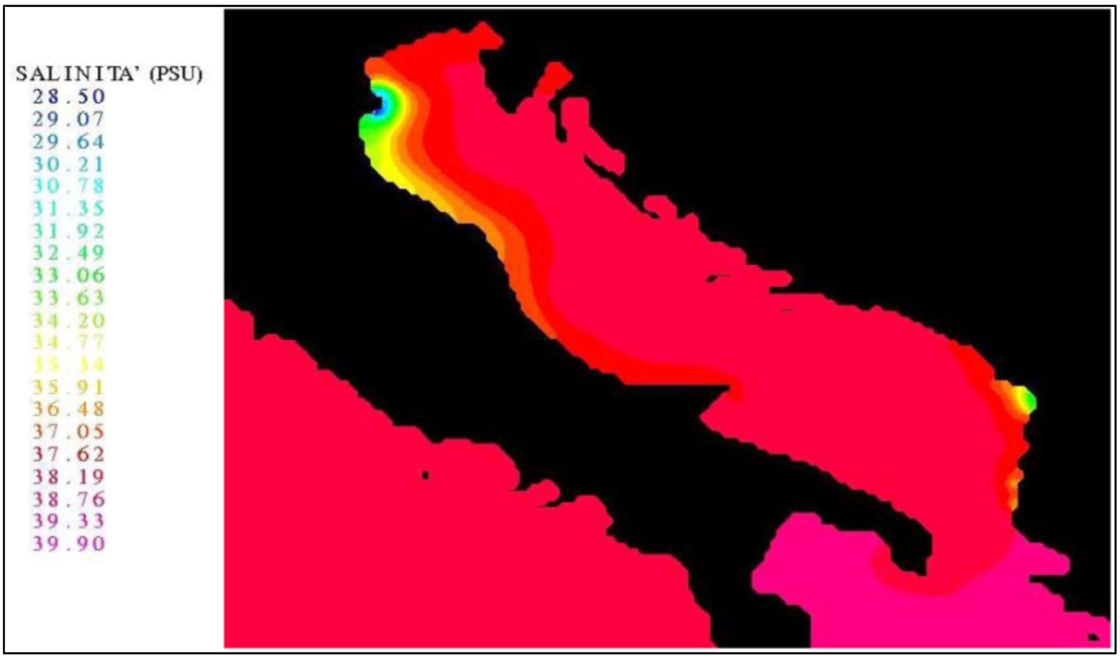


Figure 3-38 Average salinity values at the free surface (mean years 2001-2010) (Source: ISPRA, 2012).

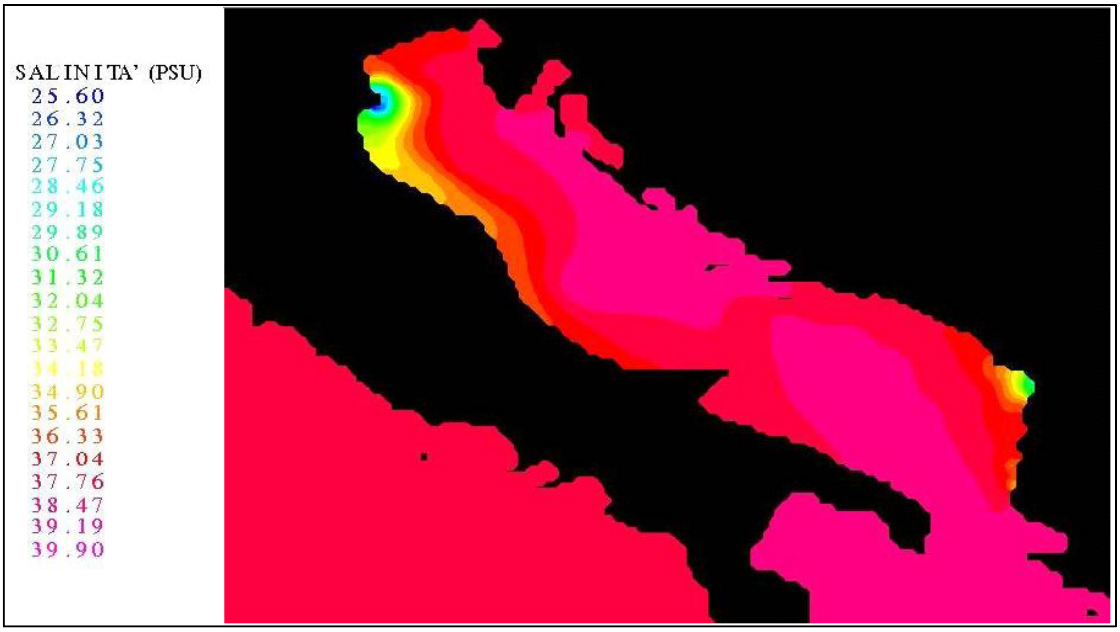


Figure 3-39 Average spring salinity values at the free surface (mean years 2001-2010) (Source: ISPRA, 2012).

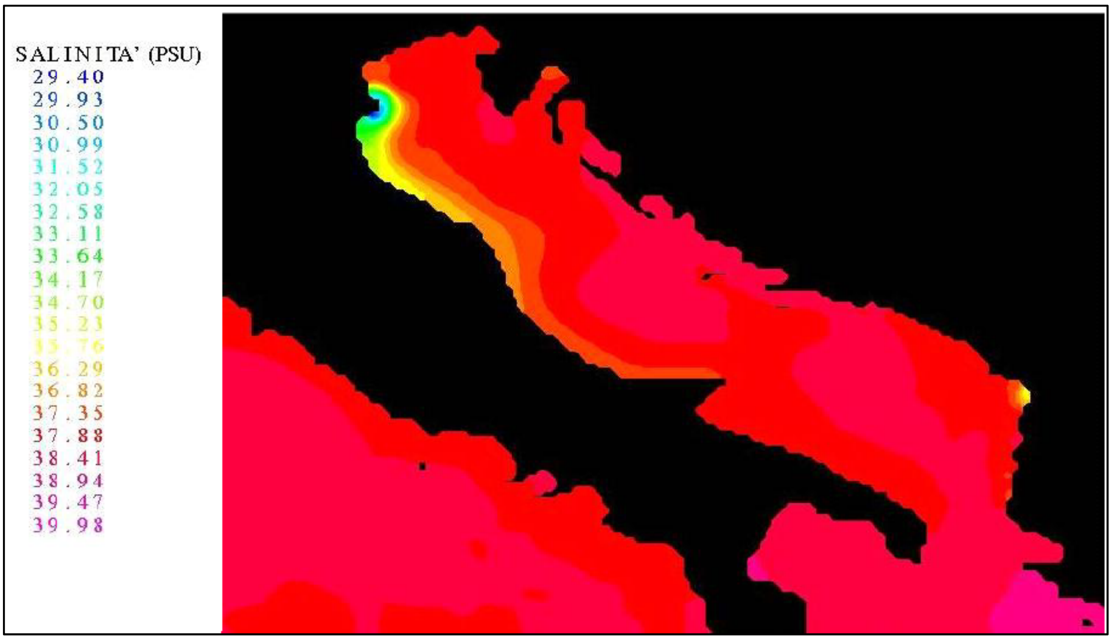


Figure 3-40 Average summer salinity values at the free surface (mean years 2001-2010) (Source: ISPRA, 2012).

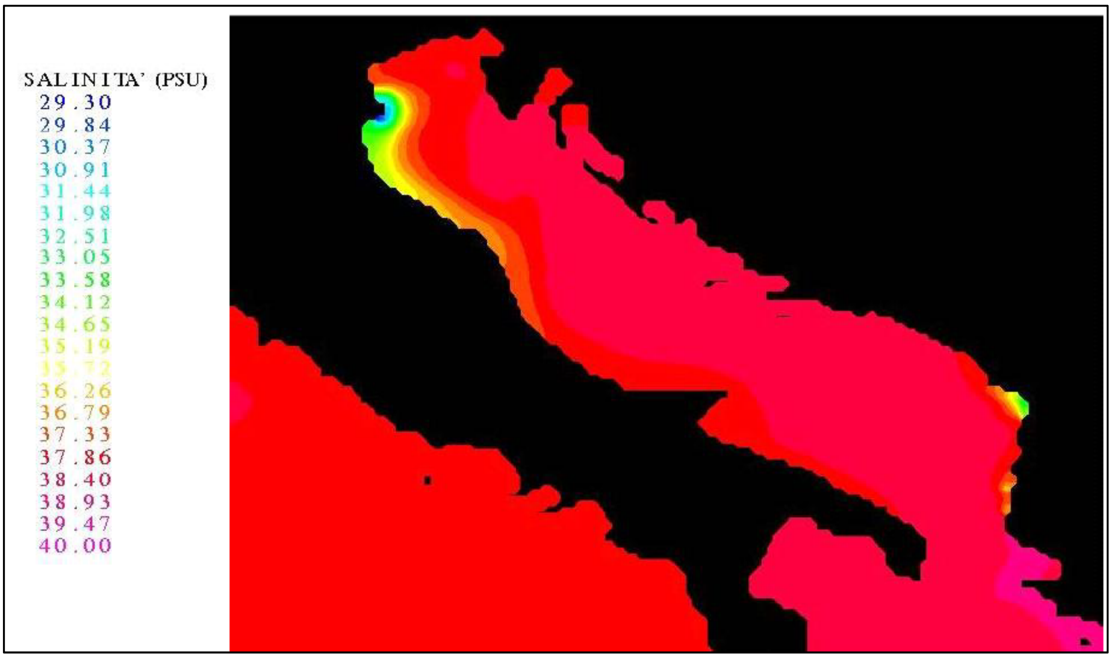


Figure 3-41 Average autumn salinity values at the free surface (mean years 2001-2010) (Source: ISPRA, 2012).

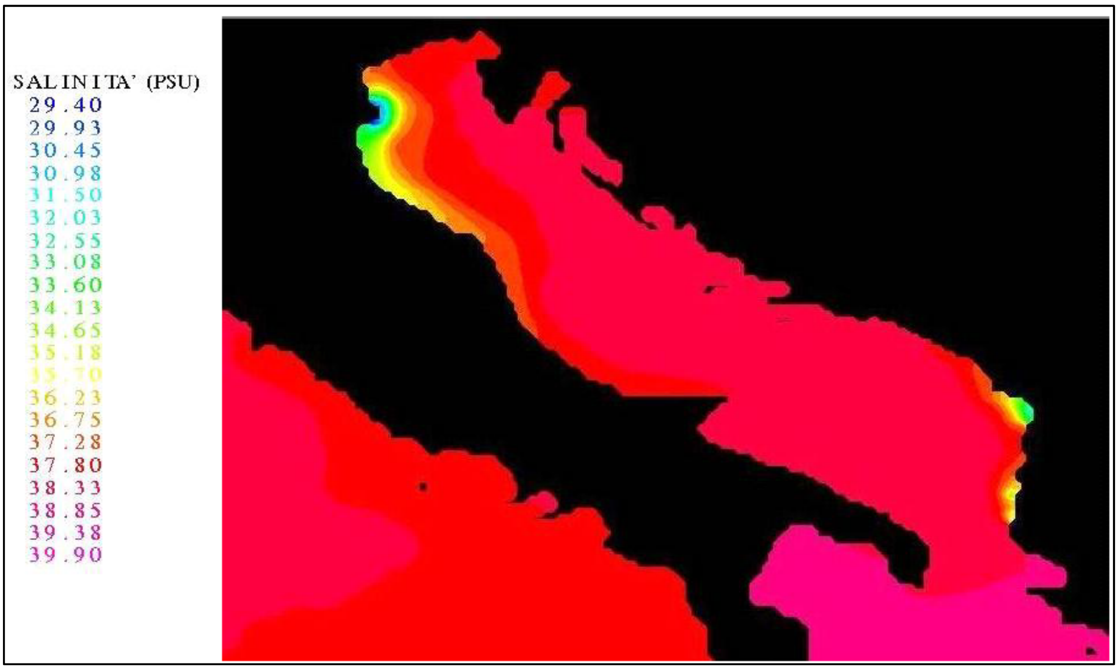


Figure 3-42 Average winter salinity values at the free surface (mean years 2001-2010) (Source: ISPRA, 2012).

Looking at previous figures the following considerations can be made:

- Two important freshwater sources can be identified in the Adriatic basin: Po river (the most important) and rivers flowing into the Adriatic in Albanian and Montenegrin coastlines;
- The most important contribute to salinity changes is given by rivers during spring followed by winter and autumn;
- As evidenced for turbidity the plume of freshwaters coming from the Po river influence salinity also southward almost until Apulia coasts.

Salinity distribution at surface with isohaline curves is also shown; results are derived from Artegiani et al (1996). At the surface (Figure 3-43) strong salinity frontal areas can be seen in all the seasons. particularly along the western coast, related to the river runoff. Frontal structures are determined by the strong gradients between the low salinity waters, which are always present along the western side of the Adriatic Sea, and the interior basin salinity field. From spring to summer the relatively fresh waters of the northern Adriatic spread south-eastward, intruding into the open sea. The maximum values of salinity are found in winter when the 38.3-psu isohaline includes all the offshore area of the entire basin. Minimum values of salinity occur in summer when the 38.3-psu isohaline encompasses only two small areas in the middle and southern Adriatic. In spring the noticeable influence of the Albanian rivers' runoff is shown by the wide area with salinity less that 38.0 psu in front of the south-eastern coastline.

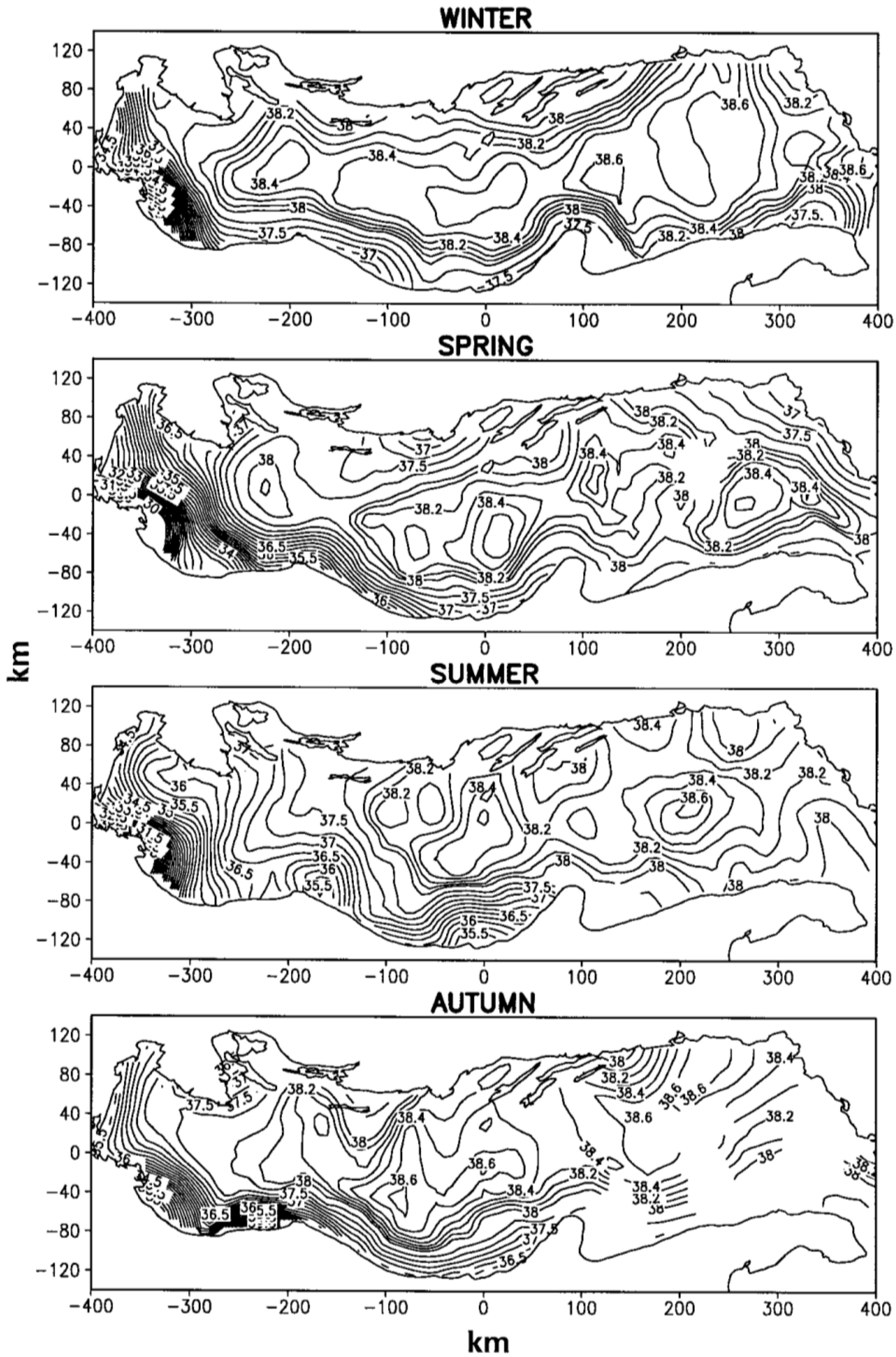


Figure 3-43 Seasonal salinity (psu) maps at the surface. The contour interval is 0.25 psu for S<38 psu and 0.1 psu for S>38 psu. Contours for S<30 psu are not shown. The field is plotted for expected error less than 30% (Source: Artegiani et al., 1996).

Concerning salinity along the water column. results derived from Artegiani et al. (1996), based on a dataset which includes measurements of salinity in the periods 1911–14 and 1947–83 are shown in Figure 3-44. Three regions with homogeneous physical water properties have been defined: the northern Adriatic extending up to the 100-m isobath in the south, the middle Adriatic characterized by the Pomo Depressions up to the Vieste transect, and the southern Adriatic up to the Otranto Channel.

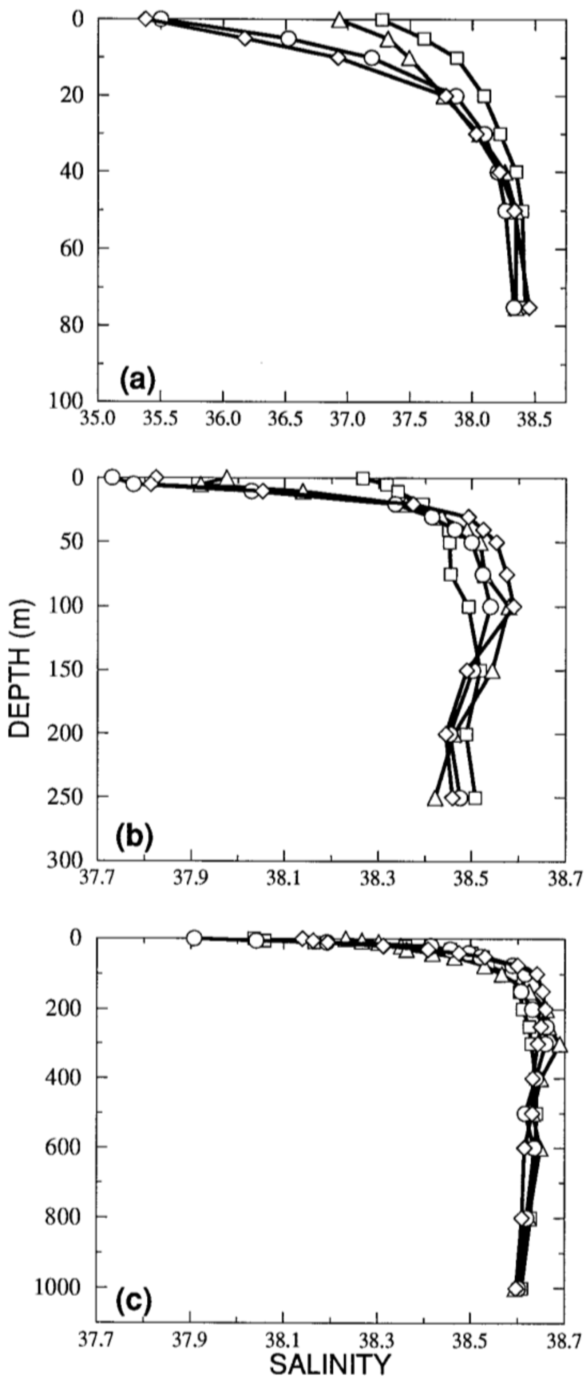


Figure 3-44 Seasonal climatological profiles of salinity (psu) for (a) northern. (b) middle. and (c) southern Adriatic for winter (□). spring (O). summer (◊). and autumn (∆) (Source: Artegiani et al., 1996).

Focusing on the north and middle Adriatic. seasonally average salinity values measured at different depths (at the surface, at 10, 20, 50 m and at the bottom) are provided by the following table (Regione Marche and Zara County, 2008).

Table 3-4 Average seasonal salinity for north and middle Adriatic at different depths (values in PSU) (Source: Regione Marche and Zara County, 2008).

Season	S at the surface	S at 10 m depth	S at 20 m depth	S at 50 m depth	S at the bottom
Winter	37.40	37.94	38.22	38.42	37.98
Spring	36.93	37.71	38.07	38.37	37.90
Summer	36.79	-	38.18	38.43	37.87
Autumn	37.05	-	38.00	38.39	37.84

Based on Figure 3-44 and Table 3-4 and results emerged from previous cited studies, the following considerations can be made:

- At the surface in the north and central Adriatic strong variability is observed. Depending on river load (principally Po river) and low depth. Values below 38 PSU are observed in the area from Po to Istria, while higher values are detected in the centre, east and south part; moreover during spring the expansion of low salinity areas offshore is observed due to Po flood and thermal stratification, while in winter and summer respectively maximum and minimum salinity values are registered;
- At -10 m depth salinity variations are reduced with respect to surface but have the same trend, with maximum salinity in winter and gradual expansion of low salinity area from the coast to open sea from winter to summer season;
- At -20 m depth salinity values are similar to those at -10 m in the middle east area of the basin, while they change in the north western part. where salinity is higher with respect to -10 m depth;
- At -50 m salinity reaches high values almost everywhere;
- At the bottom a similar trend in all season is observed, with lower values along western coast from Trieste to Abruzzo region and high values in the middle east part of the basin;
- The southern Adriatic has a seasonal cycle of the surface waters driven by the fresh coastal waters; it also has saltier waters compared to the northern and middle basin (S = 38.61 +/- 0.09 psu).

3.2.9 Spatial and temporal distribution of nutrients and oxygen

Eutrophication is a significant degradation factor of water quality, that can manifest as mucilage events, oxygen depletion of bottom water, harmful algal blooms, outbreaks of gelatinous zooplankton, invasions of non-indigenous species, loss of habitat and instability of fisheries; the process is caused by enrichment of sea water by nutrients, particularly by compounds of nitrogen and/or phosphorus; changes in the balance of nutrients cause changes to the balance of organisms and can determine water quality degradation. It becomes a nuisance if the concentration in nutrients exceeds some threshold values that vary in a large range according to the typology of the ecosystem. This state of nuisance results in lack of diversity and complexity of the considered ecosystem. involving perturbation (if not disappearance) of the secondary productivity level. Eutrophication may be linked to and be part of both organic and biological pollution on the one hand. and may cause toxic effects on the other hand (Carbenier, 1990).

These changes may even occur due to natural processes but in the case of the Adriatic sea they are mostly attributed to anthropogenic sources. One of the first factors promoting eutrophication is consequently nutrient enrichment: this is the reason why the main eutrophic areas are to be found primarily not far from the coast, mainly in areas receiving significant nutrient loadings. An increase in the amount of nutrients in coastal areas leads to increased phytoplankton biomass during the spring bloom, but also to the emergence of additional episodic blooms during summer and autumn.

For eutrophication levels definition Nixon (1995) proposed the following classes based on phytoplankton primary production (measured as carbon (C)) (European Environment Agency EEA):

- Oligotrophic: <100 g C m^{-2} y^{-1};
- Mesotrophic 100–300 g C m^{-2} y^{-1};
- Eutrophic 301–500 g C m^{-2} y^{-1};
- Hypertrophic >500 g C m^{-2} y^{-1}.

Main parameters that need to be monitored in order to identify trophic level in marine waters are: dissolved inorganic nitrogen and phosphorous, total nitrogen and total phosphorous, total organic carbon and dissolved oxygen. Directive 2008/56/EC (MSFD) requires that the evaluation of marine water quality and the definition of the Good Environmental Status (GES) are implemented in agreement with guidelines provided by Directive 2000/60/EC adopted for coastal and transitional waters. Consequently information on nutrient levels needs to be provided.

Following chapters give an overview of above mentioned parameters in the Adriatic basin, according to available data.

3.2.9.1 Dissolved inorganic nitrogen (DIN) and total nitrogen (TN)

Dissolved inorganic nitrogen is mainly made up by nitrate (NO_3), which is the most relevant component, and nitrites (NO_2); ammonia nitrogen is instead present only occasionally. These parameters are strongly influenced by river loads and their concentration in the sea can be very changeable.

Nitrogen comes mainly from widespread sources and consequently loads to the sea increase during rainy years. Maximum concentrations are usually reached during winter and minimum during summer, even due to primary producers' uptake. The contribution from point sources, like urban waste water treatment, livestock farming and metal industry, is less relevant. These in the Adriatic are mainly located along the eastern coasts (Figure 3-45).

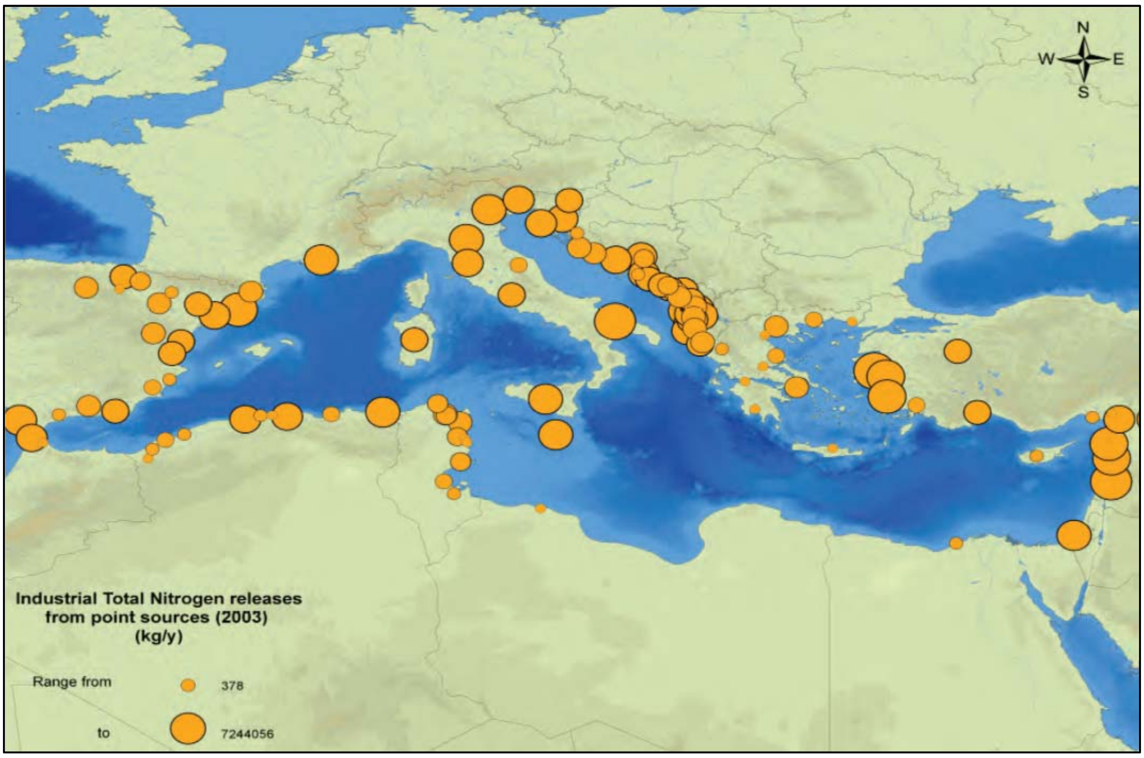


Figure 3-45 distribution of releases of total nitrogen from point sources in the Mediterranean Region year 2003 (kg/year) (Source: UNEP-MAP, 2009).

In the Adriatic estimates suggests that every year approximately 270,000 t of nitrogen are discharged (UNEP, 2002). Important areas for nitrogen load from widespread sources are:

- The north western area, which includes some important Italian rivers: Po, Adige Livenza, Piave, Brenta-Bacchiglione;
- The south eastern area in Albanian and Montenegrin coastlines.

Other central and southern regions of the Adriatic basin are not discussed because they are characterized by lower primary production. with the continental input and the benthic pelagic interactions being of minor importance in comparison to the northern area (Zavatarelli et al., 2000). The offshore central and southern Adriatic in fact show clearly oligotrophic characteristics (Vilicic et al.,1989) with the primary production cycle regulated by the nutrient supply to the euphotic zone from the deep part of the water column by different upwelling and mixing processes (Polimene et al., 2006).

The following figures illustrate nitrates concentration distribution in the north and central Adriatic at different depths (at the surface, 10, 20, 50 m depth and at the bottom); values are expressed in mmol/m^3 and are derived from a study promoted by Regione Marche (Regione Marche and Zara County, 2008). For each figure, winter concentrations are shown in the high-left, spring in the high-right, summer in the low-left, autumn in the low-right part of the figures.

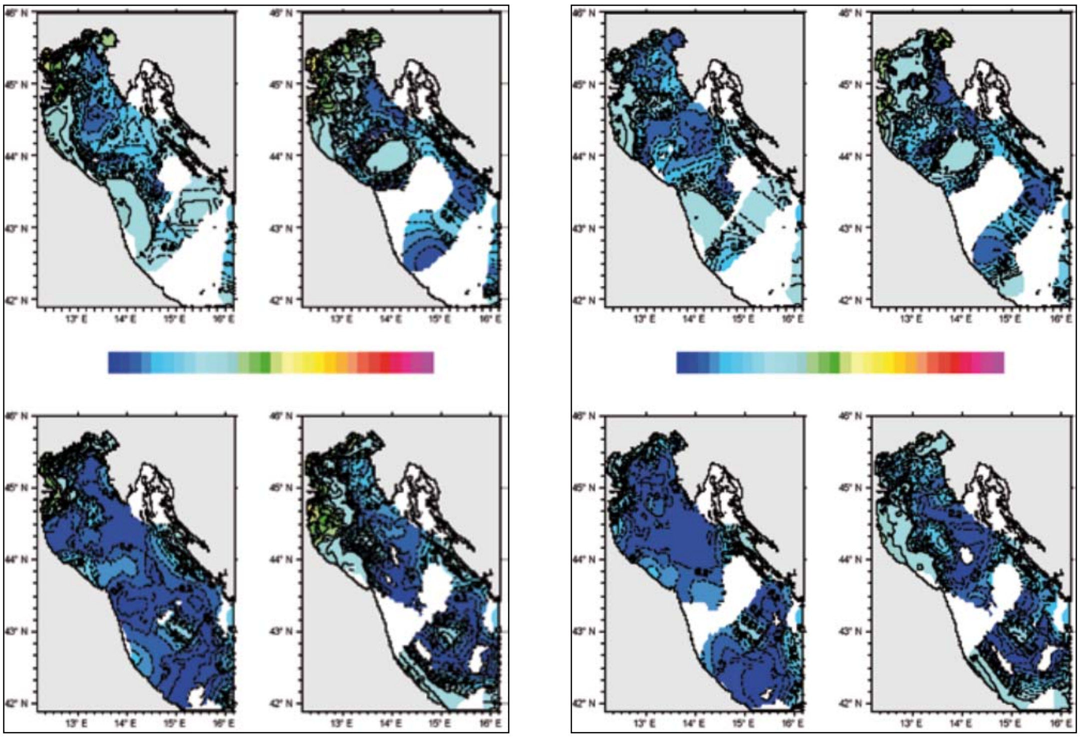


Figure 3-46 Seasonal nitrates concentration at the surface (left figure) and 10 m depth (right figure) (Source: Regione Marche and Zara County, 2008).

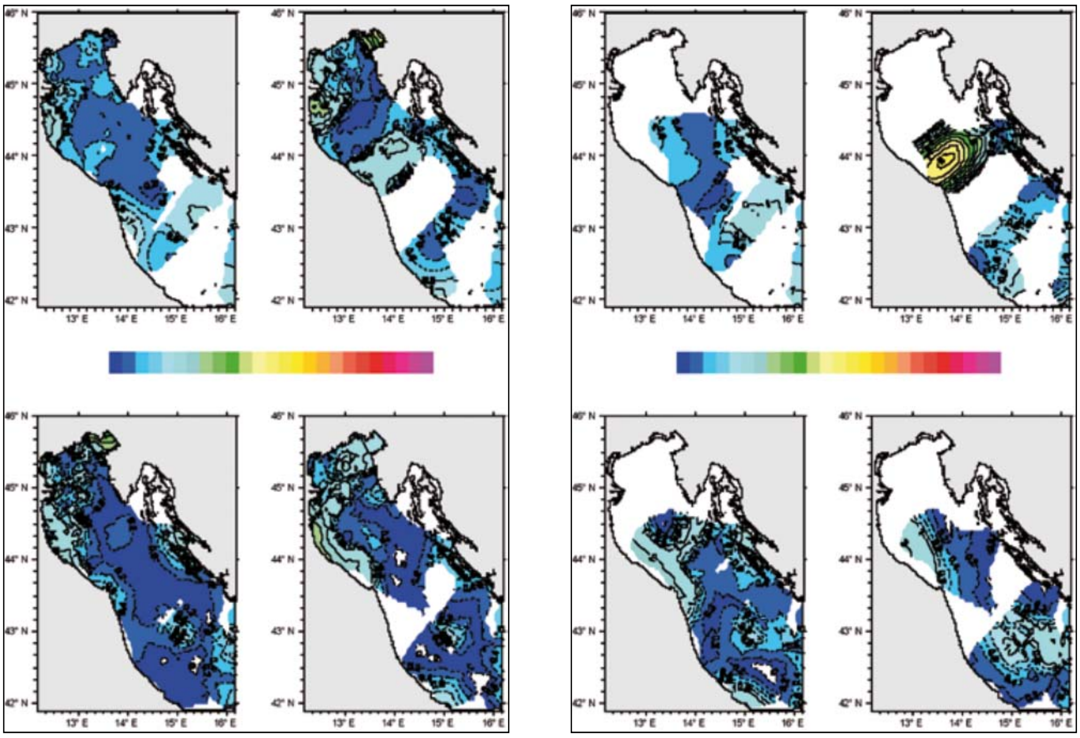


Figure 3-47 Seasonal nitrates concentration at 20 (left figure) and 50 m depth (right figure) (Source: Regione Marche, Zara County, 2008).

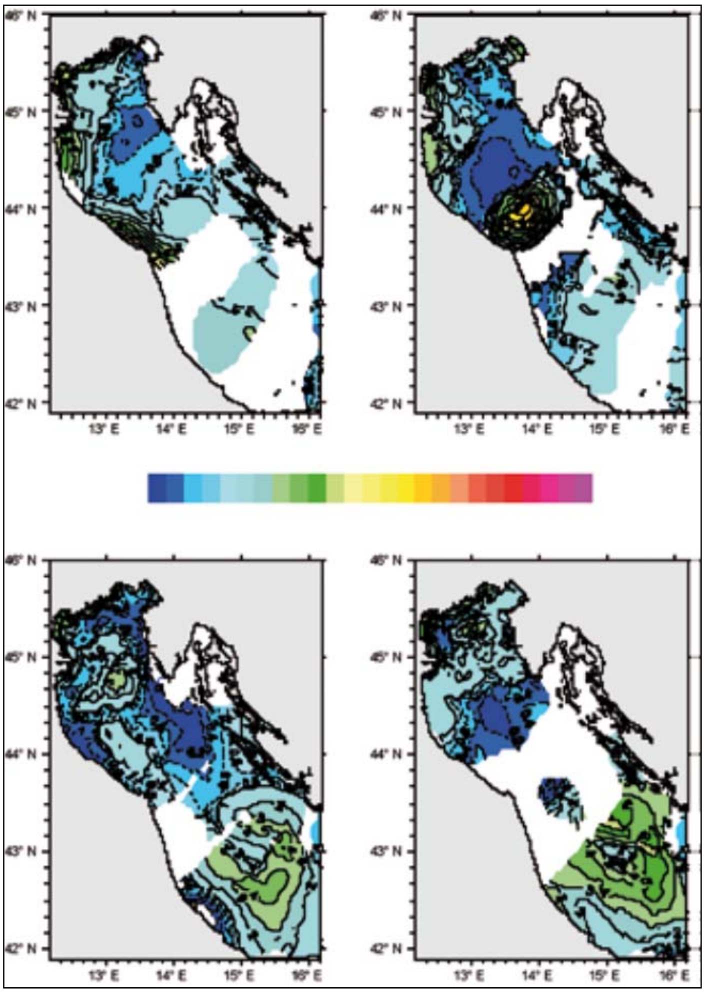


Figure 3-48 Seasonal nitrates concentration at the bottom (Source: Regione Marche and Zara County, 2008).

Higher concentrations are detected at the surface in the north western part of the basin, with the lowest values during summer, clear evidence of the relevance of river loads, Po in particular. At 10 m depth values trend is similar to surface but with lower concentrations; at 50 m depth it can be instead noted that higher values are detected in spring in the central part of the basin, mainly due to organic matter mineralization processes near the seabed; for the same reason also at the bottom higher nitrates values are detected.

A wider analysis (Socal et al., 2008) of the north Adriatic not only on coastal areas. focused on years 2003-2006, has shown that the sub basin ranges from mesotrophic and episodically trophic conditions especially in the western coastal area. and from mesotrophic to oligotrophic conditions in the central and eastern part of the basin. Results suggest that the global state of the sub basin appears to be less eutrophic than in past decades. possibly due to the reduction in riverine continental inputs caused by modifications of meteorological conditions, and also enforcement of environmental legislation.

As above said, the north western Adriatic is likely the most critical area; the following detailed information on loads and concentrations are provided. It should firstly be noted that a distinct dynamical regime between coasts and offshore zone exists. Western coastal areas are in fact dominated by the riverine discharge of land-derived nutrients (Degobbis and Gilmartin, 1990; Zavatarelli et al., 2000) which can lead to extreme ecological phenomena such as dystrophic events and, consequently, anoxia in the bottom layers of the water column. It has been estimated that a total of approximately 120,000 t/y of nitrogen is discharged into the western Adriatic, with Po river contribution of over 100,000 t/y of nitrogen; contribution of water treatment plants discharging into the Adriatic is instead approximately 8,000 t/y. Rivers which supply macronutrients contribute to the formation of a stratified and nutrient rich surface layer, where phytoplankton growth can take place. Literature data (Socal et al., 2008) for the northern Adriatic collected during a period of four years suggests that nitrate is the most relevant chemical compound while nitrites and ammonia represent a minor fraction of the total inorganic nitrogen.

The analysis elaborated by ISPRA (2012), using SINTAI and SIDIMAR databases, shows the contribute of main north Adriatic Italian rivers to total nitrogen load in the north Adriatic sea (Figure 3-49).

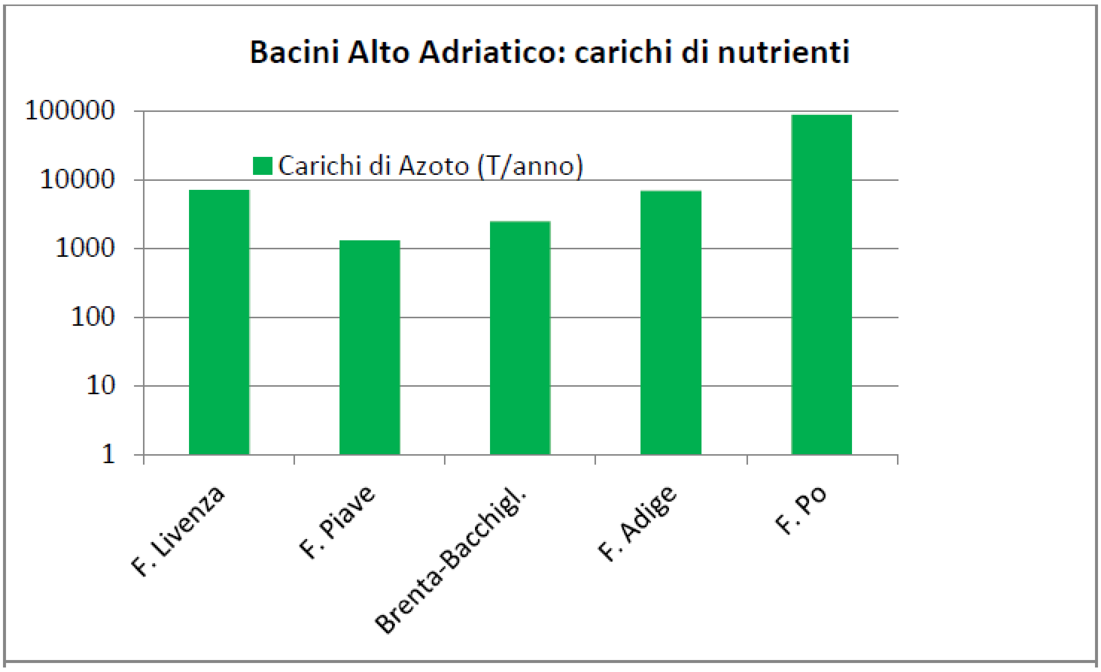


Figure 3-49 Yearly nitrogen geometric average load (t/y, in a log scale) discharged into the Adriatic sea for main north Adriatic Italian rivers, year 2005-2007 (Source: ISPRA, 2012).

Focusing on the Po, the most important river with an yearly average flow of approximately 1,480 m^3/s in the period 1917-2007, the historic trend (Figure 3-50) shows an increase of nitrogen load during years 2003-2010.

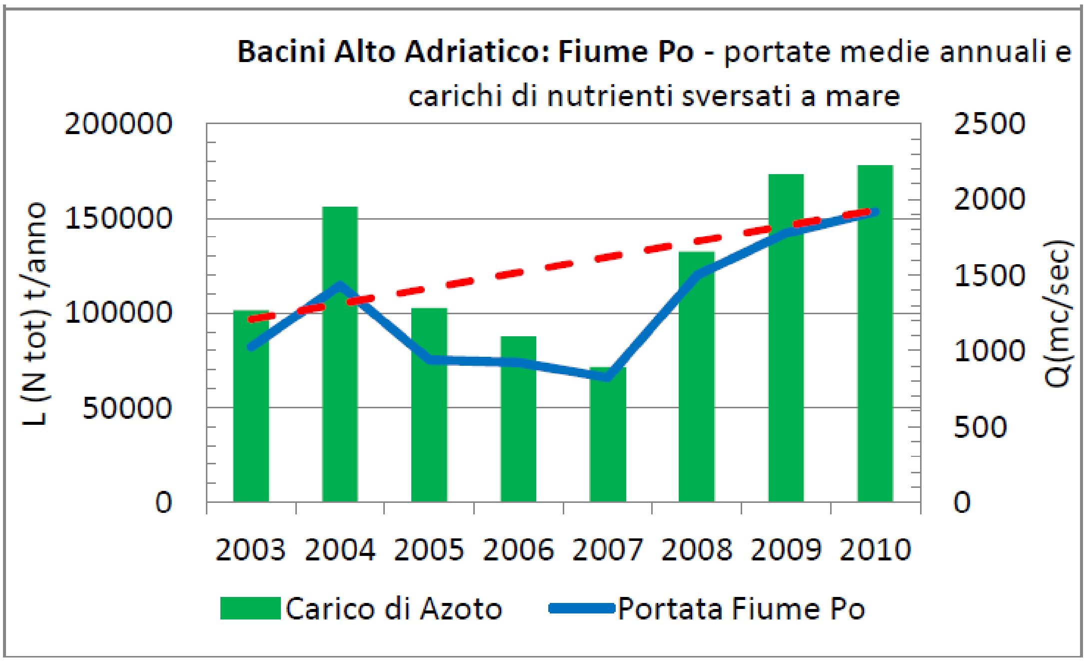


Figure 3-50 Po river yearly nitrogen load (geometric average) and discharge, years 2003-2010 (Source: ISPRA, 2012).

Figure 3-51 shows average yearly DIN concentration during years 2001-2009 in specific sampling stations. Most critical areas with higher DIN values are located near Po mouth, particularly near Rosolina and Porto Garibaldi but also northern Venice lagoon beside Cavallino and Jesolo. Important interannual differences exist, even if the whole trend is increasing, with year 2002 and 2009 characterized by high concentration values (Figure 3-52). However data are referred only to the coastal zone within 3 km.

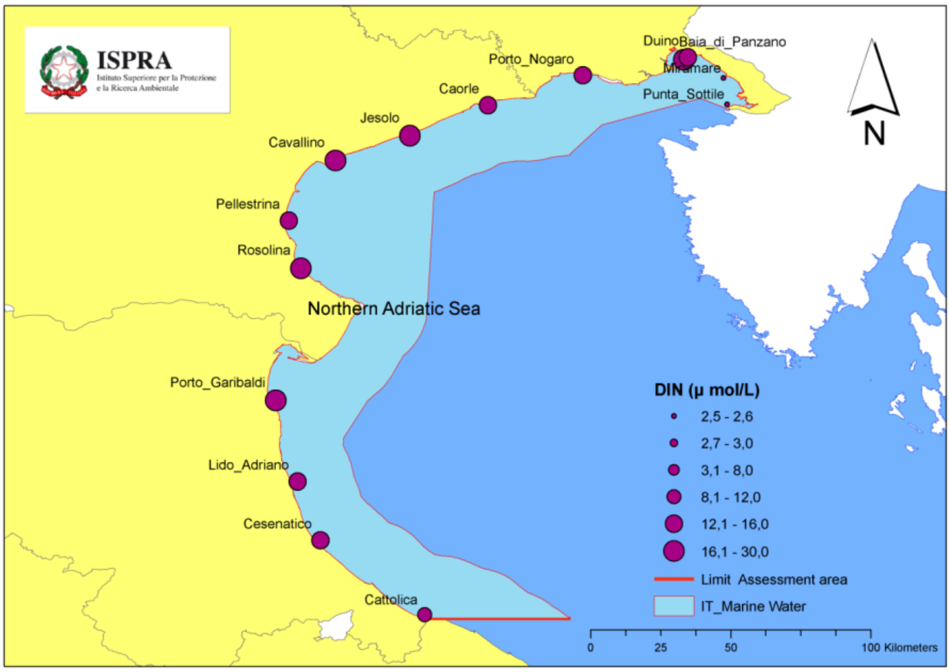


Figure 3-51 Yearly average DIN concentrations in the sampling stations during period 2001-2009 (Source: ISPRA, 2012).

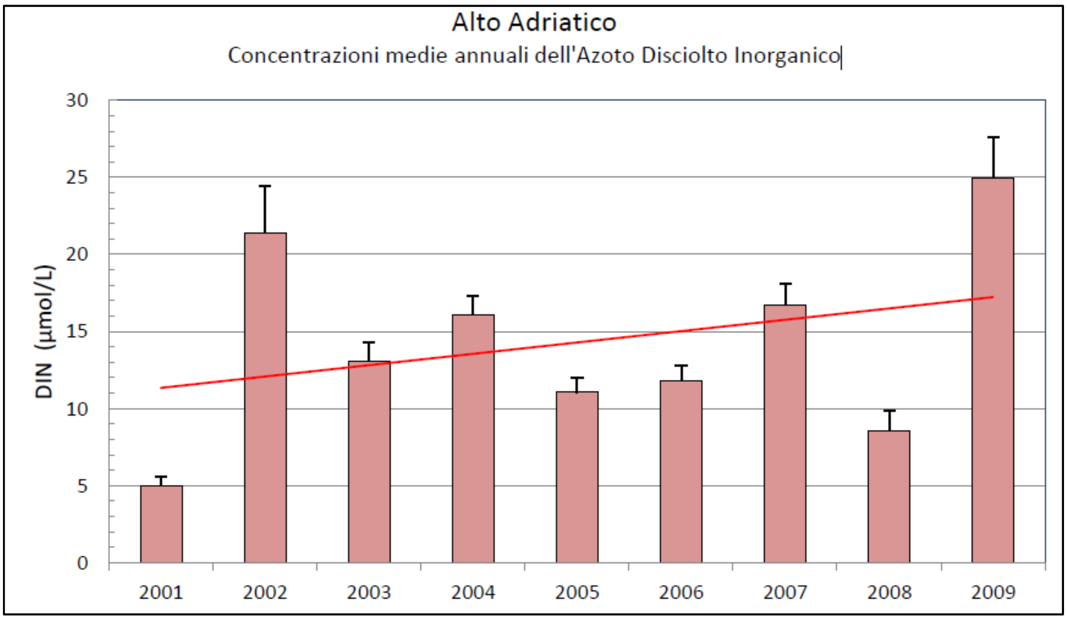


Figure 3-52 Yearly DIN geometric average concentrations in the northern Adriatic (Source: ISPRA, 2012).

Focusing on the critical area in front of Emilia Romagna coastline (Figure 3-53), results emerged for year 2010 from a study promoted by ARPA Emilia Romagna and Daphne II, show a decreasing concentration trend in the northern-southern and landside to seaside direction (Figure 3-54). Higher values are registered during winter and autumn, followed by spring; summer instead shows a relevant flexion.

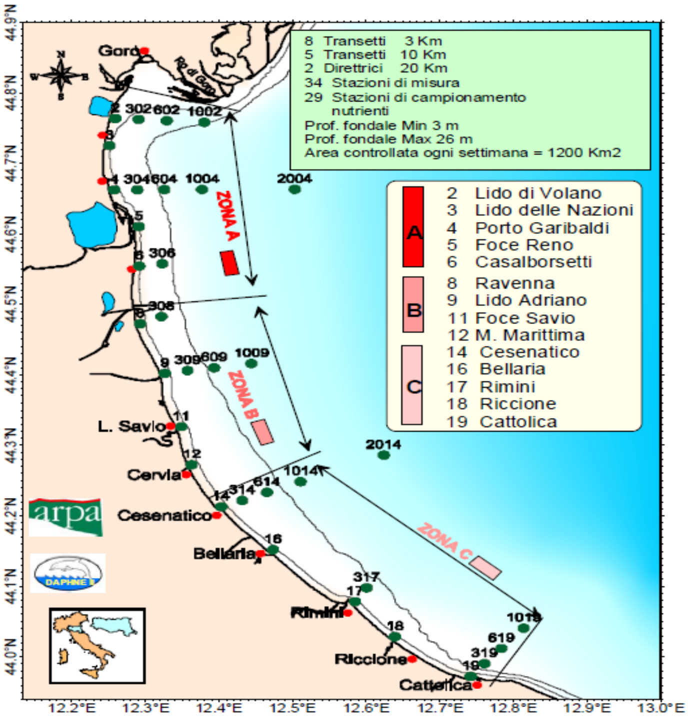


Figure 3-53 Map of monitoring station along Emilia Romagna coastline (Source: ARPA Emilia Romagna, 2008).

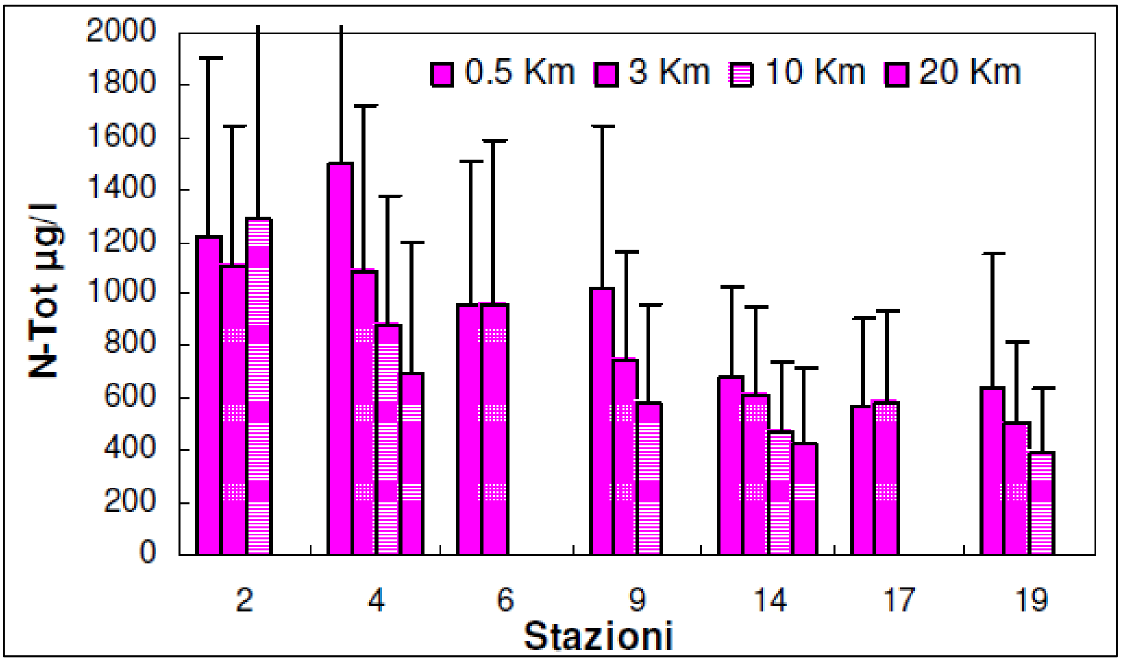


Figure 3-54 Total nitrogen average yearly values and standard deviation in different sampling station at different distances from the coast (0.5, 3, 10, 20 km) (Source: ARPA Emilia Romagna, 2010).

3.2.9.2 Dissolved inorganic phosphorus (DIP) and total phosphorus (TP)

DIP and TP do not show a strong inter annual variability, as the one highlighted for nitrogen. Total load is significantly lower than nitrogen one. As for nitrogen, diffuse pollution is the greatest source of phosphorous nutrients; point sources like the manufacture of fertilizer, livestock farming and urban waste water treatment play instead a secondary role.

Concerning phosphorous (as orthophosphates) concentration distribution in the whole Adriatic, the following figures show that at the surface values are negligible everywhere with the exception of the area nearby Po river mouth; a similar situation can be found at 10 and 20 m depth. At 50 m concentrations are very low almost in the whole basin while at the bottom values increase in the north Adriatic and near meso Adriatic depressions due to organic matter mineralization processes.

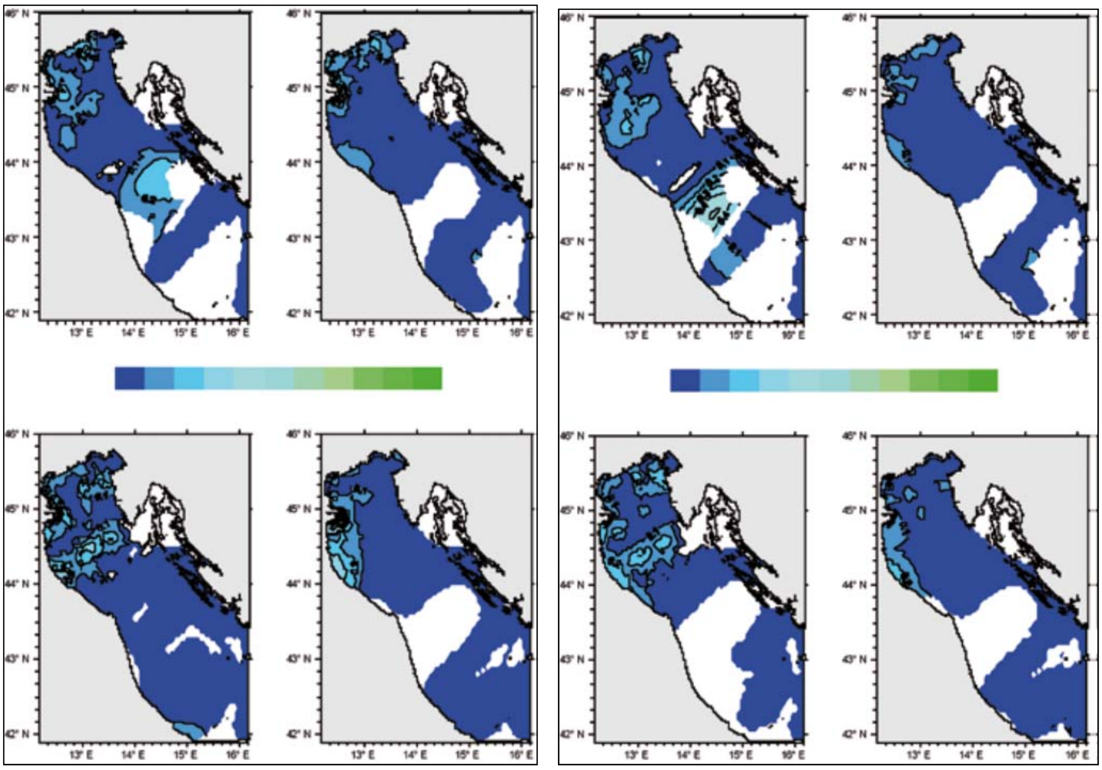


Figure 3-55 Seasonal orthophosphates (P-PO_4) concentration at the surface (left figure) and 10 m depth (right figure) (Source: Regione Marche and Zara County, 2008).

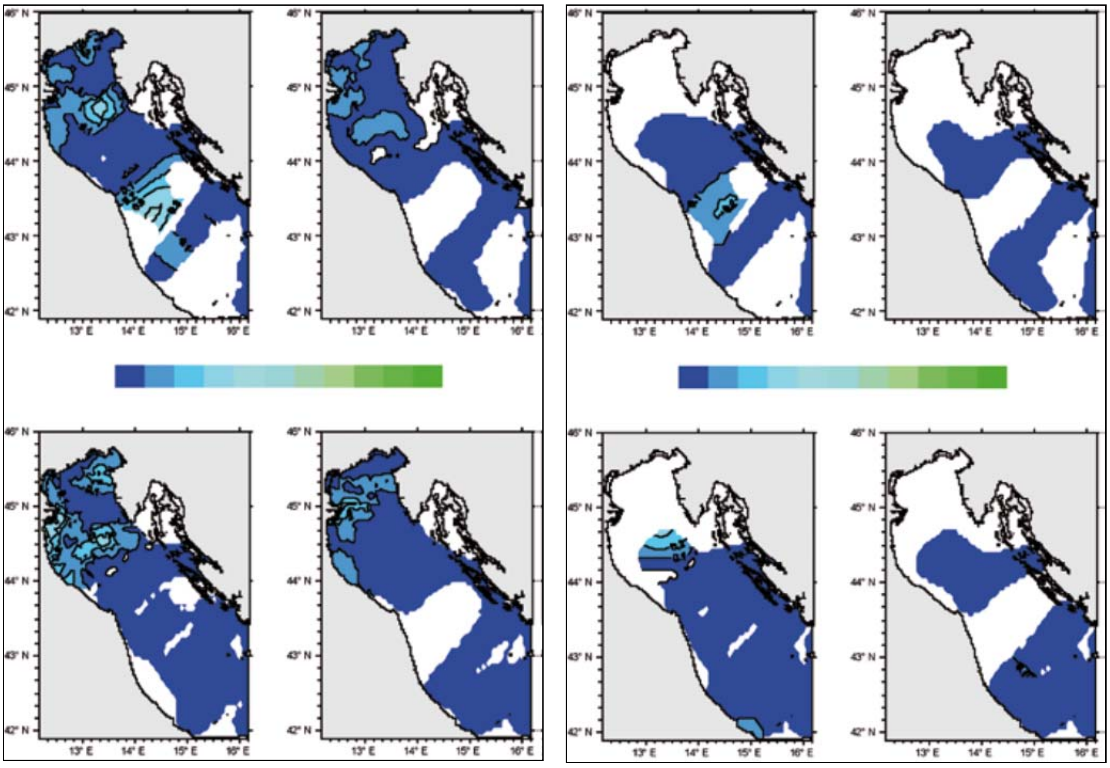


Figure 3-56 Seasonal orthophosphates (P-PO_4) concentration at 20 (left figure) and 50 m depth (right figure) (Source: Regione Marche and Zara County, 2008).

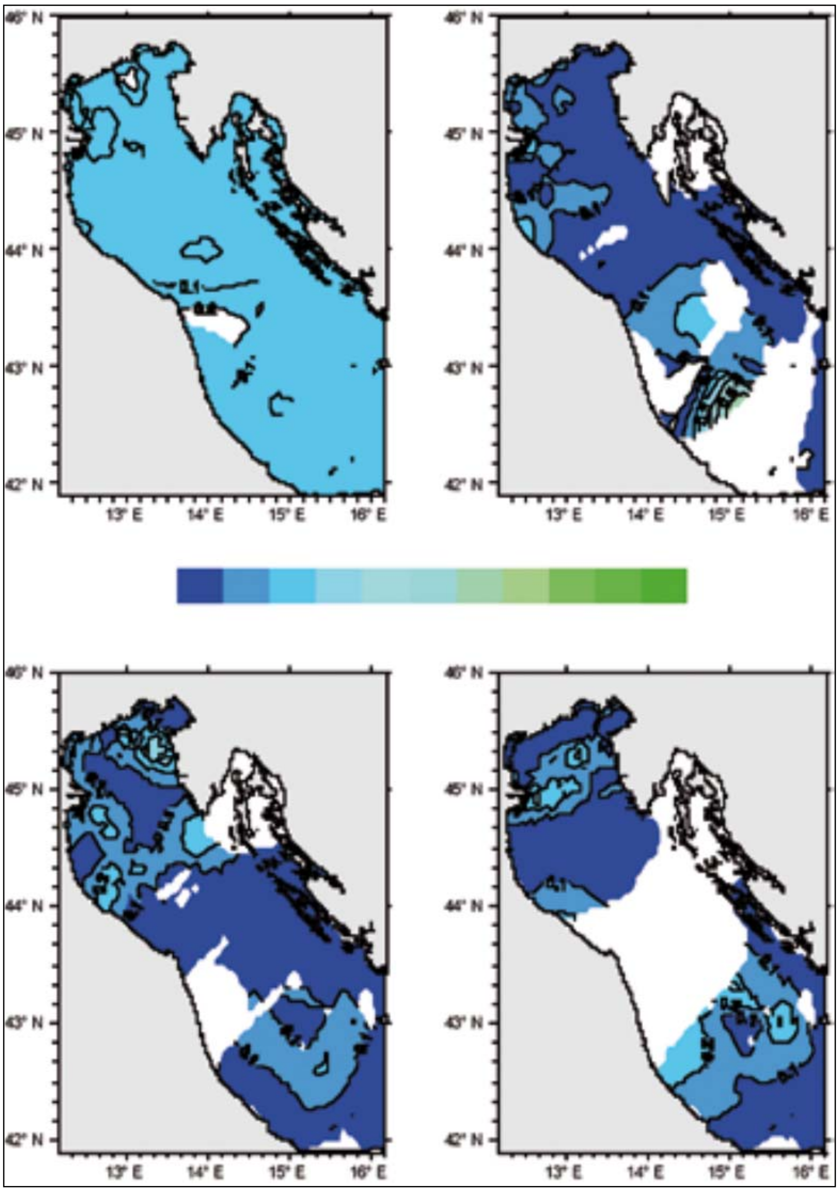


Figure 3-57 seasonal orthophosphates (P-PO_4) concentration at the bottom (Source: Regione Marche and Zara County, 2008).

The whole Adriatic approximately receives a yearly load of phosphorous of 24,000 t (UNEP, 2002). As evidenced in the previous chapter two important phosphorous sources can be identified in the Adriatic:

- The north western area, which includes some important Italian rivers: Po, Adige, Livenza, Piave, Brenta-Bacchiglione and Reno;
- The south eastern area in Albanian and Montenegrin coastlines.

Analysing the first important phosphorous source area, data collected by ISPRA (2012), refer to the coastal zone within 3 km in specific monitoring stations (Figure 3-58). Data show a low decrease from 0.8 to 0.5 µmol/l during 2001 to 2009 period (Figure 3-61). Minimum concentrations are registered during summer, with values that are reduced by half with respect to winter.

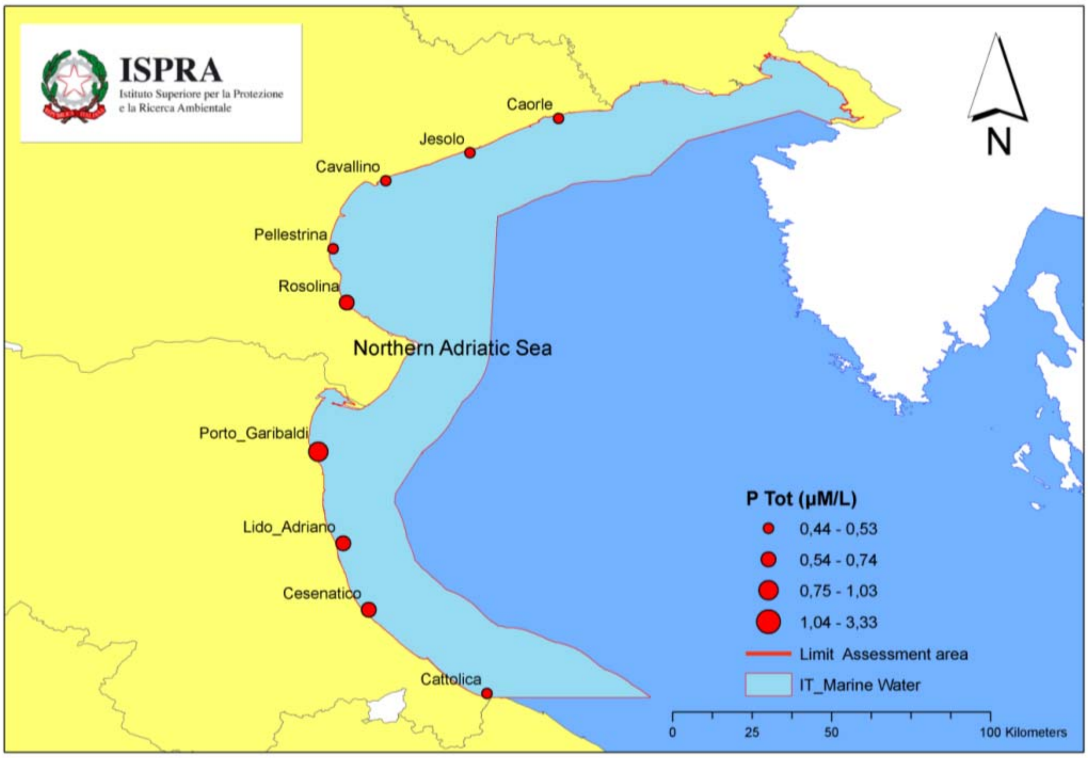


Figure 3-58 Total phosphorous yearly average concentrations in monitoring stations during period 2001-2009 (Source: ISPRA, 2012).

The main phosphorous source is, as for nitrogen, the Po river with over 7,000 t/y, followed by Adige and Livenza river (approximately 300 t/y) (Figure 3-59 and Figure 3-60). Areas with maximum total phosphorous values are those located nearby Po delta.

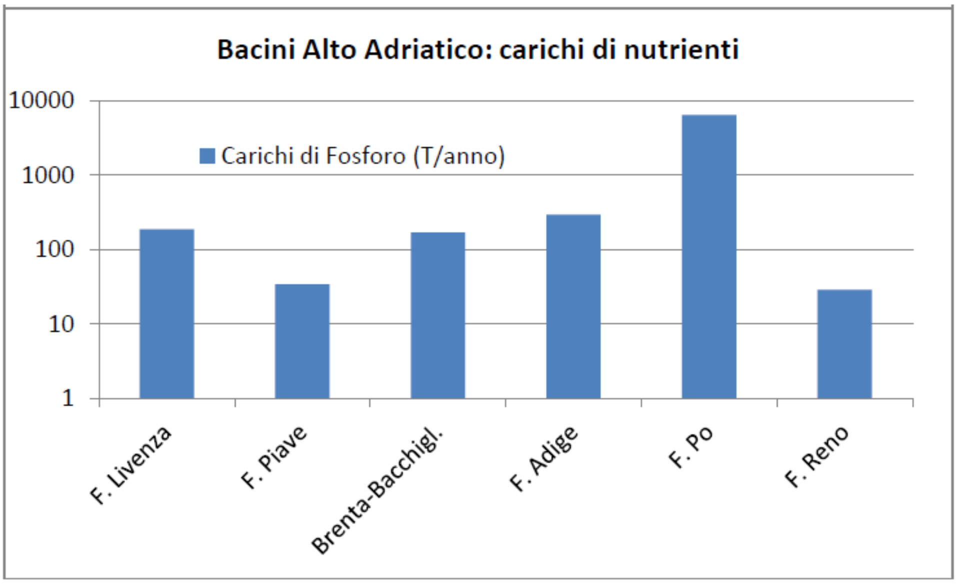


Figure 3-59 Yearly phosphorous geometric average load (t/y, in a log scale) discharged into the Adriatic Sea for main north Adriatic Italian rivers, year 2005-2007 (Source: ISPRA, 2012).

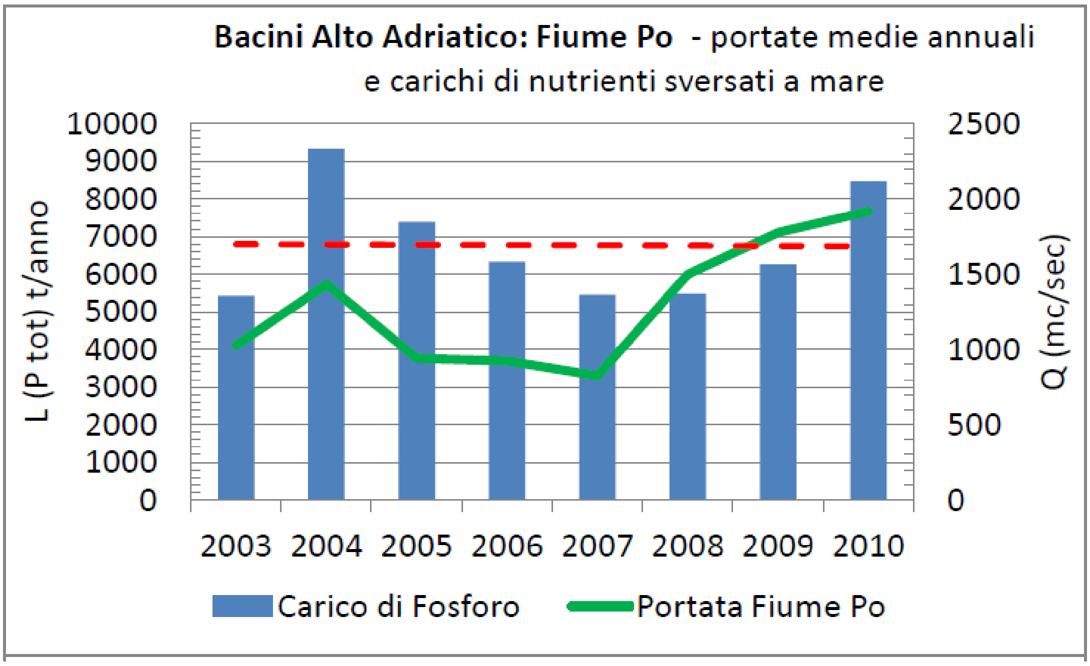


Figure 3-60 Yearly phosphorous geometric average load and capacity discharged into the Adriatic by Po river, years 2003-2010 (Source: ISPRA, 2012).

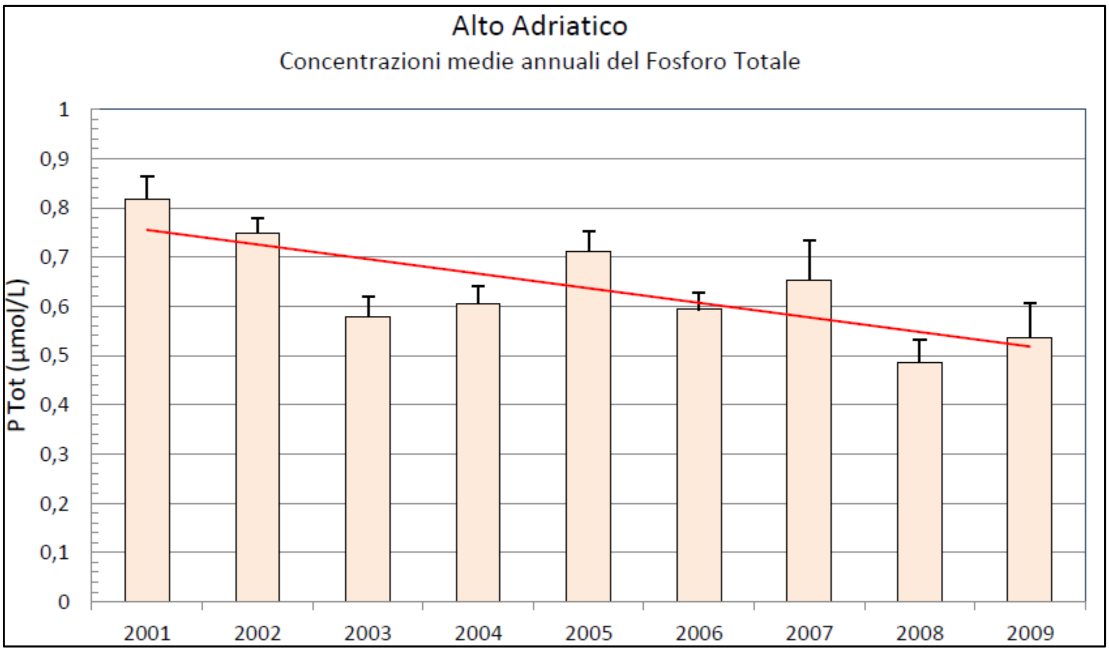


Figure 3-61 Yearly total phosphorous geometric average concentrations in the northern Adriatic (Source: ISPRA, 2012).

Focusing on the critical area in front of Emilia Romagna coastline (Figure 3-53) (in particular Po delta and Ravenna coasts, receiving approximately 294 t/y of phosphorous), results emerged for year 2010 from a study promoted by ARPA Emilia Romagna and Daphne II, are presented (ARPA Emilia Romagna, 2010).

Data registered show relevant concentration differences between the north and south part of the assessment area with a constant concentration decrease southward and from the coast-line to the open sea (Figure 3-62). Phosphorous can be nevertheless considered as the key element which limits and controls eutrophication phenomenon in the area.

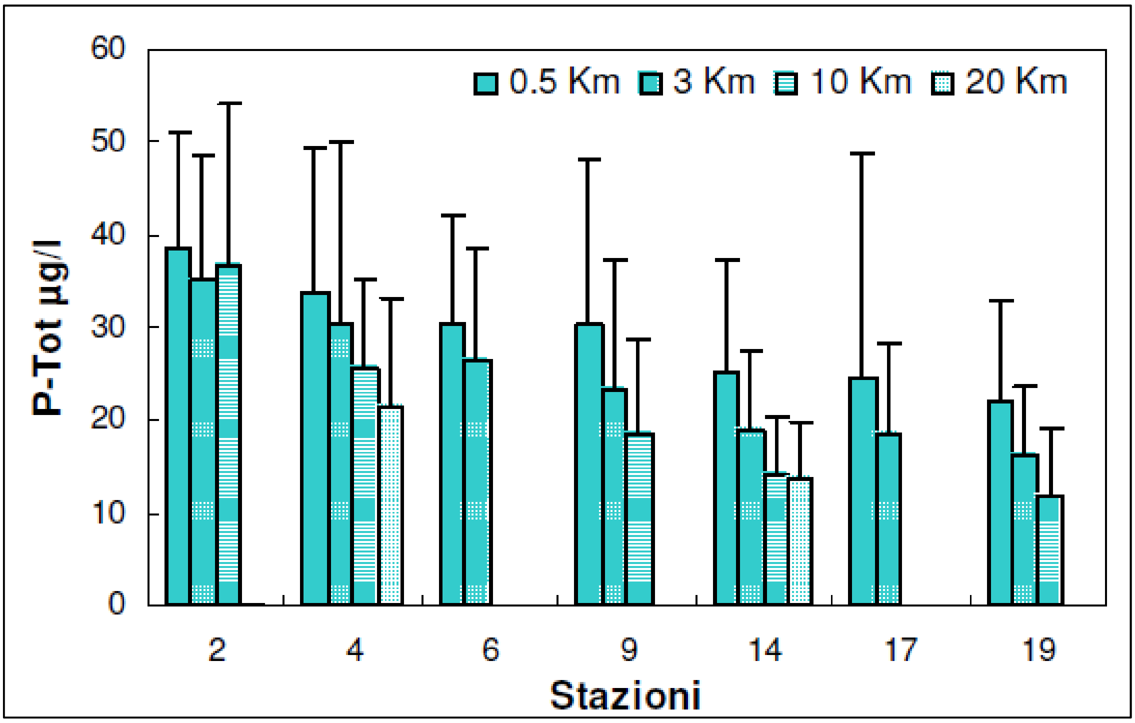


Figure 3-62 total phosphorous average yearly values and standard deviation in different sampling station at different distances from the coast (0.5, 3, 10, 20 km) (Source: ARPA Emilia Romagna, 2010).

3.2.9.3 Dissolved organic carbon (DOC)

Although the dynamics of dissolved organic carbon (DOC) in the Adriatic Sea is thought to be involved in important and extreme phenomena such as near anoxic and anoxic events, the observations on the distribution and variability of DOC and its important components are still limited (Pettine et al.,1999).

Results emerged from an explanation for the accumulation of dissolved organic carbon (DOC), observed in the Northern Adriatic Sea using a biogeochemical model based on the European Regional Seas Ecosystem Model (ERSEM), upgraded with a more detailed representation of the DOC-bacteria interactions (Polimene et al., 2007), are illustrated in Figure 3-63. This shows the surface seasonal averages of the total DOC concentrations along an horizontal distribution.

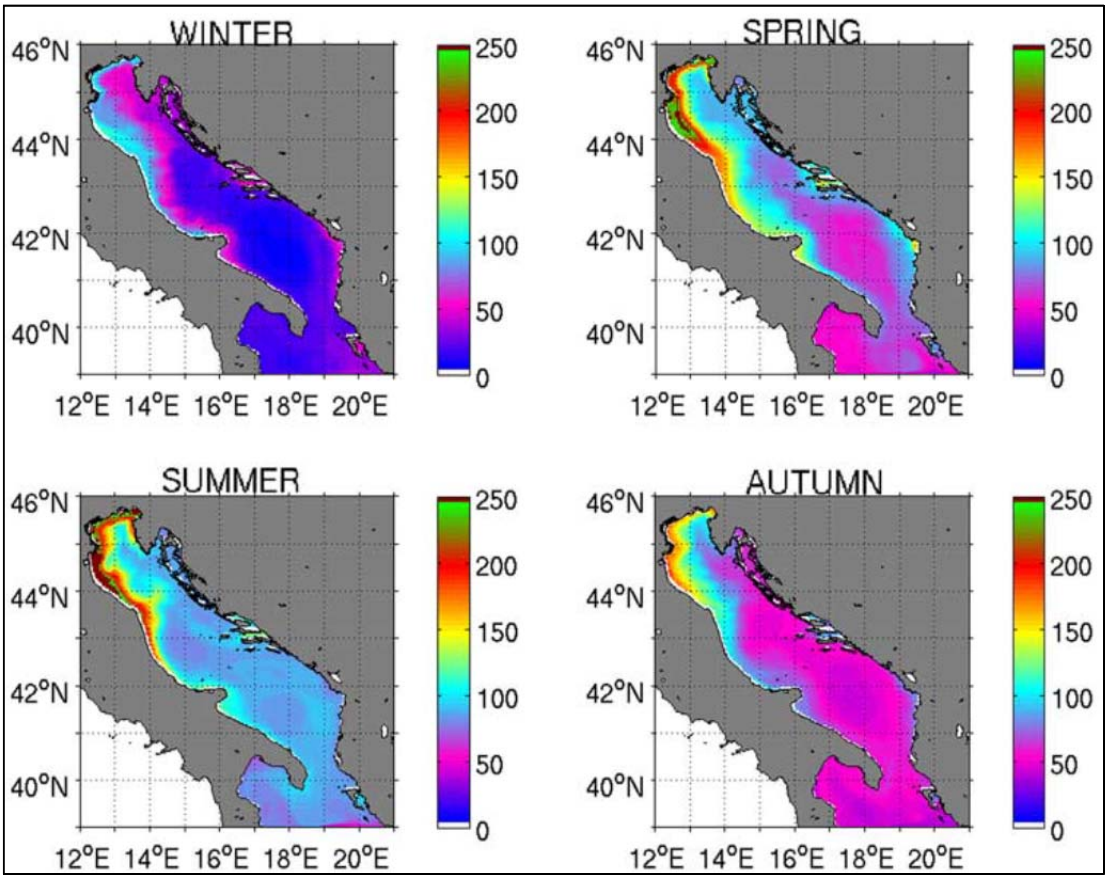


Figure 3-63 Surface, seasonally averaged, simulated total DOC (mmol L^{-1}) distribution (Source: L. Polimene et al., 2007).

The DOC winter values range from 25 mmol L^{-1} in the southern part of the basin and in the central area of the central basin, to 100 mmol L^{-1} along the Italian coasts, in the northern and central basin. During spring, DOC increases along the whole northern and western coasts, reaching values higher than 200 mmol L^{-1} in the north-western part of the basin. In the southern basin the DOC concentration is around 100 mmol L^{-1} in the coastal areas and 50 mmol L^{-1} in the open sea. In summer, the DOC concentration increases all over the basin reaching the values of about 100 mmol L^{-1} even in the open waters of the southern Adriatic. In autumn the concentration returns to the value of 50 mmol L^{-1} in the southern basin and in the eastern part of the central basin. In the north western basin concentrations higher than 150 mmol L^{-1} are still present in the coastal area. Concerning Total Organic Carbon (TOC) instead, no information at the Adriatic scale have been found.

3.2.9.4 Dissolved oxygen

The oxygen concentration in the water column depends on the interaction among surface input. Vertical/horizontal advection and diffusion, primary production and bacteria (pelagic and benthic) respiration (Bianchi et al., 2005).

The whole Adriatic Sea is a well-oxygenated basin. Results emerged from a specific study (Artegiani et al., 1996) for the dissolved oxygen profiles expressed in ml l^{-1} (Figure 3-64) show that in the warmer seasons a relatively low concentration layer is present just near the sea surface, due to oxygen equilibration with the atmosphere. During spring and summer a sub-surface maximum is formed in the euphotic zone. Between approximately 10 and 50 m, due to biological activity that results in a net production of oxygen near the pycnocline after the density stratification of the water column has become established. In autumn and winter ventilation at the surface and water column mixing create a more homogeneous oxygen distribution.

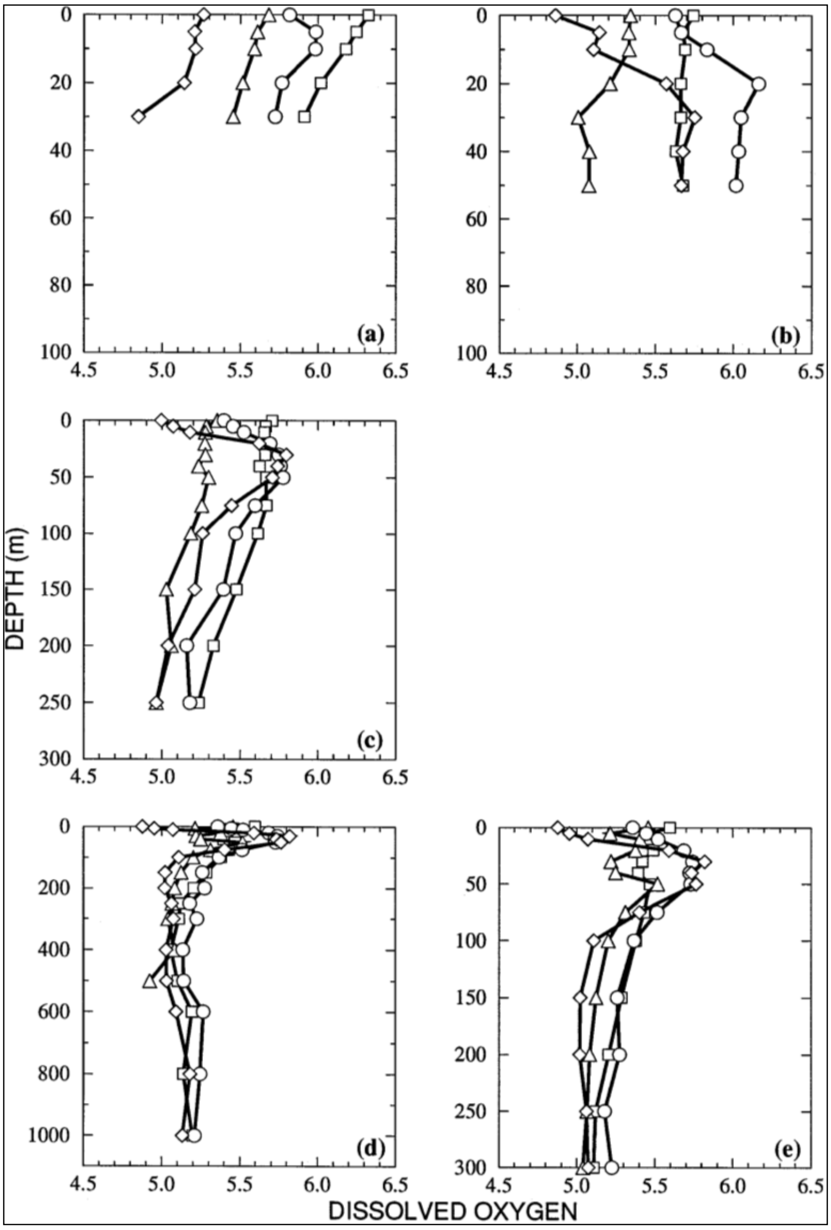


Figure 3-64 Climatological profiles of dissolved oxygen (ml l^{-1}) for (a) the northern Adriatic with bottom depth less than or equal to 50 m. (b) northern Adriatic with bottom depth greater than 50 m. (c) middle Adriatic. (d) southern Adriatic for the entire water column. and (e) southern Adriatic for the upper 300 m. Symbols indicate for winter (□). spring (O). summer (◊). and autumn (∆) (Source: Artegiani et al., 1996).

Results emerged show that in the northern Adriatic a qualitatively different shape of the average oxygen profiles with respect to middle and southern Adriatic conditions is observed. In particular north Adriatic (NA) is characterized by two different sub-regions: the first corresponds to the area shallower than 50 m, called NA-I region. and the second corresponds to the remaining part, called NA-II region.

Part (a) of Figure 3-64 for the NA-I region shows that in all seasons there is no subsurface oxygen maximum except for spring when it has been observed at 5–10 m. The NA-II region by contrast shows maximum subsurface values for spring and summer as for the middle and southern Adriatic cases. Naturally, the highest values of oxygen for the entire basin are reached during winter in the NA-I region. Thus. the NA-I region is clearly that part of the northern Adriatic basin that is characterized by shallow sea dynamics evidenced by the increased mixing throughout the water column, even during summer. In contrast deep-sea conditions are found in the NA-II region where oxygen profiles look similar to those of the middle Adriatic. Hence, the pelagic lower trophic system dynamics (i.e., nutrients and phytoplankton) are expected to be different in NA-I and NA-II regions based on different vertical distributions of oxygen. In the middle Adriatic the oxygen concentration decreases from the euphotic zone (50 m) down to the bottom, while in the southern Adriatic a minimum is found at 150–250 m due to the organic matter oxidation. Below this minimum, the oxygen concentration slightly increases down to the bottom.

An average basin value of dissolved oxygen is approximately 5.5 ml l^{-1} with a variability described by standard deviations (STD) which ranges:

- In the north Adriatic lowest variability is registered near the bottom from 0.1 ml l^{-1} in autumn and 0.4 ml l^{-1} in summer, while the highest STDs occur at the surface with values of 0.5-0.6 ml l^{-1} in all seasons except for summer when the highest STD of 0.9 ml l^{-1} is found at a depth of 30 m;
- In the middle Adriatic from 0.3–0.6 ml l^{-1};
- In the south Adriatic from 0.2–0.4 ml l^{-1}.

Focusing on a specific north Adriatic area which can be affected by eutrophication phenomenon (Figure 3-65), historic data for dissolved oxygen trend derived from ISPRA (2012), for years 2001-2009 are shown (as average) in Figure 3-66.

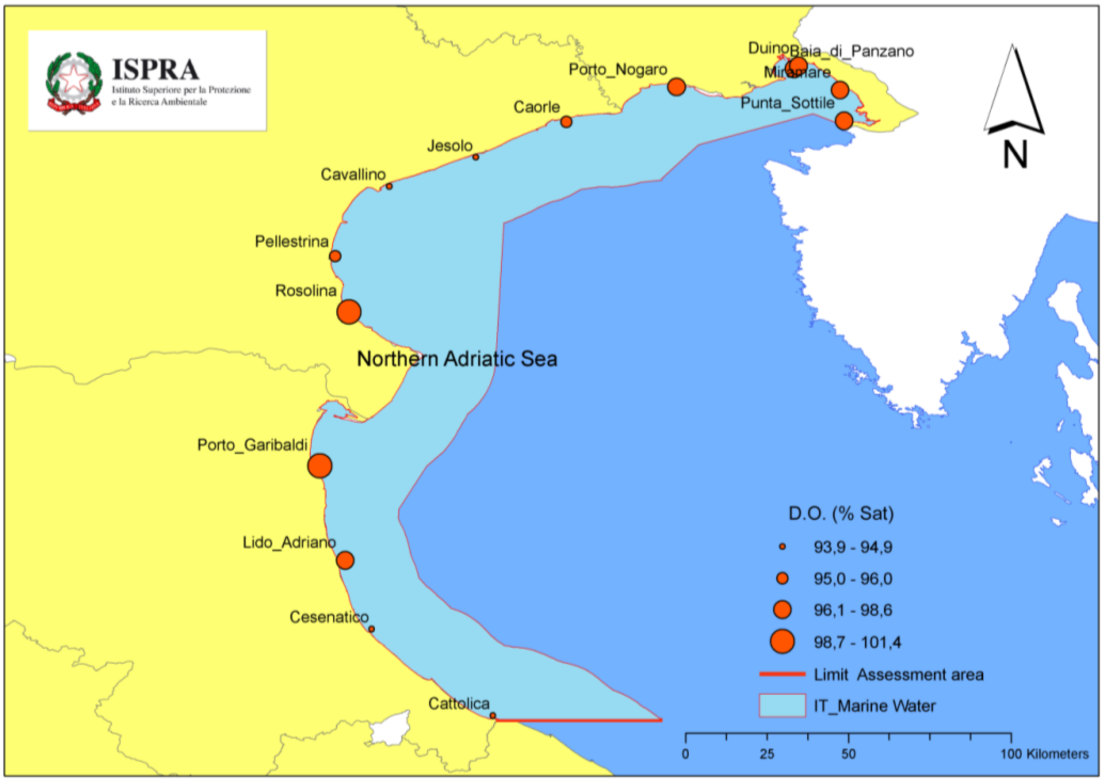


Figure 3-65 Spatial average yearly mean of dissolved oxygen (% sat) for years 2001-2009 (Source: ISPRA, 2012).

The trend is increasing during the period considered (Figure 3-66), with maximum values during 2009. Periods with over saturation concentrate during spring and summer and derive from high photosynthetic activity.

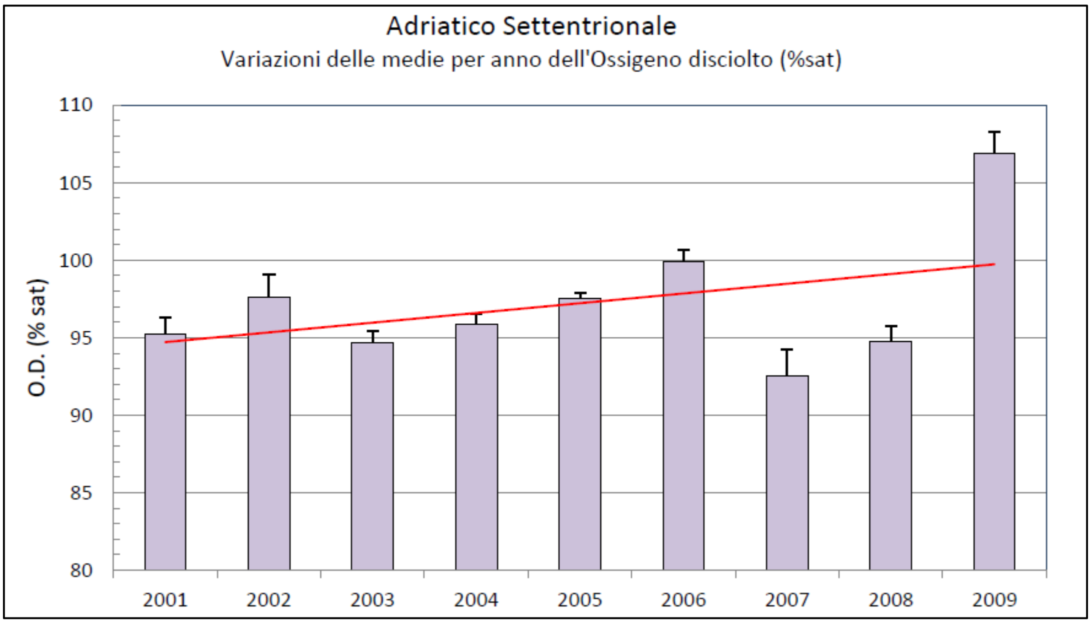


Figure 3-66 Dissolved oxygen trend (% sat) (annual mean and standard error) (Source: ISPRA, 2012).

3.2.10 pH profiles or equivalent information used to measure marine acidification

Ocean acidification refers to a reduction in the pH of the ocean over an extended period, typically decades or longer, caused primarily by the uptake of CO_2 from the atmosphere; moreover it can be caused by other chemical additions or subtractions from the ocean. This storage capacity limits the amount of human-released CO_2 remaining in the atmosphere but once dissolved in seawater, CO_2, which is a weak acid, generates a number of changes in seawater chemistry, primarily carbonate chemistry. It increases the concentration of bicarbonate ions and dissolved inorganic carbon and lowers the pH, the concentration of carbonate ions, and the saturation state of the three major carbonate minerals present in shells and skeletons (Gattuso and Hansson, 2011).

In aquatic ecosystems pH depends on the amount of dissolved CO_2 and is an indicator of animal and plant communities' metabolism (respectively respiration and photosynthesis). In marine water an average pH value is 8.2; higher values are registered in presence of high oxygen and chlorophyll values. Going below the euphotic zone pH becomes more acid because of CO_2 produced by animals. In bottom waters lower pH values are found in presence of anoxia and hypoxia conditions, which generate reduction conditions with toxic substances generation like methane and hydrogen sulphide. Moreover pressure that increases with depth melts carbonic acid, lowering pH of approximately 0.02 every 1,000 m depth. Marine water has nevertheless a high buffer power and can control pH variations.

For Italy ISPRA detects information on some marine parameters through the Italian "Rete Mareografica Nazionale" (RMN); regarding the Adriatic sea, four stations (Figure 3-67) now monitor pH parameter. Result of pH trend are shown in Figure 3-68 for Trieste, Venezia, Vieste and Otranto stations during a period of two years (September 2010-september 2012).

Figure 3-67 Adriatic stations for pH measurement displacement (Source: http://www.mareografico.it, last access 17 June 2013).

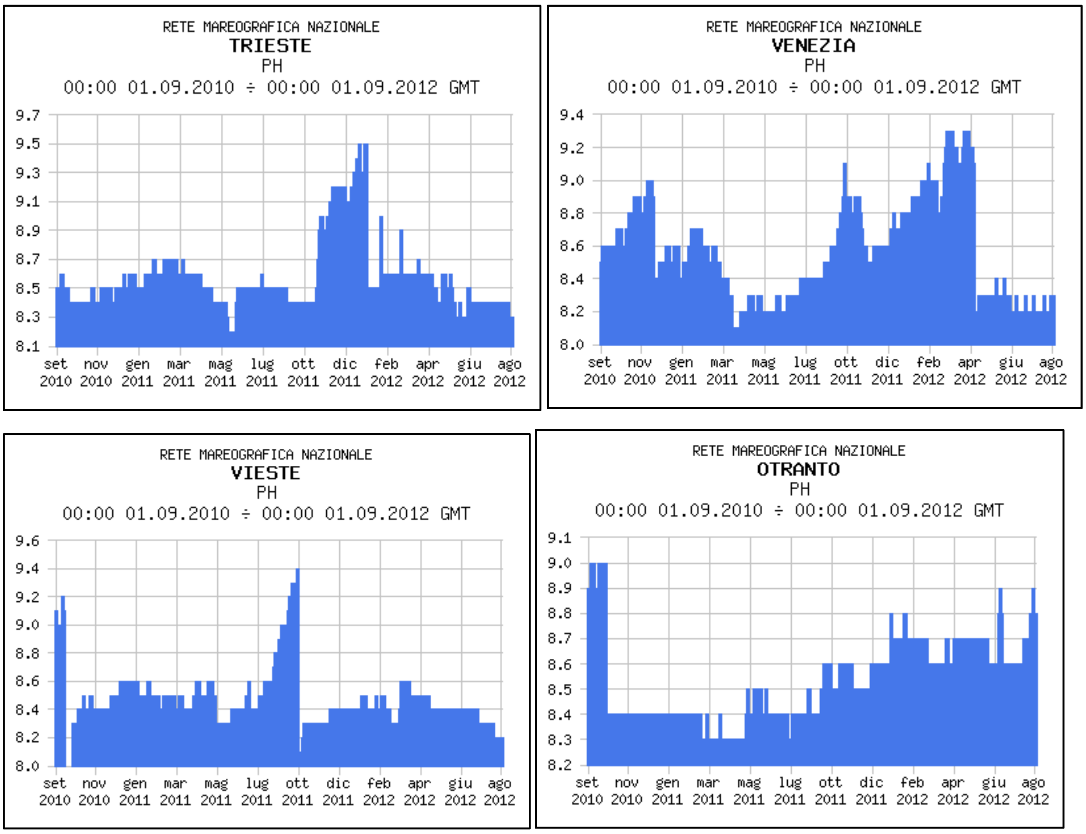


Figure 3-68 pH values and trends for some Adriatic oceanographic stations from September 2010 to September 2012 (Source: http://www.mareografico.it, last access 22 November 2012).

Peaks of pH are registered in all stations with values higher than 9 (Trieste reached the highest value of 9.5 in January 2012). In all cases however pH didn't go down the value of 8.0 and most values are over 8.4. On average higher pH values are detected in the north Adriatic. Outcomes emerged from ISPRA (2012) using logistic regression model on pH observations in Adriatic stations tried to estimate the probability of acidification (pH<7.9) and for every station probability emerged resulted to be zero.

3.3 Habitat types

Directive 2008/56/CE aims to establish a framework for community action in the field of marine environmental policy. In particular, reaffirming the relevance of concepts expressed by previous Directive 92/43/CEE and Directive 79/409/CEE, it supports the strong position taken by the Community, in the context of the Convention on Biological Diversity, on halting biodiversity loss, ensuring the conservation and sustainable use of marine biodiversity, and on the creation of a global network of marine protected areas by 2012.

Following paragraphs first illustrate main sea bottom types and habitats, evidencing those most relevant and then provide a general framework of the current Adriatic situation of marine and coastal protected areas.

3.3.1 Predominant seabed and water column habitat types

Directive 92/43 (so called Habitat Directive) defines a list of marine habitats, of which two are classified as of primary importance in the Adriatic (coastal lagoons and *Posidonia oceanica* grassland). In addition to such habitats, also relevant are moreover the coral seabed habitat and the so called "tegnue", particular rocky habitats of high ecological value spread in the north Adriatic. The north Adriatic is mainly characterized by sandy and muddy seabed as shown in Figure 3-69; Figure 3-70 focuses the seabed mapping in the area in front of Emilia Romagna coastline. Concerning the south Adriatic, the study redacted by ISPRA (2012) within the implementation process of MSFD in Italy has identified the area shown in Figure 3-71 as representative for the southern basin.

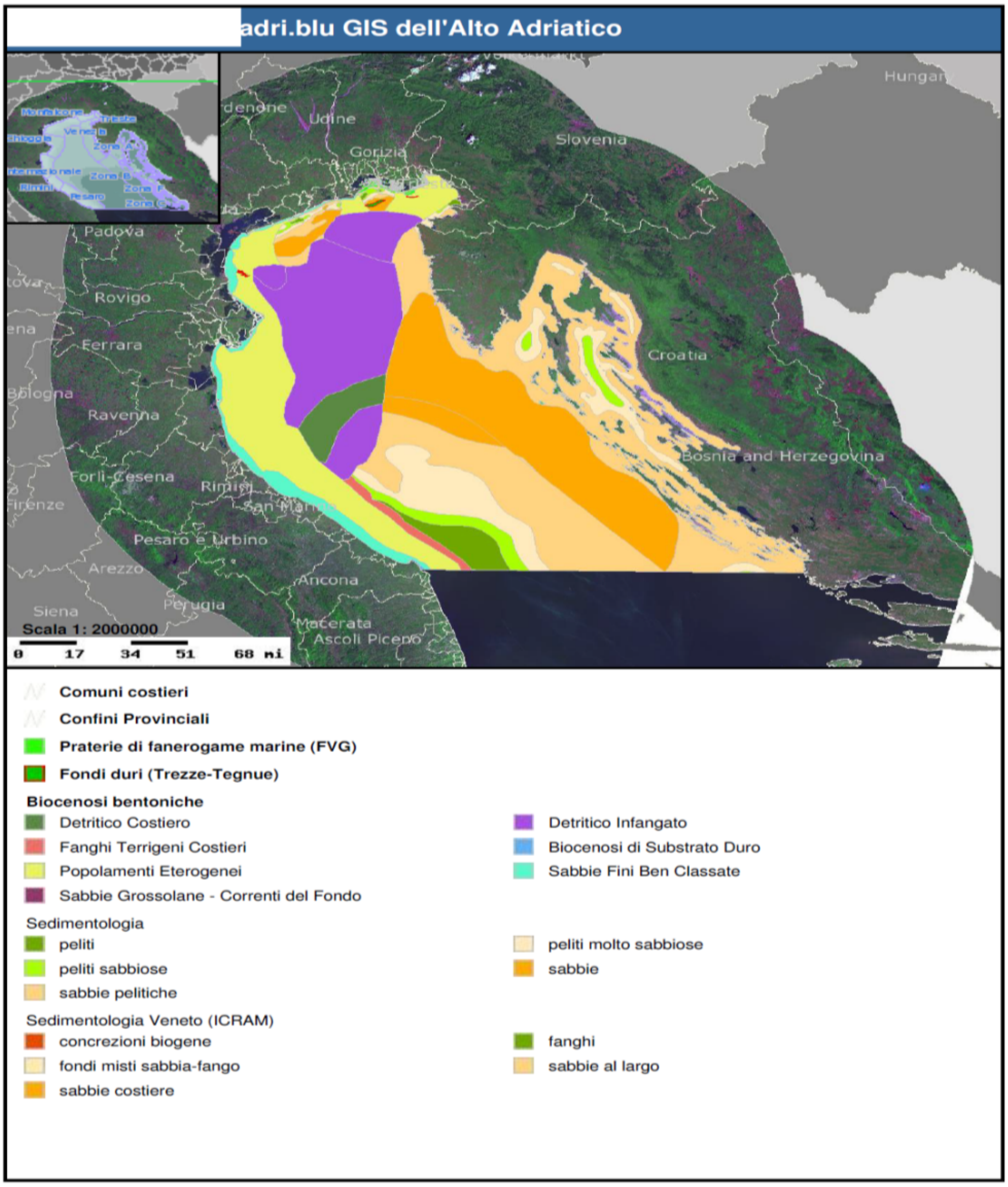
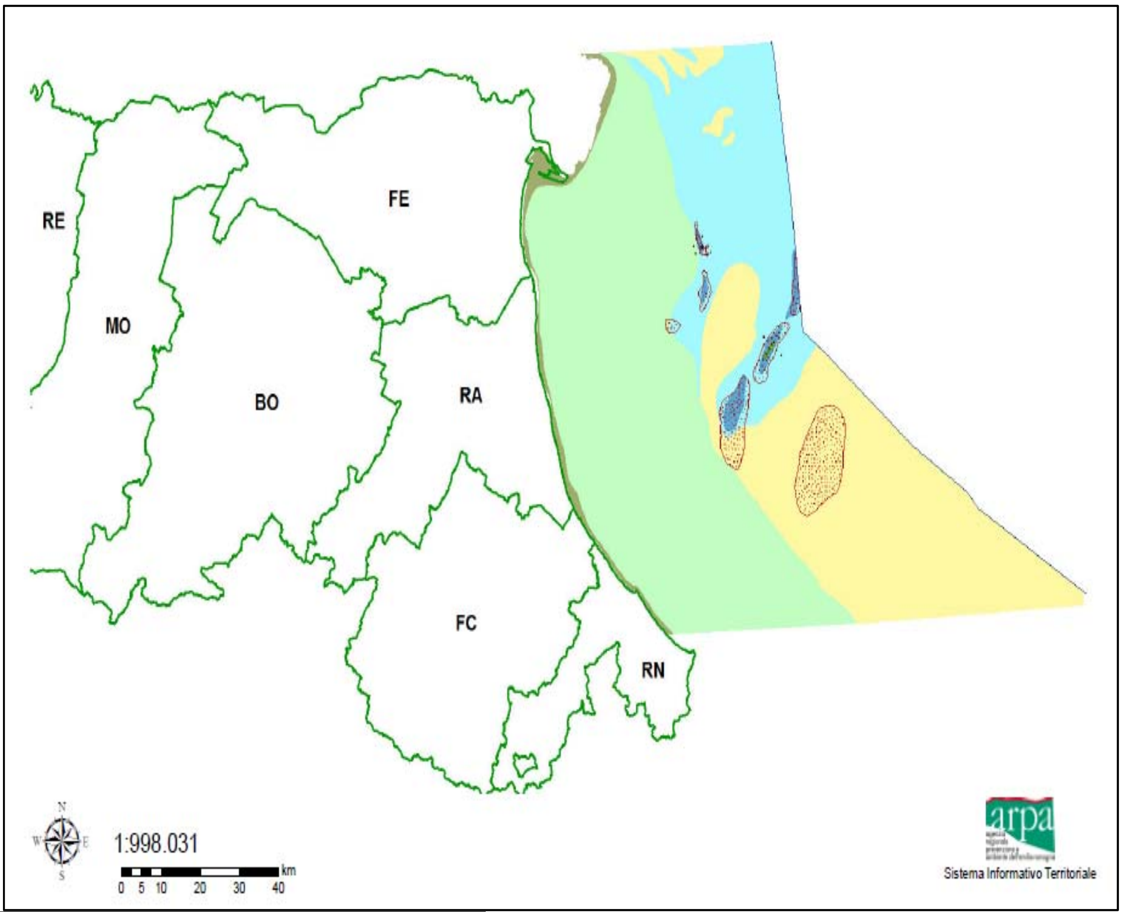


Figure 3-69 Predominant seabed in the north Adriatic (Source: ARPA Friuli Venezia Giulia, http://mapserver.arpa.fvg.it/adriblu/map.phtml, last access 22 November 2012).



Legend	
Beach sand (HST)	
Beach sand (TST)	
Lagoon pelites (TST)	
Pro delta and platform pelites (HST)	
Floodplain deposit (FSL/LST)	

Figure 3-70 Predominant seabed in front of Emilia Romagna coastline (Source: ARPA Emilia Romagna, http://servizigis.arpa.emr.it/Geovistaweb/default.aspx, last access 22 November 2012).

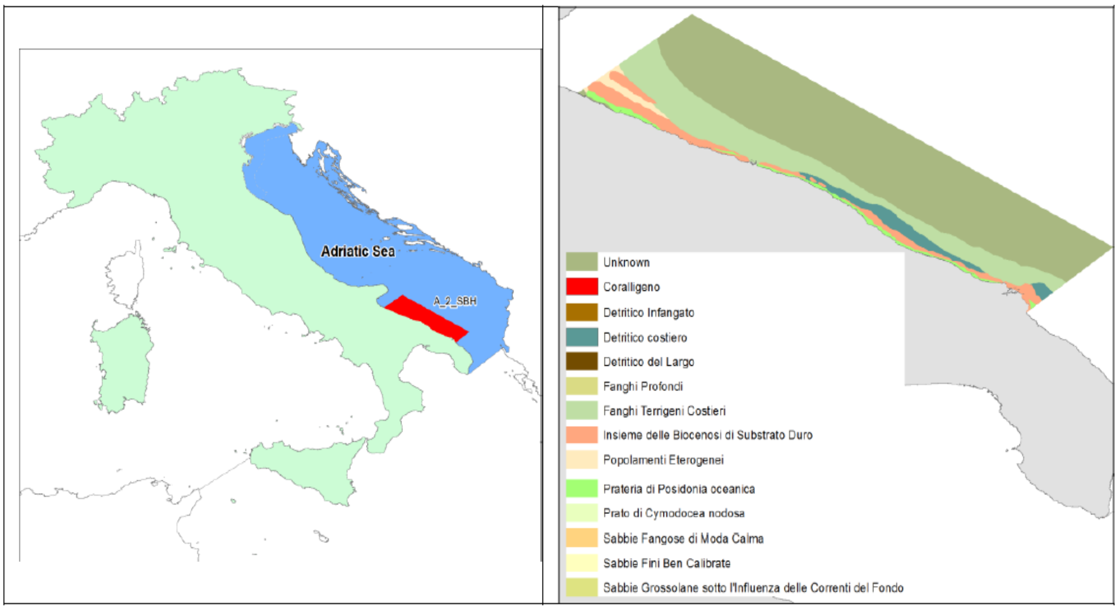


Figure 3-71 assessment area for the Italian south Adriatic coastline (Source: ISPRA, 2012).

3.3.2 Identification and mapping of special habitat types

Main EU directives on protected areas are the 1979 Wild Birds Directive (409/79/CEE) and the Habitats Directive (43/92/CEE), both of which relates to the protection of environmentally valuable sites that together constitute the Natura 2000 network.

The main purpose of the Natura 2000 network is to enable the natural habitat types and the species' habitats to be maintained and restored to a favourable conservation status, ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora. The Directives do not regulate human activities in the sites, but simply define the principle that the national states are responsible for the conservation of the Natura 2000 sites. Nature 2000 includes two different types of sites:

- Special Protection Area (SPA);
- Special Area of Conservation (SAC).

For the first category, Directive 79/409/CEE asked Member States to define SPA for geographic localization and conservation of threatened, vulnerable or rare bird species cited in Annex I of the Directive. SAC instead are set by Habitat Directive and are established with the following objectives:

- Community interest natural or semi-natural habitat conservation for their rarity or their ecologic primordial role (the list is established in Annex I of Habitat Directive);
- Community interest flora and fauna for their rarity, symbolic or essential value in the ecosystem (the list is established in Annex II of Habitat Directive).

The procedure for the classification of a site as SAC is longer than a SPA because in this case every Member State makes an inventory of all potential sites in its own territory; these sites are then proposed to the European Commission as SCI (proposal of Site of Community Importance) and after EU approval they can be considered as SCI and integrated into Nature

2000 network. Afterward they are formally designed as SAC by an act assuring the conservation measures of the nature habitats.

In Italy SCI and SPA cover altogether 21% of the National territory (Ministry of the Environment[10]). In the case of the Adriatic sea, SPA and SAC areas exist only in UE countries (Italy and Slovenia). SPA and SCI sites for the Adriatic are showed in Figure 3-72. For the other countries there are similar protected areas but that can't be formally included into Nature 2000 framework.

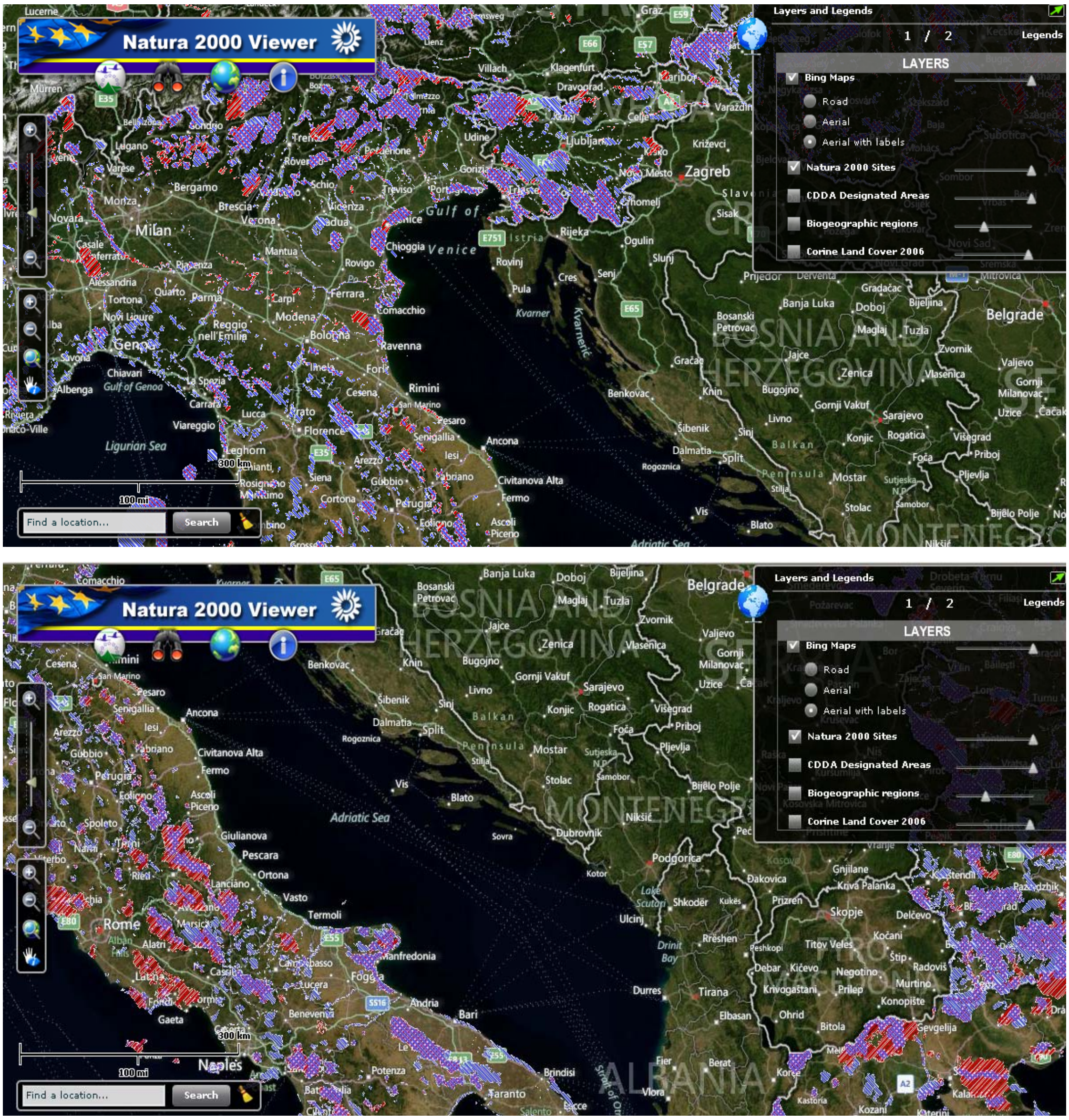


Figure 3-72 SPA and SCI sites in the Adriatic (Source: Natura 2000, http://natura2000.eea.europa.eu, last access 17 June 2013).

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10 http://www.minambiente.it/home_it/index.html?lang=it last visit 22/11/2012

Italian coastal SPA and SCI mainly concentrate along the northern and southern Adriatic coastline and in mostly cases are overlapping. The most important are concentrated in:

- Venice lagoon: area with significant historical anthropic impact and pollution caused by industrial activities in the Porto Marghera area, relevant pressure due to tourism and marine traffic fluxes, other human activities including aquaculture and fishing;
- Marano Grado lagoon: area characterized by polluted zones inside the lagoon, fishing activities and summer tourism along Grado and Lignano Sabbiadoro coastline;
- Po delta: area with high biodiversity, threatened by pollution derived from Po river flux and local fishing activities (mainly mussel and clam cultivation);
- Comacchio lagoon;
- Areas near Gargano promontory;
- Areas along Apulian coastline.

The complete list of the areas is available at Environment Ministry website[11].

Regarding specifically marine protected areas included in the Natura 2000 network, they are quite small. In the northern part of the basin most important areas that can be identified are:

- “Tegnùe di Chioggia” (Habitat Directive) offshore Venice lagoon (Figure 3-74 shows known “tegnue” of the Northern Adriatic);
- “Tegnùe di Porto Falconera” (Habitat Directive) offshore Caorle town (Figure 3-74 shows all the “tegnue” of the north Adriatic);
- “Area marina di Miramare” (Habitat Directive) near Trieste;
- “Foce dell’Isonzo isola della Cona” (Birds and Habitat Directive) in the Panzano gulf (partially marine area);
- “Valle Canavata e banco mula di Muggia” (Birds and Habitat Directive) near Grado (partially marine area);
- “Relitto della piattaforma Paguro” (Habitat Directive) offshore Ravenna coasts.

[11] http://www.minambiente.it/home_it/index.html?lang=it;last access 17 June 2013.

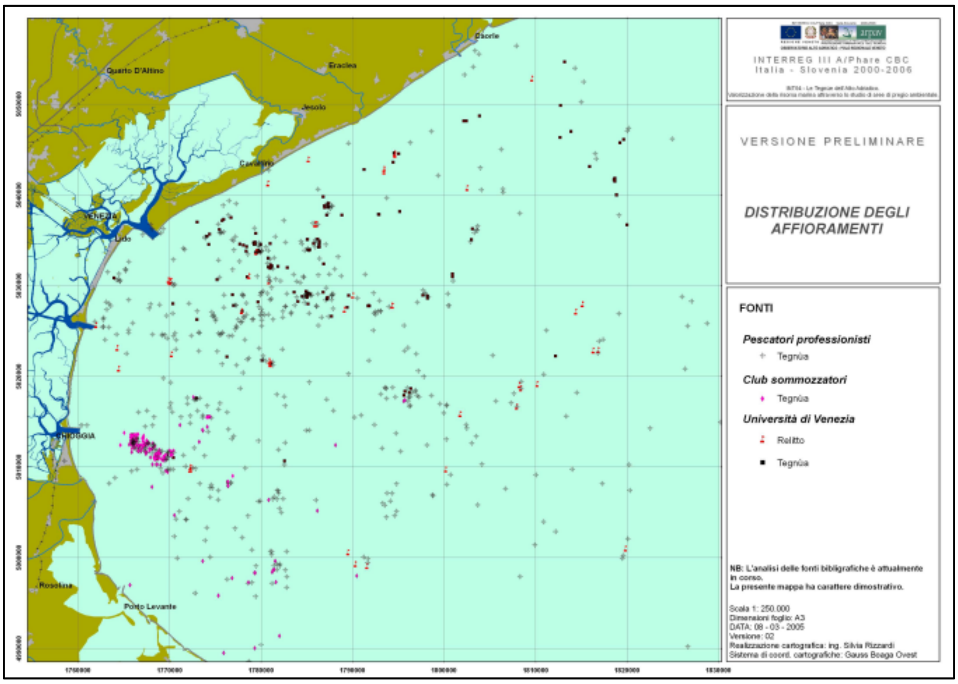


Figure 3-73 Potential rocky outcrops (Tegnue) identified by information provided by institutions, administration and operators (Source: ARPAV– FONDAZIONE MUSEI CIVICI VENEZIA, 2010).

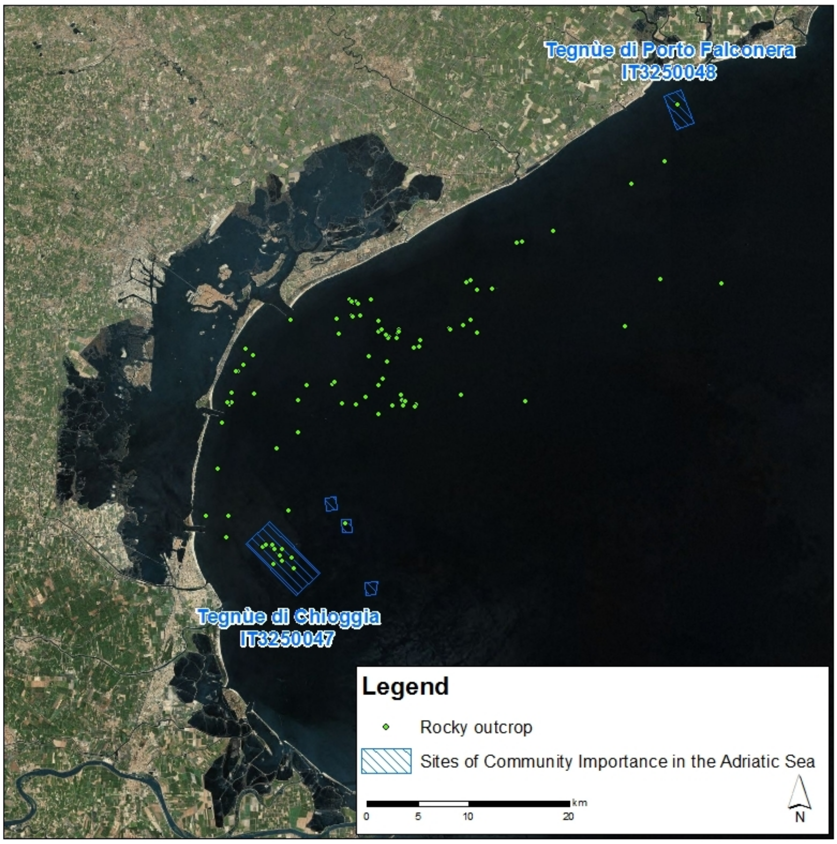


Figure 3-74 "Tegnue" distribution in the north Adriatic (Source: REGIONE VENETO-Magistrato alle Acque, 2010; 2012).

Going southern main marine protected areas are:

- “Torre del Cerrano” (Habitat Directive) in front of Pineto coast;
- “Colle San Bartolo e litorale pesarese” (Birds Directive) along Pesaro coastline (partially marine area);
- “Isole tremiti” (Habitat Directive) between S. Nicola and S. Domino islands and “Isole Tremiti” (Birds and Habitat Directive) in front of Pianosa coasts; areas characterized by important seasonal tourism;
- “Posidonieto San Vito-Barletta” (Habitat Directive) in front of Barletta and Bari; zones suffering impact deriving from industrial activities and ship traffic;
- “Litorale brindisino” (Habitat Directive) in front of Monopoli coastline (partially marine area); zones suffering impact deriving from industrial activities and ship traffic;
- “Torre Guaceto e macchia S. Giovanni” (Habitat Directive) along northern Brindisi coasts (partially marine area);
- “Stagni e saline di punta della contessa” (Birds and Habitat Directive) in front of Brindisi coasts (partially marine area);
- “Bosco Tramazzone”, “Rauccio”, “Torre Veneri”, “Aquatina di Frigole”, “Le Cesine” (Habitat Directive) offshore southern Brindisi coasts (partially marine area);
- “Alimini” (Habitat Directive) along Otranto coastline (partially marine area); zones with high seasonal tourism fluxes.

Regarding Slovenian SPA and SCI areas of specific interest are:

- “Seèoveljske soline” (Birds Directive);
- “Seèoveljske soline in estuarij dragonje” (Habitat Directive);
- “Strunjanske soline s stjuzo” (Habitat Directive);
- “Kanal sv, Jerneja” (Habitat Directive) near Portoroz;
- “Piranski klif” (Habitat Directive) near Piran;
- “Med pacugom in fieso, klif” (Habitat Directive) near Piran;
- “Med strunjanom in pacugom, klif” (Habitat Directive) near Piran;
- “Med izolo in strunjanom, klif” (Habitat Directive);
- “Zusterna ratsisee pozejdonke” (Habitat Directive) near Izola;
- “Ankaran sv Nikolaj” (Habitat Directive);
- “Debeli rtiè klif” (Habitat Directive);
- “Skocjanski zatok” (Habitat and birds Directive) near Koper.

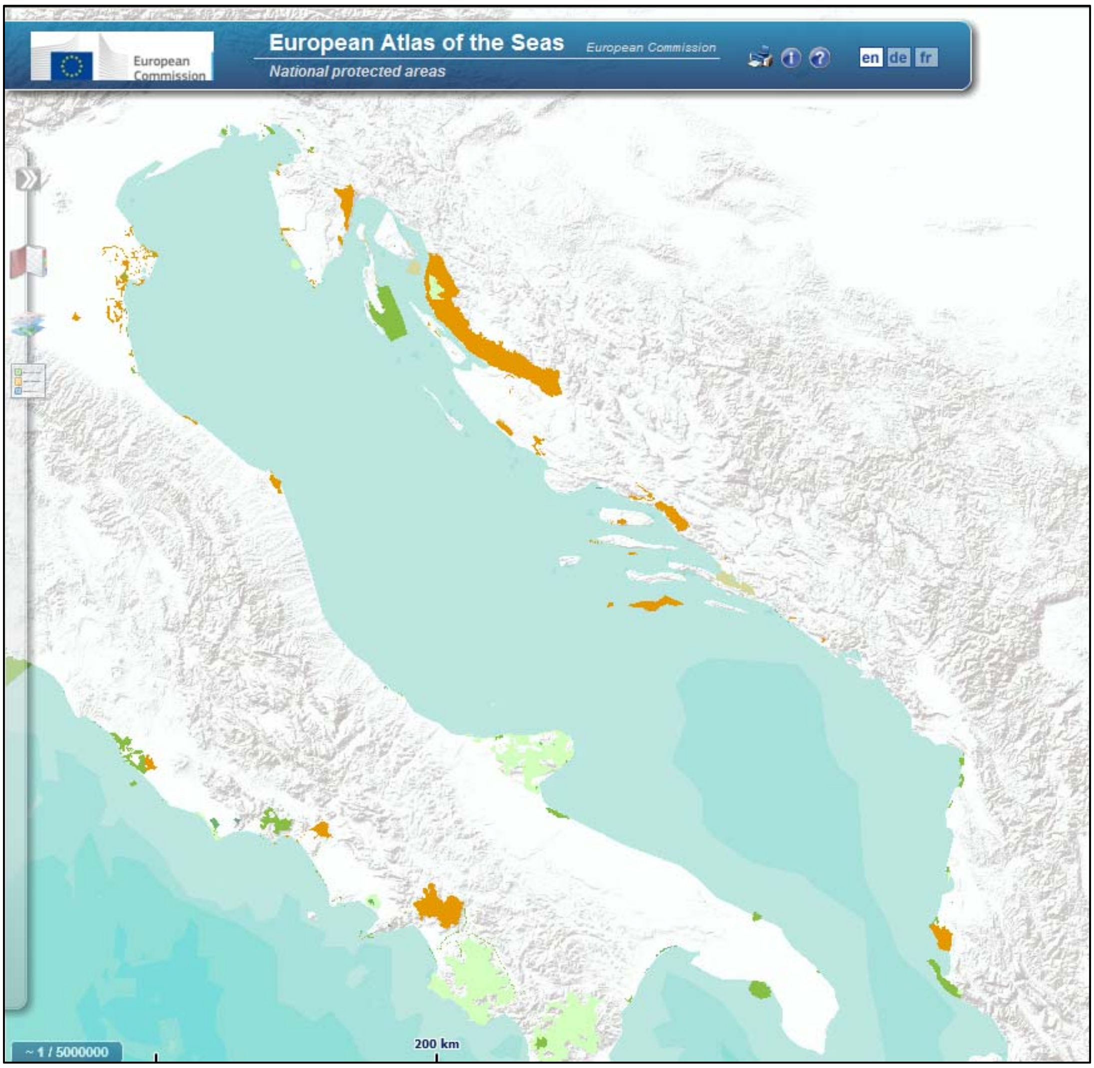
For the other non EU countries the map showed in Figure 3-75 summarizes main national protected areas, including coastal ones (year 2009). Most important areas include:

- Brijuni National park in the homonymous island in Croatia;
- Habitat/Species Management Area near Cres island in Croatia;

- Wilderness Area northern Rab island in Croatia;
- Lastovsko Otočje National park. Lastovo island, Croatia;
- Mljet National park, Croatia.

Regarding coastal protected areas, the following can be highlighted:

- Sjeverni Velebit park along Croatian coastline northern Zadar;
- Limski Zaljev Special marine reserve near Rovinj, Croatia;
- Telascica nature park, Dugi Otok island, Croatia (Important Bird Area);
- Malostonski Zaljev reserve northern Dubrovnik, Croatia (special marine reserve);
- Divjaka-Karavasta National Park southern Durres, Albania;
- Kune-Vain-Tale, Patok-Fushë Kuqe reserves northern Durres, Albania.



National protected areas

- Strict Nature Reserve: protected area managed mainly for science
- Wilderness Area: protected area managed mainly for wilderness protection
- National Park: protected area managed mainly for ecosystem protection and recreation
- Natural Monument: protected area managed mainly for conservation of specific natural features
- Habitat/Species Management Area: protected area managed mainly for conservation through management intervention
- Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation
- Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems
- Unknown

Figure 3-75 National protected areas for Adriatic countries (European Atlas of the Sea; http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/, last access 17 June 2013).

Furthermore, in Montenegro the following protected areas are significant along the coastline.

Table 3-5 Protected areas along the coastal area in Montenegro (Source: Montenegro Public Enterprise for Coastal Zone Management).

Name of the protected area	Surface	Protection Category and year of protection
Municipality of Ulcinj		
Velika ulcinjska beach	600 ha	Nature reserve since 1968, recategorization pending
Mala ulcinjska beach	1,5 ha	Nature reserve since 1968, recategorization pending
Valdanos beach	3 ha	Nature reserve since 1968, recategorization pending
Stari Ulcinj (island and beach)	2,5 ha	Nature reserve since 1968, recategorization pending
Municipality of Bar		
Veliki pijesak beach	0,5 ha	Nature reserve since 1968, recategorization pending
Topolica beach	2 ha	Nature reserve since 1968, recategorization pending
Sutomore beach	4 ha	Nature reserve since 1968, recategorization pending
Čanj beach	3,5 ha	Nature reserve since 1968, recategorization pending
Pećin beach	1,5 ha	Nature reserve since 1968, recategorization pending
Ratac semiisland with Žukotrli-ca beach	30 ha	Nature reserve since 1968, recategorization pending
Municipality of Budva		
Lučice beach	0,9 ha	Nature reserve since 1968, recategorization pending
Buljarica beach	4 ha	Nature reserve since 1968, recategorization pending
Petrovac beach	1,5 ha	Nature reserve since 1968, recategorization pending
Drobni pijesak beach	1 ha	Nature reserve since 1968, recategorization pending
Sveti Stefan beach	4 ha	Nature reserve since 1968, recategorization pending
Miločer beach	1 ha	Nature reserve since 1968, recategorization pending
Bečići beach	5 ha	Nature reserve since 1968, recategorization pending
Slovenska beach	4 ha	Nature reserve since 1968, recategorization pending
Mogren beach	2 ha	Nature reserve since 1968, recategorization pending
Jaz beach	4 ha	Nature reserve since 1968, recategorization pending
Municipality of Tivat		
"Tivatska solila" wetland	150ha	Special nature reserve since 2008.
Pržno beach	2 ha	Nature reserve since 1968, recategorization pending
Municipality of Kotor		
Kotorsko-Risanski Bay	15.000ha	UNESCO World natural and cultural Heritage since 1979.

3.4 Biological features

3.4.1 Biological communities associated with the predominant seabed and water column habitats, macro-algae and invertebrate bottom fauna

The Adriatic Sea has important morphological differences between the Italian coasts and the oriental coastline, which include Croatia, Slovenia, Bosnia, Albania and Montenegro. In fact while the western part of the basin is characterized by low, flat sandy coasts, with the exception of Gargano cape and Monte Conero, and wide lagoons in the north part and near Gargano cape, the eastern coast is high, rocky and with many islands creating channels and bays. These differences and other physical parameters like for example temperature, turbidity, salinity, etc., influence also biological communities and organisms that can be found in the water column or near/in the ocean bed.

The following paragraphs, derived from specific sector studies, give an overlook of Mediterranean species and those specifically found in the Adriatic Sea which plays a relevant role from the ecological point of view. Where data on species abundances are not available, presence information are given.

3.4.1.1 Phytoplankton

Phytoplankton and zooplankton are the main microorganisms that can be found in the water column and on the sea bed and constitute the autotrophic component of the plankton community. They are photosynthesizing microscopic organisms that inhabit the upper sunlight layer of almost all oceans and bodies of fresh water, they are agents for primary production. Phytoplankton obtains energy through the process of photosynthesis and must therefore live in the well-lighted surface layer (euphotic zone) of an ocean, sea, lake, or other body of water. Phytoplankton accounts for half of all photosynthetic activity on Earth[12].

Data on species abundance at the Adriatic basin scale are not available but important information can be obtained from chlorophyll “a”, which is a photosynthetic pigment commonly present in all phytoplankton species used as an indication for phytoplankton biomass.

Figure 3-76, derived from the European Atlas of the Seas for year 2011, shows that higher chlorophyll “a” concentrations (expressed in mg/m^3) are reached nearby coastlines and particularly near river deltas. Offshore and coastal waters in front of Po river are areas with highest chlorophyll “a” concentrations.

12 http://www.nasa.gov/topics/earth/features/modis_fluorescence.html, last access 5 December 2012

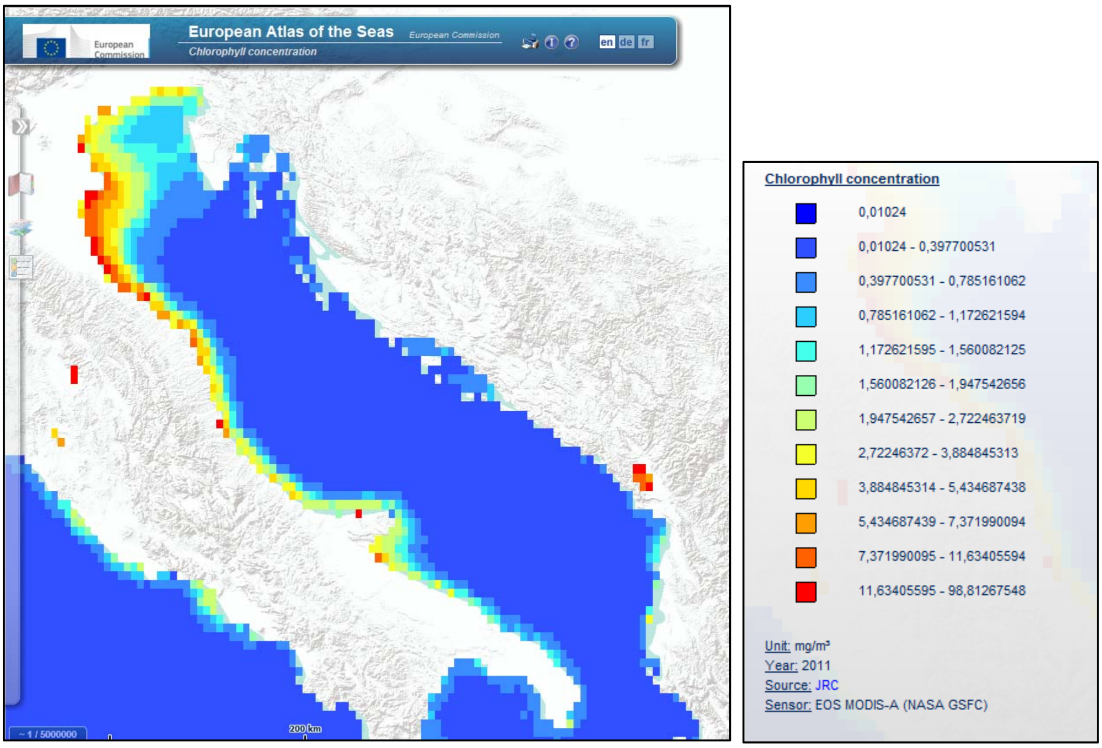


Figure 3-76 Chlorophyll "a" concentration in the north Adriatic year 2009 (Source: European Atlas of the Sea; http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/, last access 17 June 2013).

Following paragraphs describing phytoplankton groups have been divided following the classification of specific literature (MATTM and ICRAM, 2006):

- Bacillariophyceae;
- Dinophyceae;
- Prymnesiophyceae *coccolithophorales*;
- Cyanophyceae;
- Chrysophyceae;
- Chlorophyceae;
- Cryptophyceae;
- Dictyochophyceae;
- Prasinophyceae;
- Euglenophyceae;
- Prymnesiophyceae *Prymnesiales*;
- Raphydophyceae;

The first two classes and the coccolithophorales order constitute 87% of total phytoplankton.

The following chapters provide a short list of brief species found in the Adriatic. The complete list of species, divided into phytoplankton and microphytobenthos, can instead be found at:

- http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/48%20PHYTOPLANKTON.pdf, last access 17 June 2013;
- http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/49%20MICROPHYTOBENTHOS.pdf, last access 17 June 2013.

Due to its relevance, a specific paragraph on the mucilage phenomenon generated by phytoplankton in the Adriatic is also provided.

Bacillariophyceae

Bacillariophyceae, also called diatoms, represent one of the largest microalgali group, and comprise between 10,000 and 12,000 species. They are ubiquitous in coastal and oceanic aquatic ecosystems, in marine, polar, transition and freshwater environments, can be planktonic or benthic, are present in variable ways depending on latitude, occur in all seasons depending on the species. In the Adriatic abundance peaks are reached mainly during winter and secondly in spring (especially for *Chaetoceros* spp. *Pseudo-nitzschia pseudodelicatissima* and *Cylindrotheca closterium*) and autumn (especially for *Chaetoceros* spp. *Asterionellopsis glacialis, Guinardia striata* and *Lioloma pacificum*) (Regione Marche and Zara County, 2008). Main species that can be found in the Adriatic sea are summarized in Table 3-6.

Table 3-6 species belonging to bacillariophyceae class found in the Adriatic Sea (source: Società Italiana di Biologia Marina SIBM[13]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Asterionellopsis glacialis	(Castracane) Round in Round, Crawford & Mann, 1990	X	X	X	Cosmopolitan, often organized in colonies and abundant along Italian coastlines
Bacteriastrum delicatulum	Cleve, 1897	X	X	X	Common in tempered waters of almost all Italian seas
Cerataulina pelagica	(Cleve) Hendey 1937	X	X	X	Cosmopolitan, coastal and abundant along almost all Italian coastlines
Chaetoceros brevis	Schutt 1895	X	X		-
C. danicus	Cleve 1889	X	X	X	-
C. decipiens	Cleve 1873	X	X	X	-
C. didymus	Ehrenberg 1845	X	X		-

13 http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/48%20PHYTOPLANKTON.pdf, last access 17 June 2013

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
C. diversus	Cleve 1873	X	X	X	-
C. laciniosus	Schutt 1895	X	X	X	-
C. lorenzianus	Grunow 1863	X	X	X	-
C. messanensis	Castracane 1875	X	X	X	-
C. peruvianus	Brightwell 1856	X	X	X	-
C. tenuissimus	Meunier 1913	X	X	X	Present in all Italian seas
Chaetoceros simplex	Ostenfeld 1901	X	X	X	Found also along vene-tian coasts
Chaetoceros socialis	Lauder 1864	X	X	X	Cosmopolitan, common in the north Adriatic par-ticularly at the Po river mouth
Coscinodiscus sp	Ehrenberg 1939 emend. Hasle & Sims 1986	X	X	X	-
Cyclotella spp		X	X	X	Common in the north Adriatic near coastal areas
Cylindrotheca closterium	(Ehrenberg) Lewin et Reimann 1964	X	X	X	-
C. fusiformis	Reimann et Lewin 1964	X		X	-
Dactyliosolen blavyanus	(H. Peragallo) Hasle 1975		X	X	-
Entomoneis spp			X	X	Found in marine and brackish waters
Eucampia cornuta	(Cleve) Grunow in Van Heurck, 1880-1885	X	X	X	-
Guinardia flaccida	(Castracane 1886) H. Peragallo 1892	X	X	X	-
Guinardia striata	(Stolterfoth) Hasle in Hasle & Syversten, 1996	X	X	X	-
Hemiaulus hauckii	Grunow in Van Heurck 1880-1885	X	X	X	Common in tempered and warm waters and abundant along Italian coasts
Hemiaulus sinensis	Greville 1865	X	X	X	-
Leptocylindrus danicus	Cleve 1889	X	X	X	-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Leptocylindrus mediterraneus	(H. Peragallo) Hasle 1975	X	X	X	-
Leptocylindrus minimus	Gran 1915	X	X	X	Abundant along Italian coasts
Lioloma pacificum	(Cupp) Hasle in Hasle & Syvertsen, 1996	X	X	X	Present between February and May and in October
Nitzschia longissima	(Brébisson in Kützing) Ralfs in Pitchard, 1861	X	X	X	More frequent in coastal waters
Pseudo-nitzschia pseudodelicatissima	(Hasle) Hasle 1993	X	X	X	Produces neurotoxins
Pseudo-nitzschia pungens	(Grunow ex Cleve) Hasle 1993	X	X	X	Cosmopolitan, in the Adriatic sea it usually appears in autumn-winter sometimes with high abundances, produces neurotoxins
Thalassionema frauenfeldii	(Grunow) Hallegraeff 1986	X	X	X	Present in autumn-winter, sometimes also in spring with high abundances
Thalassiosira mediterranea	(Schroder) Hasle 1990	X			Found along Croatian coasts

<u>Dinophyceae</u>

The class Dinophyceae represents an important element of marine phytoplankton that can grow and reach high densities causing blooms, usually in spring or summer. Some species are known to produce toxic compounds of variable toxicity. These phenomena are named Harmful Algal Blooms (HAB) and cause harmful events to the environment and to man, even in the absence of evident bloom signs.

Dinophyceae are unicellular eukaryotic organisms both planktonic and benthic. Some species are able to move and they are heterotrophic while other species have cell walls and are photosynthetic. For these reasons dinoflagellates are included in both botanical and zoological systematic treaties. They are often ordered into two big categories: armoured dinoflagellates provided with a covering formed by cellulose and other polysaccharide plates and naked or unarmoured ones (cell covered only by a membrane).

Their abundance in the Adriatic is usually 1-2 size order lower than diatoms (Regione Marche and Zara County, 2008). Main species that can be found in the Adriatic Sea are summarized in the following table.

Table 3-7 species belonging to dinophyceae class found in the Adriatic Sea (source: Società Italiana di Biologia Marina SIBM[14]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Alexandrium minutum	Halim 1960	X			Common mainly during late winter and spring
Alexandrium pseudogonyaulax	(Biecheler) Horiguchi, ex Kita and Fukuyo 1992	X		X	Found in coastal and brackish Italian waters, produces toxins
Ceratium furca	(Ehrenberg) Claparède et Lachmann 1859	X	X	X	Abundant along all Italian coast
Ceratium symmetricum	Pavillard 1905		X	X	-
Ceratium trichoceros	(Ehrenberg) Kofoid 1908	X	X	X	Present in the central Adriatic mainly during summer
Dinophysis acuta	Ehrenberg 1839	X		X	Produces toxins
Dinophysis caudata	Saville-Kent 1881	X	X	X	Produces toxins
Dinophysis fortii	Pavillard 1923	X	X	X	Produces toxins
Dinophysis rotundata	Claparéde & Lachmann 1859	X	X	X	Produces toxins
Dinophysis sacculus	Stein 1883	X	X	X	Common along Friuli, Veneto and Emilia Romagna coasts. produces toxins
Gonyaulax fragilis	(Schutt). Kofoid 1911	X	X	X	Found along coasts and in open sea, in the Adriatic is associated to the mucilage phenomenon
Heterocapsa niei	(Loeblich III), Morrill et Loeblich III 1981	X	X	X	Abundant in the north Adriatic
Mesoporos adriaticus	(Schiller) Lillick 1928			X	-
Oxytoxum caudatum	Schiller 1937	X	X		Abundant during the summer in the Adriatic
Oxytoxum variabile	Schiller 1937	X	X	X	In the north Adriatic more abundant during the summer
Prorocentrum balticum	(Lohmann), Loeblich III 1970	X	X		Abundant from spring to autumn in the Adriatic

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Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Prorocentrum compressum	(Bailey), Abé ex Dodge 1975	X	X	X	Found mainly during the summer in the north Adriatic
Prorocentrum gracile	Schutt 1895	X	X	X	Found in the Adriatic mainly during summer
Prorocentrum lima	(Ehrenberg), Dodge 1975	X	X	X	Produces toxins
Prorocentrum minimum	(Pavillard), Schiller 1933	X	X	X	Common in coastal waters, found in the north Adriatic during late spring and summer sometimes with high abundances, produces toxins
Protoperidinium crassipes	(Kofoid), Balech 1974	X	X		Found along Emilia Romagna coastlines
Scrippsiella trochoidea	(Stein), Loeblich III 1976	X	X	X	Cosmopolitan, it caused spring and summer blooms in the north and central Adriatic

Prymnesiophyceae coccolithophorales

Coccolithophorales, commonly known as coccolitophorids, are the best known members of the class Prymnesiophyceae. They are typically unicellular, autotrophic, marine and planktonic cells. They play a relevant role in biogeochemical cycles, in particular in the carbon and sulphur cycles. Most important species that can be found in the Adriatic Sea are the followings: *Anoplosolenia brasiliensis* (Lohmann), Deflandre 1952 (found in all Italian seas), C*alciopappus caudatus* Gardeer et Ramsfijell 1954, emend. Manton et Oates 1983 (found in the central Adriatic, common in autumn), *Calciosolenia murrayi* Gran 1912 (found all year in the north Adriatic with maximum values in late summer), *Discosphaera tubifer* (Murray & Blackman), Ostenfeld 1900 (cosmopolitan), *Emiliania huxleyi* (Lohman), Hay & Mohler 1967 (cosmopolitan), *Ophiaster hydroideus* (Gran 1911, Manton & Oates 1983), Lohmann 1913 (found in all Italian seas), *Rhabdosphaera claviger* Murray & Blackman 1898 (cosmopolitan, highly spread in Italian seas mainly during the summer), *Syracosphaera pulchra* Lohmann 1902 (cosmopolitan, abundant along Italian coasts), *Umbilicosphaera sibogae* (Weber-van Bosse), Gaarder 1970 (found in the central Adriatic).

Cyanophyceae

These micro-organisms, characterized by a high ecological, morphological and nutritional diversity, are spread both in terrestrial and aquatic habitats and can sometimes produce toxic blooms (more than 55 species produce toxins) whose effects generate consequences both on humans and terrestrial/aquatic organisms.

Most important species that can be found in the Adriatic sea are the followings: *Merismopedia* sp., Meyen 1839 (found mainly in fresh waters but with also some marine species, rarely abundant along Italian coasts), *Oscillatoriales,* Helenk 1934 (not abundant in the sea, some species are toxic).

Chrysophyceae

The Class Chrisophyceae encompasses organisms which have great variability, either morphological (naked cells, free living or in loricae, with organic or inorganic scales, mono or biflagellated or with no flagella, unicellular or colonial, coccoid) or ecophysiological related to the trophic strategy (autotrophic, heterotrophic), to life cycles and distribution in different environments. They are abundant mostly in fresh waters but they play a relevant role also in the marine nano and pico plankton.

Most important species that can be found in the Adriatic sea are the followings: *Dinobryon faculiferum* (Willèn) Willèn 1992 (present in all seasons but with peaks in spring, common along coast of Marche Region), *Meringosphaera mediterranea* Lohmann 1902 (found in the north Adriatic during the whole year but without high abundances), *Ollicola vangoori* (Conrad) Vørs 1992 (common in marine and brackish waters in the north Adriatic).

Chlorophyceae

The distribution of the Chlorophyceae is mainly linked to coastal and estuarine waters: the main taxa belong to the families *Dunaliellaceae* and *Chlamydomonadaceae*. The most important species that can be found in the Adriatic sea is *Scenedesmus quadricauda*, (Turpin 1820), Brébisson 1835, abundant along coastal waters of north Adriatic.

Cryptophyceae

They play a relevant ecological role and are mostly photo-autotrophic; can live both in terrestrial and aquatic habitats and are one of the main nourishment for herbivorous zoo-plankton. In the marine plankton they can reach high densities giving an important contribute to primary production. Up to now 13 photosynthetic marine categories are known and most commons are: *Chroomonas. Falcomonas, Hemiselmis, Plagioselmis, Pyrenomonas/Rhodomonas, Storeatula, Teleaulax*. The most important species that can be found in the Adriatic sea is *Plagioselmis* cf. *prolonga*, Butcher 1967 ex Novarino, Lucas et Morrall sp. nov. cosmopolitan, common in brackish waters but also in open sea.

Dictyochophyceae

These unicellular autotrophic micro algae are constituted by three categories: *Dictyocha* (the most important), *Octactis* and *Mesocena*. Most important species that can be found in the Adriatic sea are the followings: *Dictyocha fibula* Ehrenberg 1839 (cosmopolitan), *Dictyocha speculum* Ehrenberg 1839 (common in the north Adriatic in late autumn and winter), *Octactis octonaria v. pulchra*, (Ehrenberg) Hovasse 1946 (in the Adriatic can be typically found during autumn and winter).

Prasinophyceae

They are autotrophic and are considered among the oldest algae. Most important species that can be found in the Adriatic sea are the followings: *Pyramimonas* spp. (widely spread in Italian seas), *Tetraselmis* sp. Stein 1878 (abundant along Italian coastlines).

Euglenophyceae

They are unicellular micro algae, generally green colour with dimensions ranging from 20 to 200 µm. They are common in freshwaters, where they are supported by high concentrations of dissolved organic compounds. Some genera are also common in marine waters where they can reach so high concentrations that they can discolour the water to a deep green.

Most important species that can be found in the Adriatic sea are the followings: *Euglena* cf. *acusformis* Schiller 1925 (found in coastal and open sea waters, in the Adriatic it typically appears during the summer but the presence is also linked to other factors like rain abundance), *Eutreptiella* spp. (found in coastal areas and estuaries, in the north Adriatic it appears during the summer and occasionally also in autumn).

Prymnesiophyceae Prymnesiales

This order comprises mainly marine organisms, nano- and picoplanktonic, mostly autotrophic with cells covered by scales. They represent a relevant fraction of the nanoplankton. The most important cosmopolitan species which can be found in the Adriatic is *Phaeocystis* spp.

Raphydophyceae

Raphydophyceae have autotrophic cells, microplanktonic flagellates and relatively big size (30-80 µm). Distributed both in fresh and marine waters can produce toxins and cause red tides. Most important species that can be found in the Adriatic sea are the followings: *Fibrocapsa japonica* Toriumi et Takano 1973 (cosmopolitan in coastal marine and brackish waters, in the Adriatic summer blooms which colour water of yellow and brown have been observed, it's ichtyo-toxic), *Heterosigma akashivo* (Hada) Hada ex Hara et Chihara 1987 (cosmopolitan, ichtyo-toxic).

Mucilage

Pelagic mucilage is a relevant phenomenon in the Adriatic, in particular during the period 1980-2000 (Figure 3-77). Some areas like Quarnaro gulf and the zone in front of Istria and river Po delta are especially subjected to the mucilage blooms (Giani et al., 2003). The phenomenon derives from the accumulation of planktonic organic matter and is produced by different organisms; for the phytoplankton micro-organisms responsible are:

- Diatoms: particularly *Cylindrotheca closterium*, *Chaetoceros* (species: *fragilis, affinis, insignis*) and *Nitschia delicatissima, Skeletonema costatum* and *Thalassiosira* sp.;
- Dinoflagellata: *Gonyaulax fragilis*.

Historic data available for the Adriatic confirms that the phenomenon is concentrated during the summer and change from year to year with some periods totally without mucilage. The following figure shows mucilage events during the period 1872-2004.

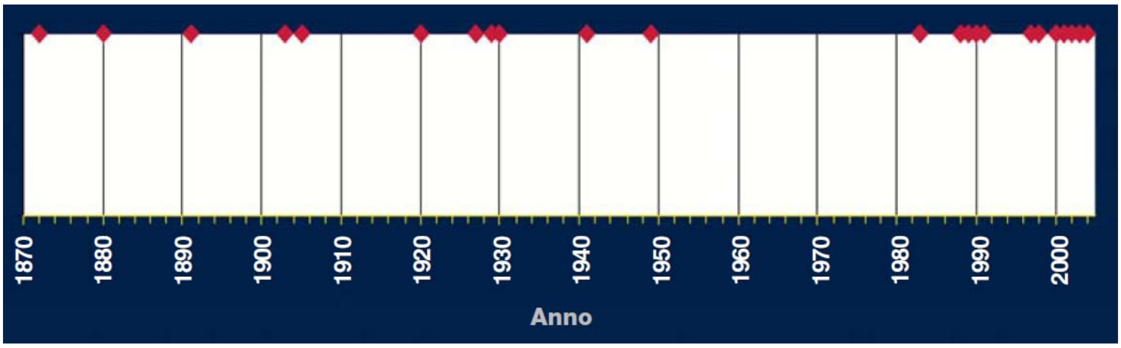

Figure 3-77 historic series of massive mucilage blooms period 1872-2004 (ICRAM and MATTM, 2005).

3.4.1.2 Zooplankton

Zooplankton with phytoplankton is the base of the food chain and is composed of organisms which aren't self-sufficient in the motion and are carried by marine currents.

In the Adriatic meso-zooplankton communities are characterized by high biomass concentrations, decreasing going north to south direction; differently meso-zooplankton variety increases from the north to the south and from the coastline to the open sea (Regione Marche and Zara County, 2008). Different types of classification exist; the following paragraphs refer to the subdivision adopted by specific literature (MATTM and ICRAM, 2006):

- Jellyfishes;
- Siphonophora;
- Ctenophora;
- Cladocera;
- Copepoda;
- Mysida;
- Euphausiacea;
- Pteropoda;
- Chaetognatha;
- Appendicularia;
- Thaliacea.

Pelagic larva and fishes' eggs have not been included.

Jellyfishes

Jellyfishes belong to Cnidarian phylum and hydrozoa class, are almost all marine and represent the basic metazoa from an evolutionary point of view. Species that can be found in the Adriatic sea are summarized in the following table.

Table 3-8 Species belonging to hydrozoa class found in the Adriatic sea (Source: Società Italiana di Biologia Marina SIBM[15]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Bougainvillia britannica	(Forbes, 1841)	X		
Bougainvillia muscus	(Allman,1863)	X	X	
Garveia franciscana	(Torrey, 1902)	X	X	
Garveia nutans	(Wright, 1859)	X		
Koellikerina fasciculata	(Péron & Lesueur, 1810)	X	X	
Lizzia blondina	Forbes, 1848	X	X	
Lizzia octostyla	(Haeckel, 1879)	X		
Pachycordyle napolitana	Weismann, 1883	X	X	

15 http://www.sibm.it/CHECKLIST/03%20CNIDARIA/Hydrozoa/Hydroidomedusae.pdf; last access 17 June 2013.

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Thamnostoma dibalia	(Busch, 1851)	X	X	X
Velkovrhia enigmatica	Matjasic & Sket, 1971	X		
Bythotiara murrayi	Günther, 1903		X	
Cordylophora caspia	(Pallas, 1771)	X		
Corydendrium parasiticum	(Linnaeus, 1767)	X		
Merona cornucopiae	(Norman, 1864)	X		
Oceania armata	Kölliker, 1853		X	
Turritopsis dohrnii	(Weismann, 1883)	X		
Cytaeis pusilla	Gegenbaur, 1857	X		
Cytaeis tetrastyla	Eschscholtz, 1829	X	X	
Cytaeis spp.		X	X	X
Eucodonium brownei	Hartlaub, 1907	X	X	
Eudendrium capillare	Alder, 1856	X		X
Eudendrium carneum	Clarke, 1882		X	
Eudendrium glomeratum	Picard, 1951		X	
Eudendrium merulum	Watson, 1985		X	
Eudendrium racemosum	(Cavolini, 1785)	X	X	
Eudendrium rameum	(Pallas, 1766)		X	
Eudendrium ramosum	(L., 1758)	X	X	X
Eudendrium simplex	Pieper, 1884	X		X
Clava multicornis	(Forskal, 1775)	X		X
Hydractinia aculeata	(Wagner, 1833)	X		
Hydractinia areolata	(Alder, 1862)	X	X	
Hydractinia borealis	(Mayer, 1900)	X		
Hydractinia exigua	(Haeckel, 1880)	X	X	
Hydractinia fucicola	(M. Sars, 1857)			X
Hydractinia inermis	(Allman, 1872)			X
Hydractinia minima	(Trinci, 1903)	X	X	
Hydractinia minuta	(Mayer, 1900)	X	X	
Amphinema dinema	(Péron & Lesueur, 1810)	X	X	
Codonorchis octaëdrus	Haeckel, 1879			X
Leuckartiara octona	(Fleming, 1823)	X	X	
Merga tergestina	(Neppi & Stiasny, 1912)	X	X	
Merga violacea	(Agassiz & Mayer, 1899)	X		
Neoturris pileata	(Forskal, 1775)	X	X	
Pandea conica	(Quoy & Gaimard, 1827)		X	
Proboscidactyla ornata	(Mc Crady, 1859)	X	X	
Protiara tetranema	(Péron & Lesueur, 1810)		X	

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Rathkea octopunctata	(M. Sars, 1835)	X	X	
Trichydra pudica	Wright, 1858		X	
Odessia maeotica	(Ostroumoff, 1896)	X		
Psammohydra nanna	Schulz, 1950	X		
Cladonema radiatum	Dujardin, 1843	X		
Eleutheria dichotoma	Quatrefages, 1842	X		
Corymorpha nutans	M. Sars, 1835	X	X	
Euphysora annulata	Kramp, 1928		X	
Coryne epizoica	Stechow, 1921	X		
Coryne eximia	Allman, 1859		X	
Coryne muscoides	(Linnaeus, 1761)		X	X
Coryne pintneri	Schneider, 1898	X		
Coryne producta	(Wright, 1858)	X	X	
Coryne pusilla	Gaertner, 1774	X	X	
Dicodonium adriaticum	Graeffe, 1884	X	X	
Dicodonium ocellatum	(Busch, 1851)	X		
Dipurena gemmifera	(Forbes, 1848)	X		
Dipurena halterata	(Forbes, 1846)	X	X	
Euphysa aurata	Forbes, 1848	X	X	
Siphonohydra adriatica	Salvini-Plawen, 1966	X		
Pennaria disticha	Goldfuss, 1820		X	
Tricyclusa singularis	(Schultze, 1876)	X		
Ectopleura crocea	(L. Agassiz, 1862)	X		
Ectopleura dumortieri	(Van Beneden, 1844)	X	X	
Ectopleura larynx	(Ellis & Solander, 1786)		X	
Ectopleura minerva	Mayer, 1900	X		
Ectopleura wrighti	Petersen, 1979	X		
Rhabdoon singulare	Keferstein & Ehlers, 1861	X	X	
Tubularia indivisa	Linnaeus, 1758		X	
Cladocoryne floccosa	Rotch, 1871	X	X	X
Porpita porpita	(Linnaeus, 1758)	X	X	X
Velella velella	(Linnaeus, 1758)	X	X	X
Halocoryne epizoica	Hadzi, 1917	X	X	X
Zanclea costata	Gegenbaur, 1857	X	X	
Zanclea sessilis	(Gosse, 1853)	X	X	
Aequorea forskalea	Péron & Lesueur, 1810	X	X	
Zygocanna vagans	Bigelow, 1912		X	
Aglaophenia elongata	Meneghini, 1845	X	X	

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Aglaophenia harpago	Von Schenk, 1965	X	X	
Aglaophenia kirchenpaueri	(Heller, 1868)		X	
Aglaophenia octodonta	(Heller, 1868)	X	X	X
Aglaophenia picardi	Svoboda, 1979	X		
Aglaophenia pluma	(Linnaeus, 1758)	X	X	
Aglaophenia tubiformis	Marktanner-Turneretscher, 1890	X	X	X
Lytocarpia myriophyllum	(Linnaeus, 1758)		X	X
Calycella syringa	(Linnaeus, 1767)	X	X	
Cuspidella humilis	(Alder, 1862)		X	
Lafoeina tenuis	G.O. Sars, 1874		X	
Eirene viridula	(Péron & Lesueur, 1810)	X	X	X
Eugymnanthea inquilina	Palombi, 1935		X	
Eutima gegenbauri	(Haeckel, 1864)	X	X	
Eutima gracilis	(Forbes & Goodsir, 1851)	X	X	X
Eutonina scintillans	(Bigelow, 1909)	X		
Helgicirrha schulzei	Hartlaub, 1909	X	X	
Neotima lucullana	(Delle Chiaje, 1822)	X		
Halecium beanii	(Johnston, 1838)		X	
Halecium delicatulum	Coughtrey, 1876		X	
Halecium halecinum	(Linnaeus, 1758)	X	X	
Halecium labrosum	Alder, 1859		X	
Halecium lankesteri	(Bourne, 1890)	X	X	
Halecium nanum	Alder, 1859	X	X	X
Halecium pusillum	(M. Sars, 1857)	X	X	X
Halecium tenellum	Hincks, 1861	X	X	
Hydrodendron mirabile	(Hincks, 1866)		X	X
Antennella secundaria	(Gmelin, 1791)	X	X	
Antennella siliquosa	(Hincks, 1877)		X	
Halopteris diaphana	(Heller, 1868)	X	X	
Halopteris liechtensterni	(Marktanner-Turneretscher, 1890)	X	X	
Schizotricha frutescens	(Ellis & Solander, 1786)	X	X	
Anthohebella parasitica	(Ciamician, 1880)	X	X	X
Hebella brochii	(Hadzi, 1913)		X	
Hebella scandens	(Bale, 1888)		X	
Scandia gigas	(Pieper, 1884)	X	X	
Kirchenpaueria pinnata	(Linnaeus, 1758)	X	X	X
Ventromma halecioides	(Alder, 1859)	X	X	X

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Filellum serpens	(Hassall, 1848)		X	
Lafoea dumosa	(Fleming, 1820)		X	
Laodicea ocellata	Babnik, 1948		X	
Laodicea undulata	(Forbes & Goodsir, 1851)	X	X	
Melicertissa adriatica	Neppi, 1915	X	X	
Eucheilota maasi	Neppi & Stiasny, 1911	X	X	
Eucheilota paradoxica	Mayer, 1900		X	
Hydranthea aloysii	(Zoja, 1893)	X	X	
Hydranthea margarica	(Hincks, 1862)	X		
Lovenella cirrata	(Haeckel, 1879)		X	
Octophialucium funerarium	(Quoy & Gaimard, 1827)		X	
Orchistomella graeffei	(Neppi & Stiasny, 1911)	X		
Mitrocoma annae	Haeckel, 1864		X	
Phialella quadrata	(Forbes, 1848)		X	X
Monotheca obliqua	(Johnston, 1847)	X	X	X
Nemertesia antennina	(Linnaeus, 1758)		X	X
Nemertesia ramosa	(Lamarck, 1816)	X	X	X
Nemertesia tetrasticha	(Meneghini, 1845)	X	X	
Plumularia setacea	(Linnaeus, 1758)	X	X	X
Amphisbetia operculata	(Linnaeus, 1758)		X	
Diphasia margareta	(Hassall, 1841)	X		
Dynamena disticha	(Bosc, 1802)	X	X	
Sertularella crassicaulis	(Heller, 1868)	X	X	
Sertularella ellisii	(Deshayes & Milne-Edwards, 1836)	X	X	X
Sertularella gayi	(Lamouroux, 1821)	X	X	
Sertularella mediterranea	Hartlaub, 1901	X	X	X
Sertularella polyzonias	(Linnaeus, 1758)	X	X	
Sertularia perpusilla	Stechow, 1919		X	X
Synthecium evansi	(Ellis & Solander, 1786)	X	X	
Krampella dubia	Russell, 1957	X	X	
Modeeria rotunda	(Quoy & Gaimard, 1827)		X	
Octogonade mediterranea	Zoja, 1896	X	X	
Tiaropsidium mediterraneum	(Metschnikoff, 1886)		X	
Campanularia hincksi	Alder, 1856	X	X	
Campanularia volubilis	(Linnaeus, 1758)	X	X	
Clytia discoida	(Mayer, 1900)		X	
Clytia gracilis	(M. Sars, 1850)	X	X	
Clytia hemisphaerica	(Linnaeus, 1767)	X	X	X

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Clytia linearis	(Thornely, 1899)			X
Clytia noliformis auct.	(McCrady, 1859)	X		
Clytia viridicans	(Leuckart, 1856)		X	X
Gastroblasta raffaelei	Lang, 1886	X		
Gonothyraea loveni	(Allman, 1859)	X		
Hartlaubella gelatinosa	(Pallas, 1766)	X		
Laomedea angulata	Hincks, 1861	X	X	
Laomedea calceolifera	(Hincks, 1871)	X	X	
Laomedea flexuosa	Alder, 1857		X	X
Laomedea neglecta	Alder, 1856	X	X	
Obelia bidentata	Clarke, 1875	X	X	
Obelia dichotoma	(Linnaeus, 1758)	X	X	X
Obelia geniculata	(Linnaeus, 1758)		X	X
Obelia longissima	(Pallas, 1766)	X		
Orthopyxis integra	(Macgillivray, 1842)	X	X	X
Pseudoclytia pentata	(Mayer, 1900)		X	
Halammohydra octopodides	Remane, 1927	X		
Halammohydra schulzei	Remane, 1927	X		
Otohydra vagans	Swedmark & Teissier, 1958	X		
Solmundella bitentaculata	(Quoy & Gaimard, 1833)	X	X	
Cunina polygonia	(Haeckel, 1879)	X		
Solmissus albescens	(Gegenbaur, 1857)		X	
Solmaris flavescens	(Kölliker, 1853)	X	X	
Solmaris leucostyla	(Will, 1844)	X	X	
Geryonia proboscidalis	(Forskål, 1775)	X	X	
Liriope tetraphylla	(Chamisso & Eysenhardt, 1821)	X	X	
Haliscera bigelowi	Kramp, 1947		X	
Ptychogastria asteroides	(Haeckel, 1879)	X		
Aglantha digitale	(O.F. Muller, 1766)			X
Aglantha elata	(Haeckel, 1879)		X	
Aglaura hemistoma	Péron & Lesueur, 1810	X	X	X
Arctapodema ampla	(Vanhöffen, 1902)		X	
Arctapodema australe	(Vanhöffen, 1912)		X	
Homeonema platygonon	Browne, 1903	X	X	
Persa incolorata	McCrady, 1859	X	X	
Rhopalonema funerarium	Vanhöffen, 1902		X	
Rhopalonema velatum	Gegenbaur, 1857	X	X	
Sminthea eurygaster	Gegenbaur, 1857	X	X	

Data on hydrozoa class distribution in the Adriatic sea are shown in the following figure, which includes also siphonophora. Colour squares indicate different density of records, while areas not covered by such squares have not been sampled.

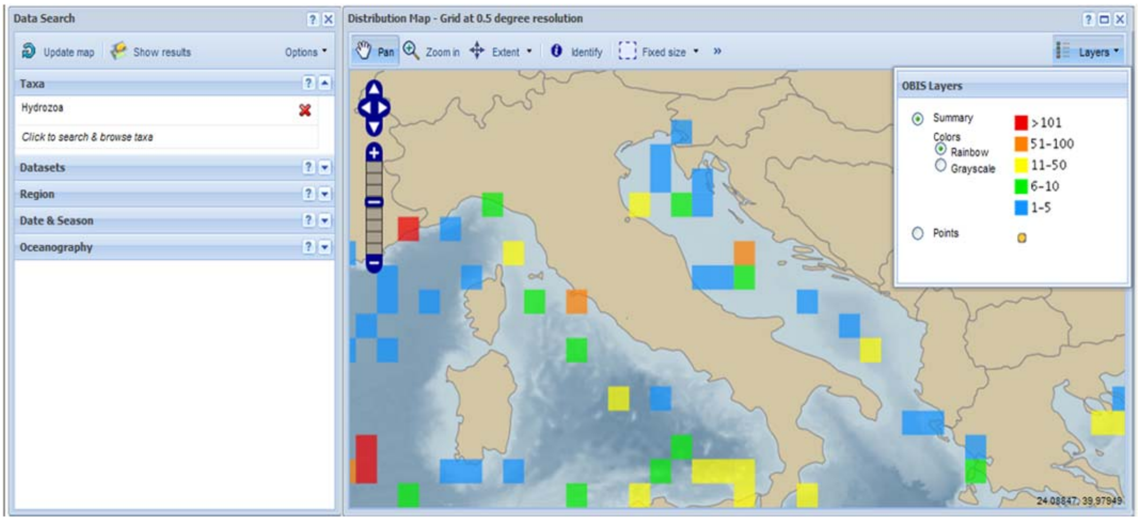

Figure 3-78 Hydrozoa distribution and densities in the Adriatic sea (Source: OBIS http://iobis.org/mapper/; last access 22 December 2012).

Siphonophora

Siphonophora are marine carnivorous organisms belonging to hydrozoa class, almost all adapted for living in colonies in pelagic environment. They are divided into three orders, based on organs for floating or swimming morphology: physonectae, cystonectae and calycophorae. Species that can be found in the Adriatic Sea are summarized in the following table.

Table 3-9 species belonging to siphonophora order found in the Adriatic sea (Source: Società Italiana di Biologia Marina SIBM[16]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Physalia physalis	(Linné, 1758)	X	X		-
Halistemma rubrum	(Vogt, 1852)	X	X	X	Common in the south Adriatic particularly in winter and early spring at depths of 0-500 m
Nanomia bijuga	(delle Chiaje, 1841)	X	X	X	-
Physophora hydrostatica	Forskål, 1775			X	-
Forskalia contorta	(Milne Edwards, 1841)	X	X		-

16 http://www.sibm.it/CHECKLIST/03%20CNIDARIA/Hydrozoa/Hydroidomedusae.pdf; last access 18 June 2013

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Rosacea cymbiformis	(Delle Chiaje, 1822)	X	X	X	-
Hippopodius hippopus	(Forskål, 1776)	X	X	X	Found mainly in the first 100 m of the water column with high densities in the Mediterranean between December and April
Vogtia pentacantha	Kölliker, 1853	X		X	-
Sulculeolaria biloba	(M. Sars, 1846)	X	X		-
Sulculeolaria chuni	(Lens & van Riemsdijk, 1908)	X	X	X	-
Sulculeolaria quad-rivalvis	Blainville, 1834	X	X	X	-
Sulculeolaria turgida	(Gegenbaur, 1853)	X	X	X	-
Diphyes dispar	Chamisso & Eysen-hardt, 1821	X	X	X	-
Lensia campanella	(Moser, 1925)	X	X	X	Common in the Mediterra-nean and abundant in au-tumn and spring at depths of 0-200 m
Lensia conoidea	(Keferstein & Ehlers, 1860)		X	X	Common during spring and summer in epipelagic Medi-terranean waters
Lensia fowleri	(Bigelow, 1911)	X	X	X	-
Lensia meteori	(Leloup, 1934)	X	X	X	-
Lensia multicristata	(Moser, 1925)	X	X	X	-
Lensia subtilis	(Chun, 1886)	X	X	X	-
Muggiaea atlantica	Cunningham, 1892	X	X	X	Common in neritic Mediter-ranean shallow waters be-tween 0-50 m
Muggiaea kochi	(Will, 1844)	X	X	X	Common in neritic Mediter-ranean shallow waters be-tween 0-50 m
Chelophyes appendic-ulata	(Eschscholtz, 1829)	X	X	X	Common in the Mediterra-nean mainly in shallow wa-ters between 0-200 m. with abundance peaks in the south Adriatic during au-tumn winter
Chelophyes contorta	(Lens & van Riemsdijk, 1908)			X	-
Eudoxoides spiralis	(Bigelow, 1911)	X	X	X	Common in south Adriatic
Clausophyes ovata	(Keferstein & Ehlers, 1860)	X	X	X	-
Sphaeronectes fragilis	Carré C., 1968	X	X	X	-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Sphaeronectes gamulini	Carré C., 1966	X	X	X	-
Sphaeronectes gracilis	(Claus, 1873, 1874)	X	X	X	Common in neritic shallow Mediterranean waters between 0-200 m, show abundance peaks during summer and autumn in the Adriatic
Sphaeronectes irregularis	(Claus, 1873)	X	X	X	Common in neritic shallow Mediterranean waters between 0-200 m, show abundance peaks during summer and autumn in the Adriatic
Abylopsis eschscholtzi	(Huxley, 1859)	X	X		-
Abylopsis tetragona	(Otto, 1823)	X	X	X	Common in the epipelagic waters of the whole Mediterranean
Bassia bassensis	Quoy & Gaimard, 1833 (1834)	X	X	X	-

Data on Siphonophora distribution in the Adriatic sea are shown in the following figure.

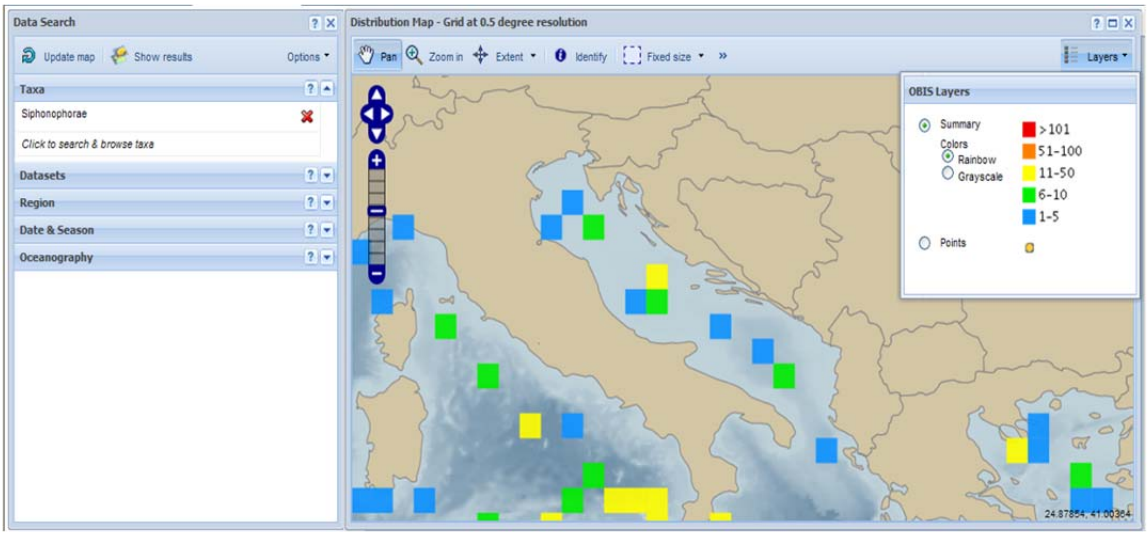

Figure 3-79 Siphonophora distribution and densities in the Adriatic sea (Source: OBIS http://iobis.org/mapper/, last access 22 November 2012).

Ctenophora

Ctenophora are metazoa exclusively marine, mainly epipelagic and with wide distribution. In the Mediterranean there are four orders of planktonic ctenophora: Cydippida, Beroida, Lobata, Cestida. Species that can be found in the Adriatic sea are summarized in the following table.

Table 3-10 species belonging to ctenophora phylum found in the Adriatic sea (Source: Società Italiana di Biologia Marina SIBM[17]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Haeckelia rubra	(Kölliker, 1853)	X	X	
Lampea pancerina	(Chun, 1880)	X	X	
Callianira bialata	Delle Chiaje, 1841	X	X	
Charistephane fugiens	Chun, 1880	X		
Hormiphora plumosa	L. Agassiz, 1860	X		
Pleurobrachia rhododactyla	L. Agassiz, 1860	X	X	
Pleurobrachia rhodopis	Chun, 1880	X	X	
Pleurobrachia sp.		X	X	
Cydippe brevicostata	Will, 1844	X	X	
Bolinopsis vitrea	(L. Agassiz, 1860)	X		
Deiopea kaloktenota	Chun, 1880	X	X	
Leucothea multicornis	(Quoy & Gaimard, 1824)	X	X	
Mnemiopsis leidyi	A. Agassiz, 1865	X		
Cestum veneris	Lesueur, 1813	X	X	
Beroe cucumis	sensu Mayer, 1912	X		
Beroe forskalii	Milne Edwards, 1841	X	X	
Beroe ovata	Bosc, 1802	X	X	

Cladocera

Cladocera, which belong to crustacean subphylum and branchiopoda class, are composed by many micro-organisms, mainly spread in fresh waters. There are almost 450 species and only about ten live in marine or brackish waters. Species that can be found in the Adriatic sea are summarized in the following table. Data on Cladocera suborder distribution in the Adriatic sea are shown in Figure 3-80.

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17 http://www.sibm.it/CHECKLIST/BMM%2015(s1)%202008%20Checklist%20I/09%20CTENOPHORA.pdf, last access 18 June 2013

Table 3-11 Species belonging to cladocera suborder found in the Adriatic sea (Source: Società Italiana di Biologia Marina SIBM[18]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Penilia avirostris	Dana, 1849	X	X	X	Lives in coastal waters, appears in June with a rapid growth
Evadne nordmanni	Lovén, 1836	X	X	X	-
Evadne spinifera	P.E. Muller, 1867	X	X	X	Common in spring and autumn
Pleopis polyphemoides	*(Leuckart, 1859)*	X	X	X	Common in lagoons and brackish ponds
Podon intermedius	Lilljeborg, 1853	X	X	X	Common mainly during spring
Pseudevadne tergestina	*Claus, 1877*	X	X	X	-

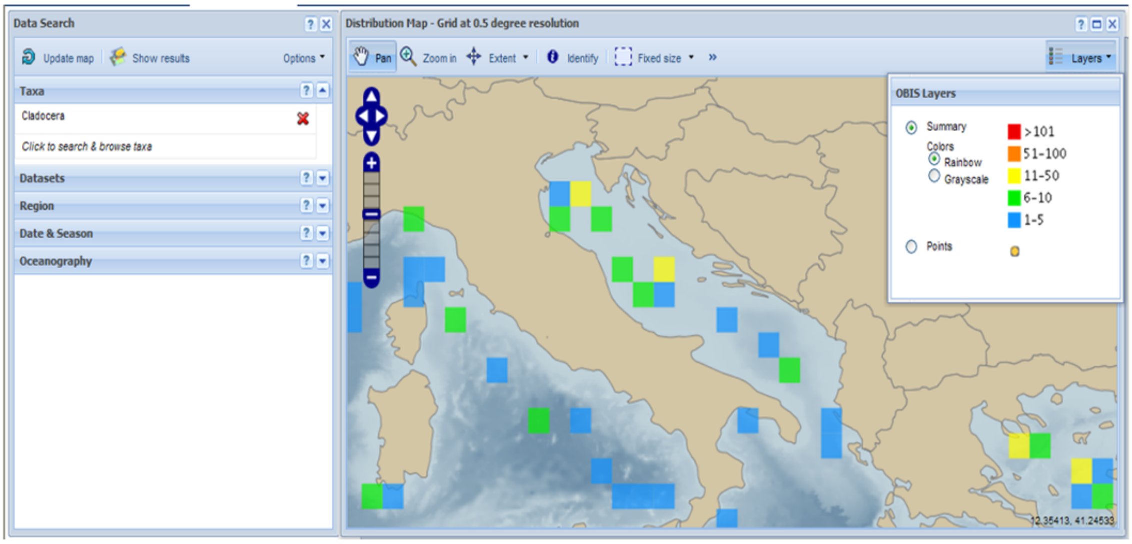

Figure 3-80 Cladocera suborder distribution and densities in the Adriatic sea (Source: OBIS http://iobis.org/mapper/ last visit 22/11/2012).

Copepoda

Copepoda constitutes a sub class of Crustaceans subphylum and are essential from a trophic point of view, being a link between the primary production and the larvae and juveniles of fishes and perhaps cephalopods. They have small dimensions reaching a maximum length of

18 http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/07%20CRUSTACEA%20BRANCHIOPODA%20CLADOCERA.pdf, last access 18 June 2013.

about ten mm. Total global number of approximately 11,500 species (2,300 planktonic marine species) is probably underestimated. Planktonic copepoda found in Mediterranean coastal waters belong to the following orders: calanoida, cyclopoida, poecilostomatoida (now included into cyclopoida), harpacticoida, mormonilloida and siphonostomatoida. In the Adriatic 282 species of copepoda have been counted (Razouls et al., 2005-2012).

The following table resumes the complete list of species found in the Adriatic; for some of the species listed below, in the column "notes" more information on spatial distribution and abundances are given.

Table 3-12 Species belonging to copepoda found in the Adriatic sea (source: Marine Planktonic Copepods[19] and Società Italiana di Biologia Marina SIBM[20]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Acartia (Acanthacartia) bifilosa	(Giesbrecht, 1881)			X	-
Acartia (Acanthacartia) italica	Steuer, 1910			X	Found in coastal waters
Acartia (Acanthacartia) tonsa	Dana, 1849	X			Very abundant in estuary environments with high trophic levels
Acartia (Acartia) danae	Giesbrecht, 1889				-
Acartia (Acartia) negligens	Dana, 1849	X	X	X	-
Acartia (Acartiura) clausi	Giesbrecht, 1889	X	X	X	Abundant in coastal and estuary waters
Acartia (Acartiura) discaudata	(Giesbrecht, 1881)	X		X	-
Acartia (Acartiura) longiremis	(Lilljeborg, 1853)	X	X	X	-
Acartia (Acartiura) margalefi	Alcaraz, 1976	X	X	X	-
Acartia (Hypoacartia) adriatica	Steuer, 1910			X	-
Aetideopsis armata	(Boeck, 1872)		X	X	-
Aetideopsis rostrata	Sars, 1903		X	X	-
Aetideus armatus	(Boeck, 1872)		X	X	-
Aetideus giesbrechti	Cleve, 1904		X	X	-

19 http://copepodes.obs-banyuls.fr/en/subloc_popup.php?loc=14&subloc=7, last access 18 June 2013
20 http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/09%20CEPODI%20PLANCTONICI.pdf, last access 18 June 2013

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Anomalocera patersoni	Templeton, 1837	X	X	X	-
Archescolecithrix auropecten	(Giesbrecht, 1892)		X	X	-
Arietellus pavoninus	Sars, 1905				-
Arietellus setosus	Giesbrecht, 1892		X	X	-
Augaptilus longicaudatus	(Claus, 1863)		X	X	-
Augaptilus spinifrons	Sars, 1907		X	X	-
Badijella jalzici	Krsinic, 2005				-
Bradfordiella fowleri	(Farran, 1926)				-
Bradyidius armatus	Giesbrecht, 1897				-
Calanipedia aquaedulcis	Kritschagin, 1873				-
Calanus helgolandicus	(Claus, 1863)	X	X	X	Common in open sea
Calocalanus adriaticus	Shmeleva, 1965	X	X	X	Found in the Mediterranean at depths of 50-300 m
Calocalanus contractus	Farran, 1926	X	X	X	In the Mediterranean live in the first 300 m of the water column, more common in open sea
Calocalanus elegans	Shmeleva, 1965	X	X	X	-
Calocalanus elongatus	Shmeleva, 1968				-
Calocalanus equalicauda	(Bernard, 1958)				-
Calocalanus gresei	Shmeleva, 1973				-
Calocalanus kristalli	Shmeleva, 1968				-
Calocalanus latus	Shmeleva, 1968				-
Calocalanus longisetosus	Shmeleva, 1965	X	X	X	-
Calocalanus neptunus	Shmeleva, 1965		X	X	In the Mediterranean live in the first 300 m of the water column, more common in open sea
Calocalanus ovalis	Shmeleva, 1965	X	X	X	-
Calocalanus parelongatus	Shmeleva, 1979				-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Calocalanus pavo	(Dana, 1849)	X	X	X	In the Mediterranean lives in the first 200 m of the water column, common in coastal waters
Calocalanus pavoninus	Farran, 1936				-
Calocalanus plumatus	Shmeleva, 1965	X	X	X	-
Calocalanus plumulosus	(Claus, 1863)	X	X	X	In the Mediterranean lives mainly in the first 100 m of the water column
Calocalanus pseudocontractus	Bernard, 1958				-
Calocalanus styliremis	Giesbrecht, 1888	X	X	X	In the Mediterranean lives mainly in the first 200 m of the water column, common also in coastal waters
Calocalanus tenuis	Farran, 1926	X	X	X	In the Mediterranean lives mainly between 50-300 m depth, more common in open sea
Candacia armata	(Boeck, 1872)	X	X	X	-
Candacia bipinnata	(Giesbrecht, 1889)	X	X	X	-
Candacia bispinosa	(Claus, 1863)		X	X	-
Candacia elongata	(Boeck, 1872)	X	X	X	-
Candacia ethiopica	(Dana, 1849)	X	X	X	-
Candacia giesbrechti	Grice & Lawson, 1977	X	X	X	-
Candacia longimana	(Claus, 1863)	X	X	X	-
Candacia simplex	(Giesbrecht, 1889)		X	X	-
Candacia tenuimana	(Giesbrecht, 1889)	X	X	X	-
Candacia varicans	(Giesbrecht, 1892)	X	X	X	-
Centropages bradyi	Wheeler, 1901			X	-
Centropages chierchiae	Giesbrecht, 1889				-
Centropages hamatus	(Lilljeborg, 1853)				-
Centropages kroyeri	Giesbrecht, 1892	X	X	X	-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Centropages ponticus	Karavaev, 1894	X	X	X	-
Centropages typicus	Kröyer, 1849	X	X	X	In the Mediterranean abundant at depth of 0-200 m with peaks within 50 m, it's a dominant copepod in coastal waters
Centropages violaceus	(Claus, 1863)	X	X	X	-
Chiridius poppei	Giesbrecht, 1892	X	X	X	-
Clausocalanus arcuicornis	(Dana, 1849)	X	X	X	-
Clausocalanus furcatus	(Brady, 1883)	X	X	X	-
Clausocalanus jobei	Frost & Fleminger, 1968	X	X	X	-
Clausocalanus lividus	Frost & Fleminger, 1968	X	X	X	-
Clausocalanus mastigophorus	(Claus, 1863)	X	X	X	-
Clausocalanus parapergens	Frost & Fleminger, 1968	X	X	X	-
Clausocalanus paululus	Farran, 1926	X	X	X	In the Mediterranean lives mainly between 0-800 m of the water column but concentrates in the first 200 m, abundant during winter
Clausocalanus pergens	Farran, 1926	X	X	X	In the Mediterranean lives mainly between 0-800 m of the water column but concentrates in the first 400 m, abundant. especially during spring
Clytemnestra gracilis	(Claus, 1891)				-
Copilia mediterranea	(Claus, 1863)	X	X	X	-
Copilia quadrata	Dana, 1849	X	X	X	-
Copilia vitrea	(Haeckel, 1864)	X	X	X	-
Corycaeus (Agetus) flaccus	Giesbrecht, 1891	X	X	X	Abundant at depth of 50-100 m
Corycaeus (Agetus) limbatus	Brady, 1883	X	X	X	-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Corycaeus (Agetus) typicus	(Krøyer, 1849)	X	X	X	Abundant at 100-200 m depth
Corycaeus (Corycaeus) clausi	F. Dahl, 1894	X	X	X	-
Corycaeus (Corycaeus) speciosus	Dana, 1849				-
Corycaeus (Ditrichocorycaeus) anglicus	Lubbock, 1857	X	X	X	-
Corycaeus (Ditrichocorycaeus) brehmi	Steuer, 1910	X	X	X	Common in coastal environments
Corycaeus (Ditrichocorycaeus) lubbocki	Giesbrecht, 1891				-
Corycaeus (Ditrichocorycaeus) minimus	F. Dahl, 1894				-
Corycaeus (Onychocorycaeus) catus	F. Dahl, 1894				-
Corycaeus (Onychocorycaeus) giesbrechti	F. Dahl, 1894	X	X	X	-
Corycaeus (Onychocorycaeus) latus	Dana, 1849	X	X	X	-
Corycaeus (Onychocorycaeus) ovalis	Claus, 1863	X	X	X	-
Corycaeus (Urocorycaeus) furcifer	Claus, 1863	X	X	X	-
Ctenocalanus vanus	Giesbrecht, 1888	X	X	X	In the Mediterranean lives mainly between 0-500 m of the water column but concentrates in the first 100 m, abundant during spring
Cymbasoma longispinosum	(Bourne, 1890)				-
Cymbasoma rigidum	Thompson, 1888				-
Cymbasoma thompsoni	(Giesbrecht, 1892)				-
Diaixis pygmaea	(T. Scott, 1896)	X	X	X	-
Disco minutus	Grice & Hulsemann, 1965		X	X	-
Disseta palumbii	Giesbrecht, 1889				-
Epicalymma exigua	(Farran, 1908)				-
Euaugaptilus filigerus	(Claus, 1863)		X	X	-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Euaugaptilus hecticus	(Giesbrecht, 1889)		X	X	-
Eucalanus hyalinus	(Claus, 1866)				-
Euchaeta acuta	Giesbrecht, 1892	X	X	X	In the Mediterranean lives until 1000 m depth but concentrates in the first 200 m
Euchaeta marina	(Prestandrea, 1833)	X	X	X	In the Mediterranean lives until 300 m depth but concentrates in the first 50 m
Euchaeta spinosa	Giesbrecht, 1892		X	X	-
Euchirella messinensis	(Claus, 1863)		X	X	-
Euchirella rostrata	(Claus, 1866)		X	X	-
Euterpina acutifrons	(Dana, 1848)	X	X	X	-
Farranula curta	(Farran, 1911)				-
Farranula rostrata	(Claus, 1863)	X	X	X	In the Mediterranean more abundant in the first 100 m of the water column, it's the most common and abundant species of *Farranula* in coastal waters
Gaetanus kruppii	Giesbrecht, 1903		X	X	-
Gaetanus tenuispinus	(Sars, 1900)			X	-
Goniopsyllus clausi	Huys & Conroy-Dalton, 2000				-
Haloptilus acutifrons	(Giesbrecht, 1892)		X	X	-
Haloptilus angusticeps	Sars, 1907				-
Haloptilus fertilis	(Giesbrecht, 1892)		X	X	-
Haloptilus longicornis	(Claus, 1863)		X	X	-
Haloptilus mucronatus	(Claus, 1863)		X	X	-
Haloptilus ornatus	(Giesbrecht, 1892)		X	X	-
Haloptilus oxycephalus	(Giesbrecht, 1889)		X	X	-
Haloptilus plumosus	(Claus, 1863)		X	X	-
Haloptilus spiniceps	(Giesbrecht, 1892)		X	X	-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Haloptilus tenuis	Farran, 1908		X	X	-
Haloptilus validus	Sars, 1920		X	X	-
Heterorhabdus abyssalis	(Giesbrecht. 1889)		X	X	-
Heterorhabdus norvegicus	(Boeck, 1872)				-
Heterorhabdus papilliger	Claus, 1863		X	X	In the Mediterranean concentrates at 150-300 m depth, it's the most common species of *Heterorhabdus*
Heterorhabdus spinifrons	(Claus, 1863)		X	X	-
Isias clavipes	Boeck, 1864		X	X	-
Labidocera acutifrons	(Dana, 1849)				-
Labidocera brunescens	(Czerniavski, 1868)	X	X	X	-
Labidocera wollastoni	(Lubbock, 1857)	X	X	X	-
Lubbockia aculeata	Giesbrecht, 1891	X	X	X	-
Lubbockia squillimana	Claus, 1863	X	X	X	-
Lucicutia clausi	(Giesbrecht, 1889)		X	X	-
Lucicutia curta	Farran, 1905		X	X	-
Lucicutia flavicornis	(Claus, 1863)		X	X	-
Lucicutia gaussae	Grice, 1963		X	X	-
Lucicutia gemina	Farran, 1926		X	X	-
Lucicutia longiserrata	(Giesbrecht, 1889)		X	X	-
Lucicutia ovalis	(Giesbrecht, 1889)		X	X	-
Lucicutia pera	A. Scott, 1909		X	X	-
Macrosetella gracilis	(Dana, 1848)	X	X	X	-
Mecynocera clausi	Thompson, 1888	X	X	X	In the Mediterranean lives mainly in the first 100 m of the water column, abundant during summer
Mesaiokeras hurei	Krsinic, 2003				-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Mesocalanus tenuicornis	(Dana, 1849)	X	X	X	In the Mediterranean lives in the first 300 m of the water column and is abundant during spring
Metridia brevicauda	Giesbrecht, 1889				-
Metridia curticauda	Giesbrecht, 1889				-
Metridia princeps	Giesbrecht, 1889				-
Microcalanus pusillus	Sars, 1903				-
Microsetella norvegica	(Boeck, 1864)	X	X	X	Found all year also in brackish environment
Microsetella rosea	(Dana, 1848)	X	X	X	-
Mimocalanus brodskyi	Razouls, 1974				-
Mimocalanus cultrifer	Farran, 1908			X	-
Miracia efferata	(Dana, 1849)				-
Monacilla typica	Sars, 1905		X	X	-
Monothula subtilis	(Giesbrecht, 1892)	X	X	X	-
Monstrilla longiremis	Giesbrecht, 1892				-
Nannocalanus minor	(Claus, 1863)	X	X	X	In the Mediterranean lives in the first 200 m of the water column
Neocalanus gracilis	(Dana, 1849)	X	X	X	Concentrated in depths ranging from 50-200 m
Neocalanus robustior	(Giesbrecht, 1888)				-
Neomormonilla minor	(Giesbrecht, 1891)		X	X	-
Oculosetella gracilis	(Dana, 1852)				-
Oithona atlantica	Farran, 1908	X	X	X	-
Oithona brevicornis	Giesbrecht, 1891	X	X	X	-
Oithona decipiens	Farran, 1913	X	X	X	-
Oithona hebes	Giesbrecht, 1891	X	X	X	-
Oithona linearis	Giesbrecht, 1891	X	X	X	-
Oithona longispina	Nishida, 1977	X	X	X	-
Oithona nana	Giesbrecht, 1892	X	X	X	-
Oithona parvula	(Farran, 1908)				-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Oithona plumifera	Baird, 1843	X	X	X	In the Mediterranean found at depth of 0-600 m, abundant in the first 100 m of the water column
Oithona pseudofrigida	Rosendorn, 1917				-
Oithona pulla	(Farran, 1913)				-
Oithona robusta	Giesbrecht, 1891				-
Oithona setigera	(Dana, 1849)	X	X	X	-
Oithona similis	Claus, 1866	X	X	X	Abundant both in coastal waters and open sea
Oithona simplex	Farran, 1913				-
Oithona tenuis	Rosendorn, 1917	X	X	X	-
Oithona vivida	Farran, 1913	X	X	X	-
Oncaea bathyalis	Shmeleva, 1968				-
Oncaea brodskii	Shmeleva, 1968				-
Oncaea crypta	Böttger-Schnack, 2005				-
Oncaea curta	Sars, 1916	X	X	X	-
Oncaea longipes	Shmeleva, 1968				-
Oncaea longiseta	Shmeleva, 1968				-
Oncaea media	Giesbrecht, 1891	X	X	X	Common in coastal waters in the first 100 m of the water column
Oncaea mediterranea	(Claus, 1863)	X	X	X	-
Oncaea minima	Shmeleva, 1968				-
Oncaea mollicula	Gordejeva, 1975				-
Oncaea obscura	Farran, 1908				-
Oncaea ornata	Giesbrecht, 1891	X	X	X	-
Oncaea ovalis	Shmeleva, 1966				-
Oncaea prendeli	Shmeleva, 1966				-
Oncaea scottodicarloi	Heron & Bradford-Grieve, 1995	X	X	X	-
Oncaea tenella	Sars, 1916				-
Oncaea tregoubovi	Shmeleva, 1968				-
Oncaea venusta	Philippi, 1843	X	X	X	-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Oncaea vodjanitskii	Shmeleva & Delalo, 1965				-
Oncaea waldemari	Bersano & Boxshall, 1994 [\"1996\"]				-
Oncaea zernovi	Shmeleva, 1966				-
Onchocalanus trigoniceps	Sars, 1905		X	X	-
Pachos punctatum	(Claus, 1863)	X	X	X	-
Paracalanus aculeatus	Giesbrecht, 1888	X			-
Paracalanus denudatus	Sewell, 1929	X	X	X	In the Mediterranean lives in the first 100 m of the water column, common in coastal waters
Paracalanus nanus	Sars, 1907	X	X	X	In the Mediterranean lives in the first 200 m of the water column, common in coastal waters
Paracalanus parvus	(Claus, 1863)	X	X	X	In the Mediterranean lives in the first 200 m of the water column, is one of the most abundant species in coastal waters
Paracartia grani	Sars, 1904	X	X	X	-
Paracartia latisetosa	(Kriczagin, 1873)	X	X	X	Found in lagoons and estuaries, in particular in the Venice lagoon and Comacchio valleys
Paraeuchaeta hebes	(Giesbrecht, 1888)		X	X	In the Mediterranean lives mainly in the first 200 m of the water column, more frequent in open sea
Parapontella brevicornis	(Lubbock, 1857)			X	-
Pareucalanus sewelli	(Fleminger, 1973)				-
Phaenna spinifera	Claus, 1863		X	X	-
Pleuromamma abdominalis	(Lubbock, 1856)		X	X	-
Pleuromamma gracilis	(Claus, 1863)		X	X	-
Pleuromamma piseki	Farran, 1929		X	X	-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Pleuromamma robusta	(F. Dahl, 1893)		X	X	-
Pontella atlantica	(Milne Edwards, 1840)				-
Pontella lobiancoi	(Canu, 1888)		X	X	-
Pontella mediterranea	(Claus, 1863)	X	X	X	-
Pontellina plumata	(Dana, 1849)		X	X	-
Pontellopsis regalis	(Dana, 1849)		X	X	-
Pontellopsis villosa	Brady, 1883				-
Pontoeciella abyssicola	(T. Scott, 1894)		X	X	-
Pseudoamallothrix ovata	(Farran, 1905)				-
Pseudocalanus elongatus	(Boeck, 1865)	X	X	X	Neritic species which lives in the whole Adriatic and near Po river delta
Pseudodiaptomus marinus	Sato, 1913				-
Pteriacartia josephinae	(Crisafi, 1974)		X	X	-
Ratania flava	Giesbrecht, 1892		X	X	-
Rhincalanus cornutus	(Dana, 1849)		X	X	-
Rhincalanus nasutus	Giesbrecht, 1888		X	X	-
Sapphirina angusta	Dana, 1849	X	X	X	-
Sapphirina auronitens	Claus, 1863	X	X	X	-
Sapphirina bicuspidata	Giesbrecht, 1891	X	X	X	-
Sapphirina darwini	Haeckel, 1864	X	X	X	-
Sapphirina gemma	Dana, 1849	X	X	X	-
Sapphirina intestinata	Giesbrecht, 1891	X	X	X	-
Sapphirina iris	Dana, 1849	X	X	X	-
Sapphirina lactens	Giesbrecht, 1892	X	X	X	-
Sapphirina maculosa	Giesbrecht, 1892	X	X	X	-
Sapphirina metallina	Dana, 1849	X	X	X	-
Sapphirina nigromaculata	Claus, 1863	X	X	X	-
Sapphirina opalina	Dana, 1849	X	X	X	-
Sapphirina ovatolanceolata	Dana, 1849	X	X	X	-
Sapphirina pyrosomatis	Giesbrecht, 1892	X	X	X	-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Sapphirina sali	Farran, 1929	X	X	X	-
Sapphirina scarlata	Giesbrecht, 1891	X	X	X	-
Sapphirina sinuicauda	Brady, 1883	X	X	X	-
Sapphirina vorax	Giesbrecht, 1891	X	X	X	-
Scaphocalanus affinis	(Sars, 1905)				-
Scaphocalanus curtus	(Farran, 1926)		X	X	-
Scaphocalanus invalidus	Hure & Scotto di Carlo, 1968		X	X	-
Scolecithricella abyssalis	(Giesbrecht, 1888)		X	X	-
Scolecithricella dentata	(Giesbrecht, 1892)		X	X	In the Mediterranean abundant in open sea at depth of 100-400 m, mainly in spring
Scolecithricella orientalis	Mori, 1937				-
Scolecithricella propinqua	(Sars, 1920)				-
Scolecithricella tenuiserrata	(Giesbrecht, 1892)				-
Scolecithricella vittata	(Giesbrecht, 1892)		X	X	-
Scolecithrix bradyi	Giesbrecht, 1888		X	X	In the Mediterranean lives mainly between 0-300 m of the water column but concentrates between 100-150 m
Scolecithrix danae	(Lubbock, 1856)		X	X	-
Speleohvarella gamulini	Krsinic, 2005				-
Speleophria mestrovi	Krsinic, 2008				-
Spinocalanus abyssalis	Giesbrecht, 1888		X	X	-
Spinocalanus caudatus	Sars, 1920				-
Spinocalanus longicornis	Sars, 1900		X	X	-
Spinocalanus magnus	Wolfenden, 1904		X	X	-
Spinocalanus oligospinosus	Park, 1970		X	X	-
Spinoncaea ivlevi	(Shmeleva, 1966)				-

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Spinoncaea tenuis	Böttger-Schnack, 2003				-
Subeucalanus crassus	(Giesbrecht, 1888)	X	X	X	-
Subeucalanus monachus	(Giesbrecht, 1888)	X	X	X	-
Temora longicornis	(Müller, 1792)	X	X	X	In the Adriatic is linked to low salinity waters. common near Po river delta, during the summer expands its distribution southern until Otranto channel becoming a relevant component of planktonic population
Temora stylifera	Dana, 1849	X	X	X	Neritic, abundant in the Trieste gulf during autumn
Temorites brevis	Sars, 1900		X	X	-
Temoropia mayumbaensis	T. Scott, 1894		X	X	-
Tharybis macrophthalma	Sars, 1902				-
Triconia conifera	(Giesbrecht, 1891)	X	X	X	-
Triconia dentipes	(Giesbrecht, 1891)	X	X	X	-
Triconia minuta	Giesbrecht, 1892	X	X	X	-
Triconia similis	(Sars, 1918)	X	X	X	-
Vettoria granulosa	(Giesbrecht, 1891)	X	X	X	-
Vettoria longifurca	(Rose & Vaissière, 1952)	X	X	X	-
Vettoria parva	(Farran, 1936)	X	X	X	-
Xanthocalanus agilis	Giesbrecht, 1892		X	X	-
Xanthocalanus minor	Giesbrecht, 1892				-

Data on Copepoda subclass distribution in the Adriatic sea are shown in the following figure.

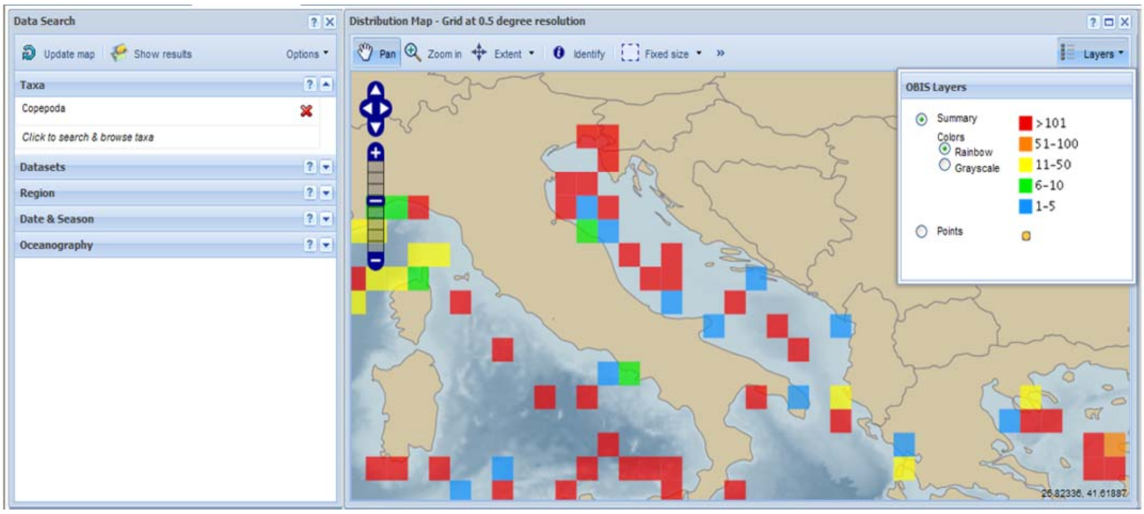

Figure 3-81 Copepoda distribution and densities in the Adriatic sea (Source: OBIS http://iobis.org/mapper/, last access 22 November 2012).

Mysida

This order includes a wide variety of benthonic and planktonic organisms which can live in all aquatic ecosystems, both in coastal and pelagic waters. Marine species play a relevant role along the trophic chain being an important nourishment source for many species of fishes. In the Mediterranean 86 species of mysida have been registered; for the Adriatic species found are summarized in the following table. Data on Mysida order distribution in the Adriatic Sea is shown in Figure 3-82.

Table 3-13 Species belonging to mysida order found in the Adriatic (source: Società Italiana di Biologia Marina SIBM[21] last visit 22/11/2012).

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Lophogaster typicus	M. Sars, 1857		X	
Eucopia unguiculata	(Willemoes-Suhm, 1875)		X	
Boreomysis arctica	(Kroyer, 1861)		X	
Boreomysis megalops	G.O. Sars, 1872		X	
Siriella armata	(H. Milne Edwards, 1837)	X	X	X
Siriella castellabatensis	Ariani & Spagnuolo, 1976	X		
Siriella clausii	G.O. Sars, 1877	X	X	X
Siriella gracilipes	Nouvel, 1942	X	X	X

21 http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/18%20LOPHOGASTRIDA%20&%20MYSIDA.pdf, last access 18 June 2013

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Siriella jaltensis	Czerniavsky, 1868	X	X	X
Siriella norvegica	G.O. Sars, 1869	X	X	X
Siriella thompsonii	(H. Milne Edwards, 1837)		X	X
Anchialina agilis	(G.O. Sars, 1877)	X	X	X
Anchialina oculata	Hoenigman, 1960	X	X	X
Gastrosaccus mediterraneus	Bacescu, 1970			X
Gastrosaccus sanctus	(Van Beneden, 1861)	X	X	X
Haplostylus bacescui	Hatzakis, 1977	X		
Haplostylus lobatus	(H. Nouvel, 1951)	X	X	X
Haplostylus normani	(G.O. Sars, 1877)	X	X	X
Erythrops elegans	(G.O. Sars, 1863)	X		
Erythrops neapolitanus	Colosi, 1929		X	
Leptomysis buergii	Bacescu, 1966	X	X	X
Leptomysis gracilis	(G.O. Sars, 1864)	X	X	X
Leptomysis heterophila	Wittmann, 1986	X		
Leptomysis lingvura adriatica	Wittmann, 1986	X	X	X
Leptomysis mediterranea mediterranea	G.O. Sars, 1877	X	X	X
Leptomysis megalops	Zimmer, 1915	X	X	
Leptomysis posidoniae	Wittmann, 1986	X		
Leptomysis truncata truncata	(Heller, 1863)	X	X	X
Mysideis parva	Zimmer, 1915		X	
Mysidopsis angusta	G.O. Sars, 1864	X		
Mysidopsis didelphys	(Norman, 1863)	X		
Mysidopsis gibbosa	G.O. Sars, 1864	X	X	X
Paraleptomysis apiops	(G.O. Sars, 1877)		X	X
Paraleptomysis banyulensis	(Bacescu, 1966)	X	X	X
Pyroleptomysis rubra	Wittmann, 1985	X		
Acanthomysis longicornis	(H. Milne Edwards, 1837)	X	X	X
Diamysis bacescui	Wittmann & Ariani, 1998			X
Diamysis mesohalobia meso-halobia	Ariani & Wittmann, 2000			X
Diamysis mesohalobia gracili-pes	Ariani & Wittmann, 2000	X	X	X
Diamysis mesohalobia heter-andra	Ariani & Wittmann, 2000	X	X	
Hemimysis lamornae mediter-ranea	Bacescu, 1937	X	X	X
Mesopodopsis aegyptia	Wittmann, 1992			X
Mesopodopsis slabberi	(van Beneden, 1861)	X	X	X

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Paramysis arenosa	(G.O. Sars, 1877)	X	X	X
Paramysis helleri	(G.O. Sars, 1877)	X	X	X
Schistomysis assimilis	(G.O. Sars, 1877)	X	X	X
Heteromysis microps	(G.O. Sars, 1877)	X		

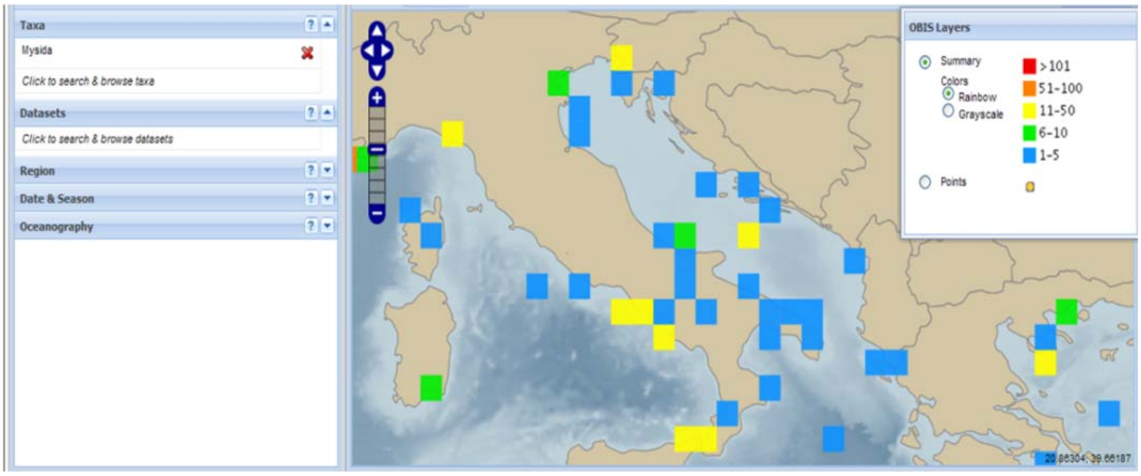

Figure 3-82 Mysida distribution and densities in the Adriatic Sea (Source: OBIS http://iobis.org/mapper/, last access 22 November 2012).

Euphausiacea

Euphausiacea (called also krill) are small marine oloplanktonic crustaceans belonging to Eucarida superorder. Their distribution is strictly associated with particular water masses like frontal and upwelling zones characterized by high productivity. Euphausiacea order is composed of 86 species; 13 species have been registered in the Mediterranean. In the Adriatic species registered are summarized in the following table.

Table 3-14 Species belonging to euphausiacea order found in the Adriatic (source: Società Italiana di Biologia Marina SIBM[22]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Thysanopoda aequalis	Hansen 1905		X	X
Meganyctiphanes norvegica	(M. Sars 1857)		X	X
Nyctiphanes couchi	(Bell 1853)	X	X	X
Euphausia krohni	(Brandt 1851)		X	X
Euphuasia brevis	Hansen 1905		X	X
Euphausia hemigibba	Hansen 1910		X	X
Thysanoessa gregaria	G.O. Sars 1883		X	
Nematoscelis megalops	G.O. Sars 1883	X	X	X
Nematoscelis atlantica	Hansen 1910	X	X	
Stylocheiron abbreviatum	G.O. Sars 1883	X	X	X
Stylocheiron maximum	Hansen 1908		X	X
Stylocheiron longicorne	G.O. Sars 1883	X	X	X
Stylocheiron suhmi	G.O. Sars 1883	X	X	X

Data on Euphausiacea order distribution in the Adriatic sea is shown in the following figure.

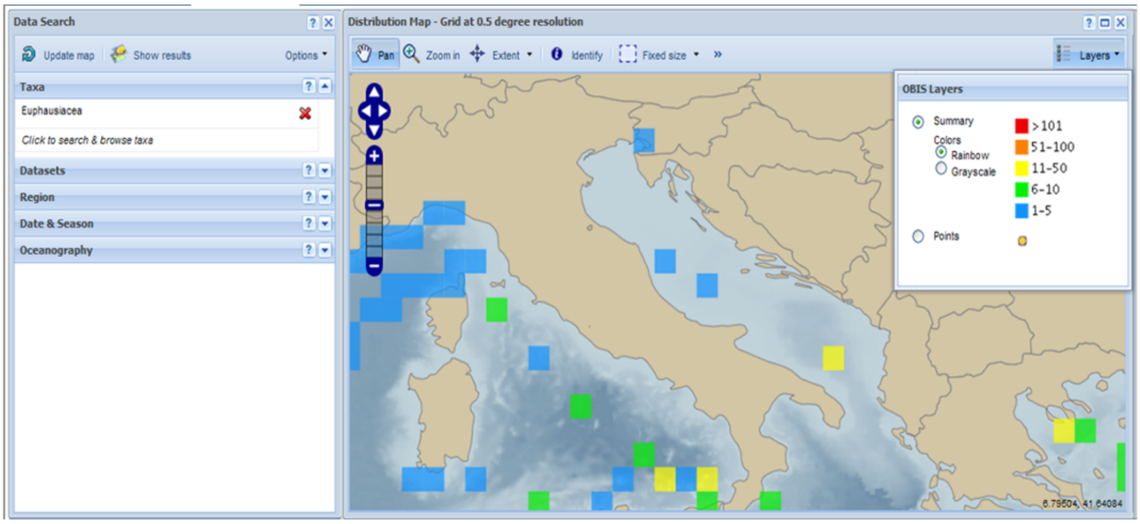

Figure 3-83 Euphausiacea distribution and densities in the Adriatic sea (Source: OBIS http://iobis.org/mapper/, last access 22 November 2012).

22 http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/23%20EUPHAUSIACEA.pdf, last access 18 June 2013.

Pteropoda

Pteropoda belong to Mollusca phylum and gastropoda class have small size and are adapted to pelagic waters. They are divided into Gymnosomata, carnivorous without shell and Thecosomata, herbivorous with calcareous shell. In the Adriatic species registered are summarized in the following table. Data on pteropoda superorder distribution in the Adriatic Sea is shown in the Figure 3-84.

Table 3-15 Species belonging to pteropoda superorder found in the Adriatic (source: Società Italiana di Biologia Marina SIBM[23]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Cavolinia inflexa	(Lesueur, 1813)		X	X	Maximum abundances during winter and summer
Cavolinia tridentata	Niebuhr, 1775 ex Forskål ms.)		X	X	-
Clio piramidata lanceolata	(Lesueur, 1813)		X	X	Proper in meso-batipelagic waters
Creseis acicula	Rang, 1828		X	X	More abundant in surface waters, peaks in autumn-winter
Styliola subula	(Quoy & Gaimard, 1827)		X	X	-
Limacina bulimoides	(D'Orbigny, 1836)			X	-
Limacina inflata	(D'Orbigny, 1836)			X	In surface is more abundant during autumn-winter
Limacina trochiformis	(D'Orbigny, 1836)			X	-
Pneumodermopsis ciliata	(Gegenbaur, 1855)	?	X	X	-

23 http://www.sibm.it/CHECKLIST/BMM%2015(s1)%202008%20Checklist%20I/36%20OPISTHOBRANCHIA.pdf, last access 18 June 2013.

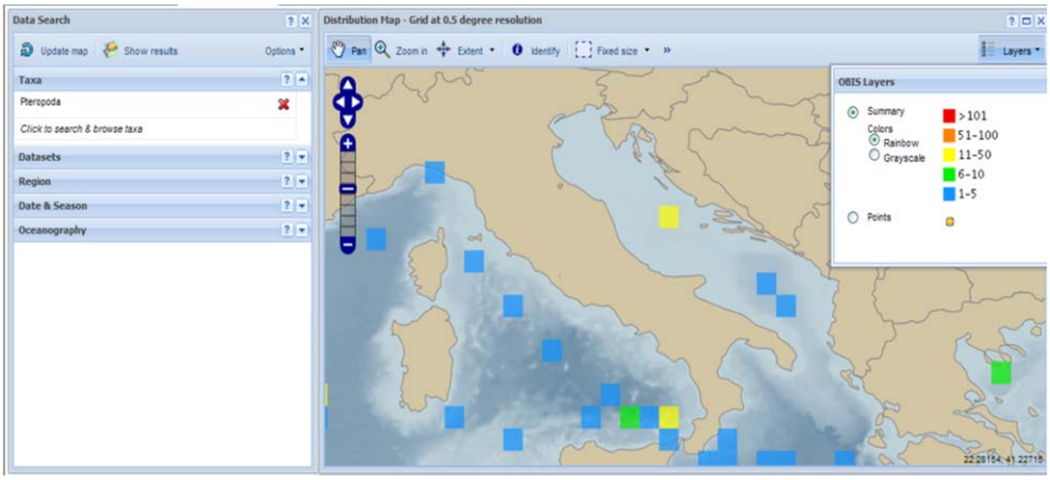

Figure 3-84 Pteropoda distribution and densities in the Adriatic sea (Source: OBIS http://iobis.org/mapper/, last access 22 November 2012).

Chaetognatha

Chaetognatha are marine hermaphrodite organism mainly pelagic, spread in all seas and oceans. They have a relatively long life and are useful as indicators of particular water masses. The Mediterranean hosts 20 species, 16 are planktonic and 4 are benthonic. In the Adriatic species registered are summarized in the following table. Data on chaetognatha phylum distribution in the Adriatic Sea is shown in the Figure 3-85.

Table 3-16 species belonging to chaetognatha phylum found in the Adriatic (source: Società Italiana di Biologia Marina SIBM[24] last visit 22/11/2012).

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Spadella cephaloptera	Busch, 1851	X		
Sagitta bipunctuata	Quoy e Guimard, 1827	X		
Sagitta decipien	Fowler,1905		X	X
Sagitta hexaptera	d'Orbigny, 1835		X	
Sagitta enflata	Grassi,1883	X	X	X
Sagitta friderici	Ritter-Zahony, 1911		X	
Sagitta lyra	Krohn, 1853		X	X
Sagitta minima	Grassi, 1881	X	X	X
Sagitta serratodentata	Krohn, 1853	X	X	X
Sagitta setosa	Müller, 1847	X	X	X
Krohnitta subtilis	Grassi, 1881	X	X	X
Pterosagitta draco	Krohn, 1883	X	X	X

24 http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/35%20CHAETOGNATA.pdf, last access 18 June 2013

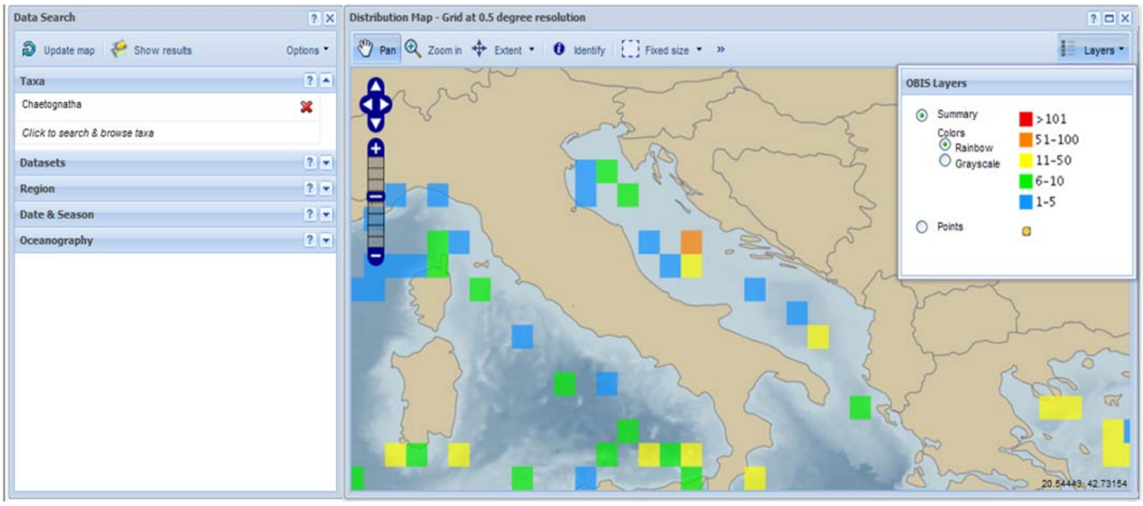

Figure 3-85 Chaetognatha distribution and densities in the Adriatic sea (Source: OBIS http://iobis.org/mapper/, last access 22 November 2012).

Appendicularia

Appendicularia is a class of pelagic tunicate (subphylum), belonging to chordate phylum; they are composed by three families: fritillariidae, kowalevskiidae and oikopleuridae. Appendicularia constitute an important food source for fish larva because of the high content of proteins and carbohydrate. Up to now 65 species of appendicularia have been described; in the Italian seas at least 41 species have been described. In the Adriatic species registered are summarized in the following table. Data on appendicularia class distribution in the Adriatic Sea is shown in Figure 3-86.

Table 3-17 Species belonging to appendicularia class found in the Adriatic (source: Società Italiana di Biologia Marina SIBM[25]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Megalocercus abyssorum	Chun, 1887			X
Oikopleura albicans	(Leuckart, 1854)	X	X	X
Oikopleura cophocerca	(Gegenbaur, 1855)			X
Oikopleura dioica	Fol, 1872	X	X	X
Oikopleura fusiformis	Fol, 1872	X	X	X
Oikopleura graciloides	Lohmann & Bückmann, 1924			X
Oikopleura intermedia	Lohmann, 1896			X
Oikopleura longicauda	(Vogt, 1854)	X	X	X
Oikopleura mediterranea	Lohmann, 1896			X
Oikopleura rufescens	Fol, 1872			X

25 http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/39%20TUNICATA.pdf, last access 18 June 2013

Species	Author	North Adriatic	Central Adriatic	South Adriatic
Oikopleura vanhoeffeni	Lohmann, 1896	X		
Pelagopleura haranti	Vernières, 1934			X
Stegosoma magnum	(Langerhans, 1880)			X
Appendicularia sicula	Fol, 1874			X
Fritillaria borealis	Lohmann, 1896			X
Fritillaria borealis sargassi	Lohmann, 1896	X	X	X
Fritillaria borealis intermedia	Lohmann, 1905	X	X	X
Fritillaria fagei	Fénaux, 1961			X
Fritillaria formica	Fol, 1872			X
Fritillaria fraudax	Lohmann, 1896			X
Fritillaria gracilis	Lohmann, 1896			X
Fritillaria haplostoma	Fol, 1872			X
Fritillaria megachile	Fol, 1872			X
Fritillaria messanensis	Lohmann, 1899			X
Fritillaria pellucida	(Busch, 1851)	X		X
Fritillaria pellucida typica	Busch, 1851	X	X	X
Fritillaria tenella	Lohmann, 1896			X
Fritillaria venusta	Lohmann, 1896			X
Kowalevskia tenuis	Fol, 1872			X

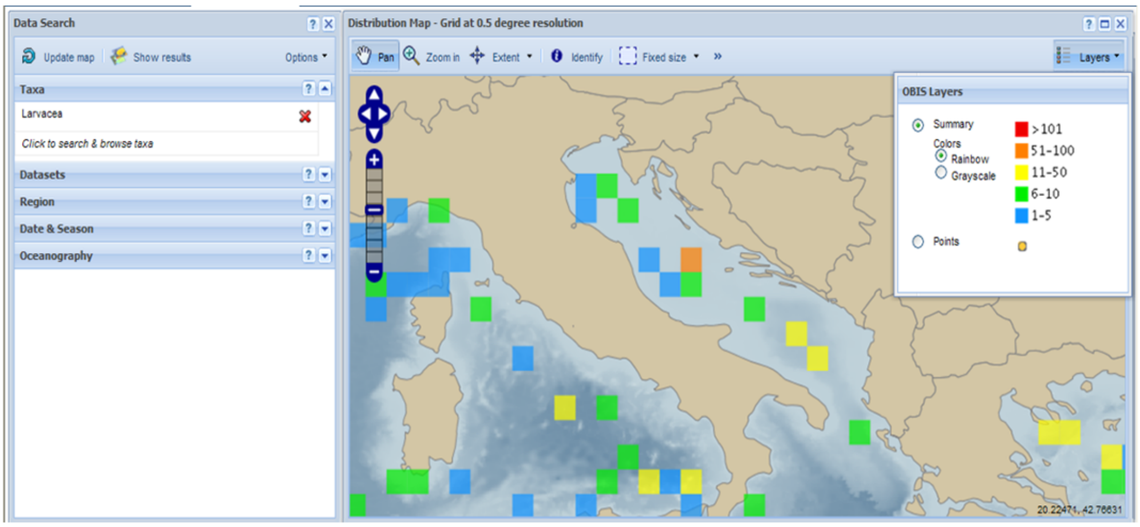

Figure 3-86 Appendicularia distribution and densities in the Adriatic sea (Source: OBIS http://iobis.org/mapper/ last access 22 November 2012).

<u>Thaliacea</u>

Thaliacea belong to tunicata subphylum and are subdivided into three orders: doliolida, pyrosomatida, salpida. They are characterized by a life cycle which alternates sexual (blastozooid) and asexual (oozoid) stages. In the Adriatic species registered are summarized in the following table. Data on thaliacea class distribution in the Adriatic Sea is shown in the following Figure 3-87.

Table 3-18 Species belonging to thaliacea class found in the Adriatic (source: Società Italiana di Biologia Marina SIBM[26]).

Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Pyrosoma atlanticum	Péron, 1804			X	-
Brooksia rostrata	(Traustedt, 1893)			X	-
Salpa fusiformis	Cuvier, 1804	X	X	X	Common in surface waters, abundant in winter. spring and autumn
Salpa maxima	Forsskål, 1775			X	-
Thalia democratica	(Forsskål, 1775)	X	X	X	High grow rates
Dolioletta gegenbauri	Uljanin, 1884	X		X	Common in neritic waters, reaches high concentrations and give an important contribute to carbon and nitrogen contribution in the water column and in the seabed
Doliolina muelleri	(Krohn, 1852)			X	Is one of the most abundant species in neritic waters (50 m depth)
Doliolum denticulatum	Quoy & Gaimard, 1834			X	Is one of the most abundant species in the open sea
Doliolum nationalis	Borgert, 1893			X	Reaches high concentration in neritic waters in September - November

26 http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/39%20TUNICATA.pdf, last access 18 June 2013

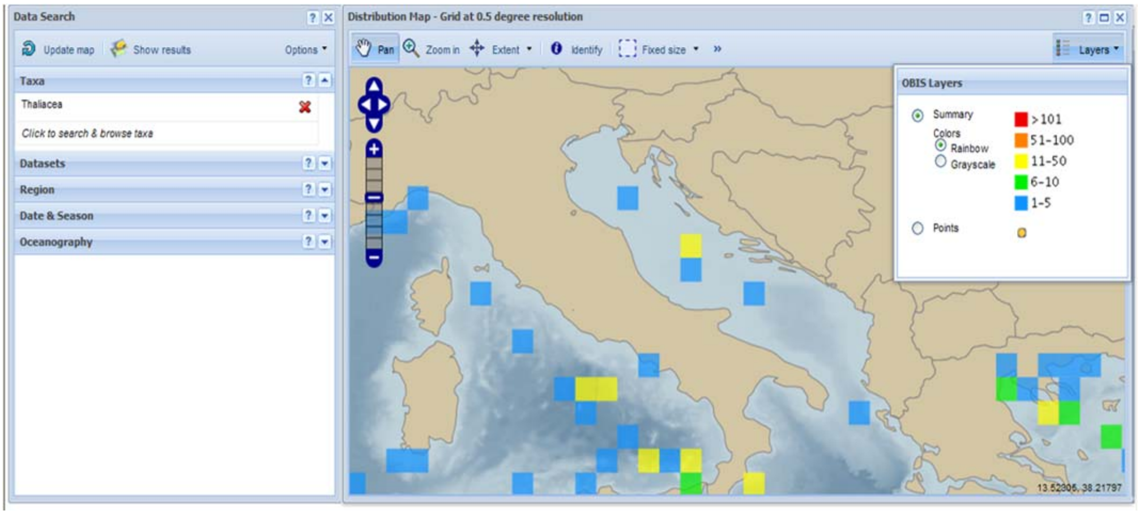

Figure 3-87 thaliacea distribution and densities in the Adriatic Sea (Source: OBIS http://iobis.org/mapper/, last access 22 November 2012).

3.4.1.3 Seaweed

In the last three decades, changes in the benthic algal flora, which is regarded as a good descriptor of environmental characteristics, have been reported for many Mediterranean regions and a decline in the most sensitive taxa has occurred as a result of anthropogenic disturbance (sewage, dredging, aquaculture, industrial and agricultural discharge) (Falace et al., 2010).

The following information is derived from Falace et al. (2010) and describes the status and main changes in the benthic algal flora that have occurred over past decades along the coastline of the Italian Adriatic Sea. From a floristic point of view, the Adriatic Sea, compared with other Italian seas, is 'structurally' characterized by a lower number of species (577 taxa with only 39 exclusive species, Table 3-19).

Table 3-19 Italian macro-algal flora: composition of the whole flora. the flora of each Sea, species common to the three seas and sole species of the Adriatic Sea (Source: Falace et al., 2010).

	Italy	Tyrrhenian Sea	Adriatic Sea	Ionian Sea (including the Straits of Sicily)	Common species	Sole species of the Adriatic Sea
Rhodophyta	509 (58.4%)	470 (61.1%)	340 (58.9%)	444 (63.2%)	314	4
Phaeophyta	208 (23.9%)	169 (22.0%)	124 (21.5%)	148 (21.1%)	93	21
Chlorophyta	154 (17.7%)	130 (16.9%)	113 (19.6%)	110 (15.7%)	84	14
TOTAL	871	769 (88.3%)	577 (66.2%)	702 (80.6%)	491 (56.4%)	39 (4.5%)

It also shows a different chorological spectrum, characterized by dominance of the Atlantic element, followed by the Cosmopolitan, Mediterranean, Circumtropical, Indo-Pacific and Circumboreal elements (Table 3-20).

Table 3-20 Chorological spectra of the floras from each sea around the Italian coast (Source: Falace et al., 2010).

Phytogeographic elements	Tyrrhenian Sea	Adriatic Sea	Ionian Sea (including the Straits of Sicily)
Atlantic	342 (44.5%)	253 (43.8%)	302 (43.0%)
Mediterranean	204 (26.5%)	132 (22.9%)	180 (25.6%)
Cosmopolitan	147 (19.1%)	137 (23.7%)	145 (20.7%)
Indo-Pacific	33 (4.3%)	20 (3.5%)	32 (4.6%)
Circumtropical	31 (4.0%)	24 (4.2%)	29 (4.1%)
Circumboreal	12 (1.6%)	11 (1.9%)	14 (2.9%)
TOTAL	769	577	702

Currently the Adriatic sea is subjected to changes in the marine vegetation involving the structure of the algal communities. In particular migration of sciaphilous macroalgae in shallower waters, a reduction in habitat-forming species (mainly *Cystoseira* spp., and *Sargassum* spp.), together with an increase in Rhodophyta and opportunistic species were observed (Falace et al., 2010). These shifts have generally been considered to be one of the main effects of environmental variations on macroalgal communities.

Analyzing the three macro areas (North, Middle and South) of the Adriatic, based on previous specific study (Falace et al., 2010) the following considerations can be made:

- North Adriatic: comparisons between studies along the artificial and natural rocky shores of the Gulf of Trieste. conducted in 1999–2000 and 1967. Data highlighted environmental stresses (overgrazing, aquaculture and loss of habitats) which had led to large changes in benthic algal vegetation in terms of floristic diversity and dominant algal associations. The current algal assemblages are characterized by the absence of well-structured communities. Floristic comparisons showed a 20% decrease in the number of species and a reduction in Fucales stands which made the vegetation uniform and dominated by perennial *Gelidium*, *Gelidiella* and *Pterosiphonia* species. In particular, a 28% reduction in species among the Phaeophyceae (*Ectocarpales* and *Fucales*) and a 27% reduction among the Ulvophyceae (*Cladophorales*) were recorded. The disappearance of a large number of epiphytic species is attributable to the decline in the larger Phaeophyceae. Another phenomenon, which has been related to increased turbidity, is the upward migration of several species from the lower sublittoral zone to the eulittoral zone. Despite the observed current reduction in floristic richness compared with 1967, the total number of species is fairly high compared with other areas of the north Adriatic Sea. The specific richness found may indicate the presence of a genetic reservoir and the potential capability for restoration of the environment following conservation planning and habitat protection.

  A specific mention needs to be made for two other specific areas. The first are the rocky outcrops of biogenic concretions. called 'tegnúe', scattered at different distances from the coast (3–13 nautical miles) and at depths between 9 and 40 m, on the sandy–muddy bottom of the north Adriatic Sea. These zones, whose number is still unknown (1,000 or up to 3,000 including the smallest ones), range in size from a single small block of one square meter to a few thousand square meters and represent a 'hotspot' of biodiversity. The other relevant zones are the low-crested coastal defence structures (i.e. breakwaters, sea walls, dykes) for protection against erosion that have become the main structural feature of the north Adriatic coastline, in particular along Veneto coast. Data collected from both artificial and natural hard substrata of the Veneto marine areas report a total of 215 species (130 Rhodophyta, 42 Ochrophyta and 43 Chlorophyta) and a significant presence of *C. barbata* and *C. compressa,* although restricted to a depth of 2–3 m;

- Middle Adriatic: the Adriatic flora catalogue reported 202 species (127 Rhodophyta including five *taxa inquirenda* and two *taxa excludenda*, 41 Ochrophyta including one *taxon excludendum* and 34 Chlorophyta including one *taxon inquirendum*);
- South Adriatic: the total flora of south Adriatic (Apulia coast) consists of 569 taxa. In particular for the Gargano promontory 234 taxa (169 Rhodophyta, 33 Ochrophyta and 32 Chlorophyta) were reported. With respect to previous observations some changes in this area have been registered, in particular a decrease in 'canopyforming' species and an increase in 'turf-forming' ones, mainly represented by Ceramiaceae Ectocarpaceae, Cladophoraceae and Gelidiaceae, were observed. The decrease in Ulvaceae and the occurrence of sciaphilous taxa on shallow waters were also recorded.

  Other relevant zone is the area in front of S. Cesarea Terme, characterized by an elevated richness if compared with other areas of the Apulia. with 154 species collected.

The complete list of seaweed species registered in the Adriatic can be found at: http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/50%20MACROPHYTOBENTHOS.pdf.

3.4.1.4 Seagrass

A spawning ground and nursery for many commercial species and the source of major primary production, magnoliophytes seagrass beds constitute one of the Mediterranean's sensitive habitats. They also play an important role in oxygenating the water. trapping and fixing sediment and by protecting the beaches against erosion. Seagrass meadows extend from 0.2 to 45 m depth in the open seas and in the brackish and saltwater coastal lagoons.

Posidonia oceanica (Linnaeus) Delile is generally considered the dominant species of the nine in the Mediterranean Sea (Short and Coles, 2001), with an estimated covered area of the seabed of 35,000 km^2 (UNEP-MAP). However, there are several other abundant species like *Zostera marina* Linnaeus, *Zostera noltii* (Hornemann) Tomlinson et Posluzny and *Cymodocea nodosa* (Ucria) Ascherson (see Figure 3-88, Figure 3-89). All these species are also present in the Adriatic Sea.

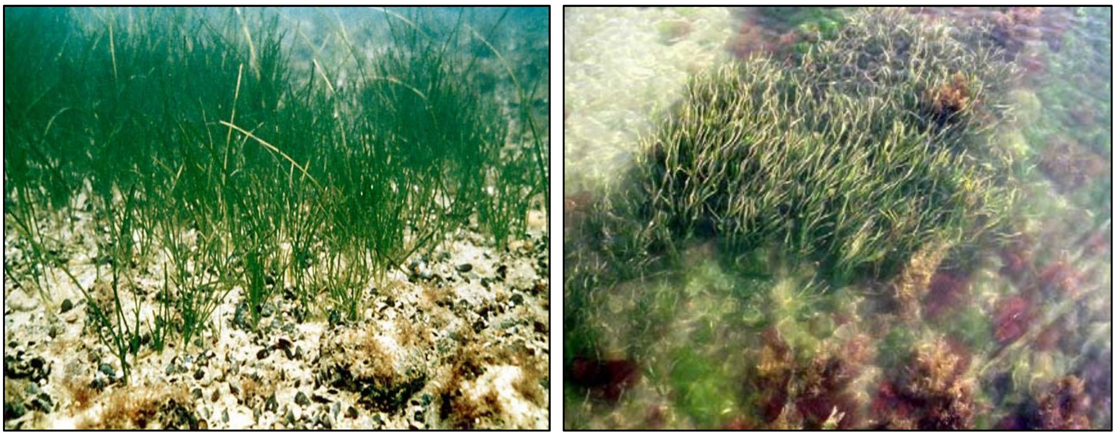

Figure 3-88 *Zostera marina* (left image) and *Zostera noltii* (right image).

Figure 3-89 *Cymodocea nodosa* (left image) and *Posidonia oceanica* (right image).

Zostera marina is considered to be a relict species in the Mediterranean, where it forms perennial meadows distributed from the intertidal to a few meters deep, can grow on sandy and muddy substrate and is also present in coastal lagoons. *Zostera noltii* grows from the interdal to depths of a few meters on sandy and muddy substrate; it is also present in enclosed and sheltered zones, where it can form mixed beds with *Cymodocea nodosa*. *Cymodocea nodosa* most commonly occurs in shallow water but exceptionally can reach a depth of 30-40 meters, is usually found on sandy substrate and sheltered sites and is considered a pioneer species in the succession leading to a *Posidonia oceanica* climax system (Green and Short, 2010).

Information on magnoliophytes extension in marine areas of different Adriatic countries is provided in the following table. Values include also corallogenic reefs which, with magnoliophytes, constitute the most important benthic habitats in the Mediterranean basin. Percentages of total magnoliophytes and corallogenic reefs with respect to total area georeferenced are also provided.

Data on *Zostera marina*. *Zostera noltii* and *Cymodocea nodosa*, available only for the Italian portion of the Adriatic sea, confirms that (Procaccini et al., 2003):

- They are present in particular along Veneto and Friuli coastlines;
- Only *Zostera marina* is present along central Adriatic coasts;
- *Cymodocea nodosa* and *Zostera noltii* are present along Apulia coasts.

Concerning the Venice lagoon many studies on sea grass population have been made during years. The following figure, updated at 2010, shows the extension and distribution of *Zostera marina, Zostera noltii* and *Cymodocea nodosa* inside the lagoon, while the relative table indicates the coverage of the species in the same area.

Table 3-21 Mediterranean marine ecosystem (Source: UNEP-MAP, 2009).

Country	Georeferenced magnoliophytes and corallogenic reefs	
	km	Percentage
Italy (includes also non-Adriatic coasts)	5,000	68
Slovenia	8	17
Croatia	5,600	96
Bosnia-Herzegovina	0	0
Montenegro	2	1
Albania	6	1

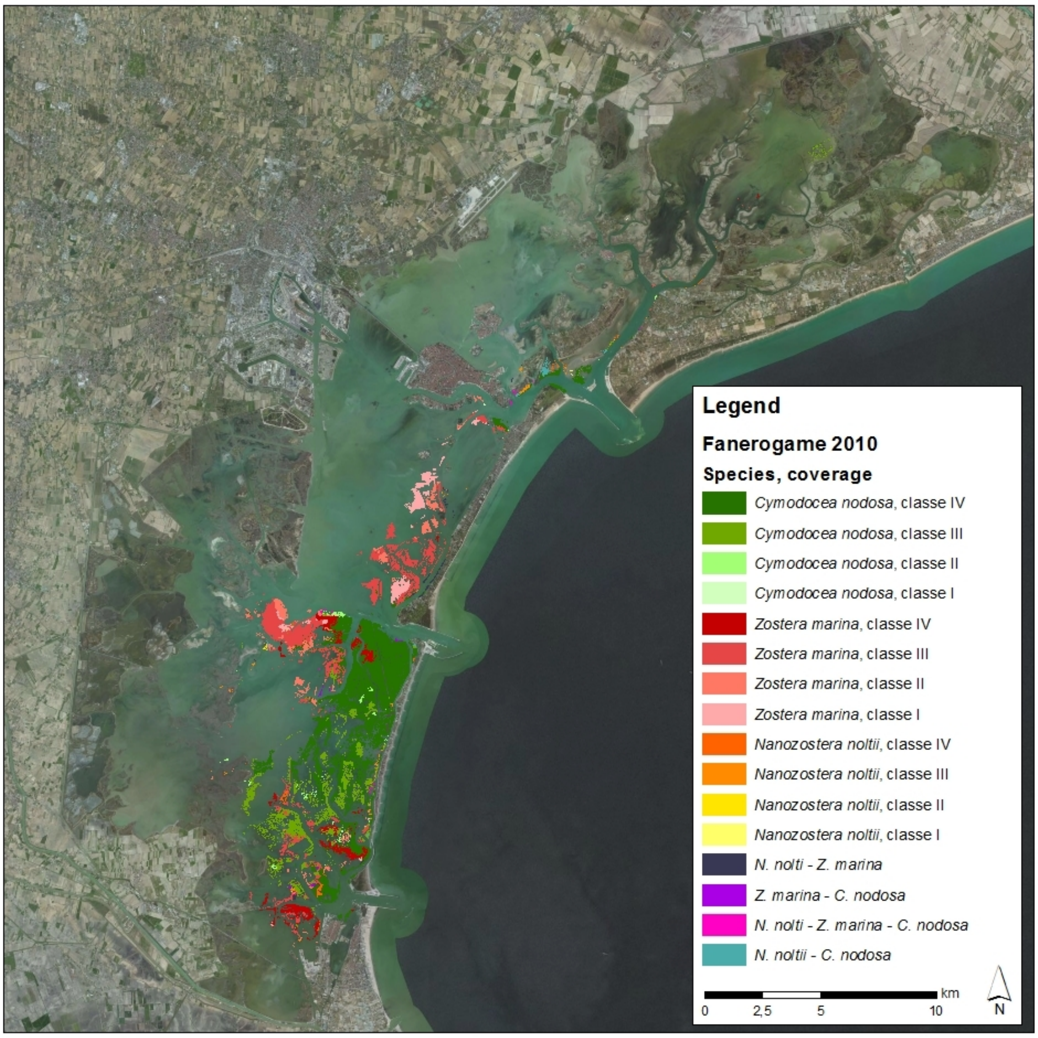

Figure 3-90 Seagrass population in the Venice lagoon (Source: MAG-ACQUE – Selc, 2009, 2010).

Table 3-22 seagrass extension in the Venice lagoon (Source: MAG-ACQUE – Selc, 2009, 2010).

Seagrass type/associations	Area covered by seagrass (hectares)
Cymodocea nodosa	2,276.1
Zostera marina	1,404.5
Zostera marina - Cymodocea nodosa	12.1
Nanozostera noltii	57,4
Nanozostera noltii - Cymodocea nodosa	19.4
Nanozostera noltii - Zostera marina	26.7
Nanozostera noltii - Zostera marina - Cymodocea nodosa	11.4

Regarding *Posidonia oceanica* (Figure 3-89), which is considered a good coastal marine water quality bioindicator, it forms continuous meadows from the surface to a maximum depth of some 45 m and is common on different types of substrate, from rocks to sand with the exception of estuaries where the input of freshwaters and fine sediments is high and limit its growth. *Posidonia oceanica* beds have classically been considered one of the climax communities of the Mediterranean coastal area. The horizontal and vertical growth of rhizomes, and the slow decay of this material. causes *Posidonia oceanica* to form a biogenic structure called "matte" that arises from the bottom up to a few meters and can be thousands of years old. In the Adriatic data (Flagella et al., 2010), available only for Italy, confirms that the species (Figure 3-91):

- Is frequent along the southern coast where meadows grow on old "matte" remains;
- Is almost absent from the Po river delta to the northern Apulian coasts;
- Is rare or absent in the north Adriatic.

Figure 3-91 *Posidonia oceanica* distribution in the Adriatic sea (Source: Flagella, 2010).

For the southern Adriatic the following figures show a more detailed distribution of *Posidonia oceanica* along north and south Apulian coasts, distinguishing between colonies on rocks, on “matte”, on sand, dead “matte”, patchwork areas with dead “matte” and patchwork areas with hard substratum. It has been estimated that the extension of *Posidonia oceanica* along these areas is approximately 330 km^2 (Regione Puglia et al.).

The complete list of seagrass species registered in the Adriatic can be found at: http://www.sibm.it/CHECKLIST/BMM%2017(s1)%202010%20Checklist%20II/50%20MACROPHYTOBENTHOS.pdf

Figure 3-92 *Posidonia oceanica* distribution along north Apulian coasts (Source: Regione Puglia et al.).

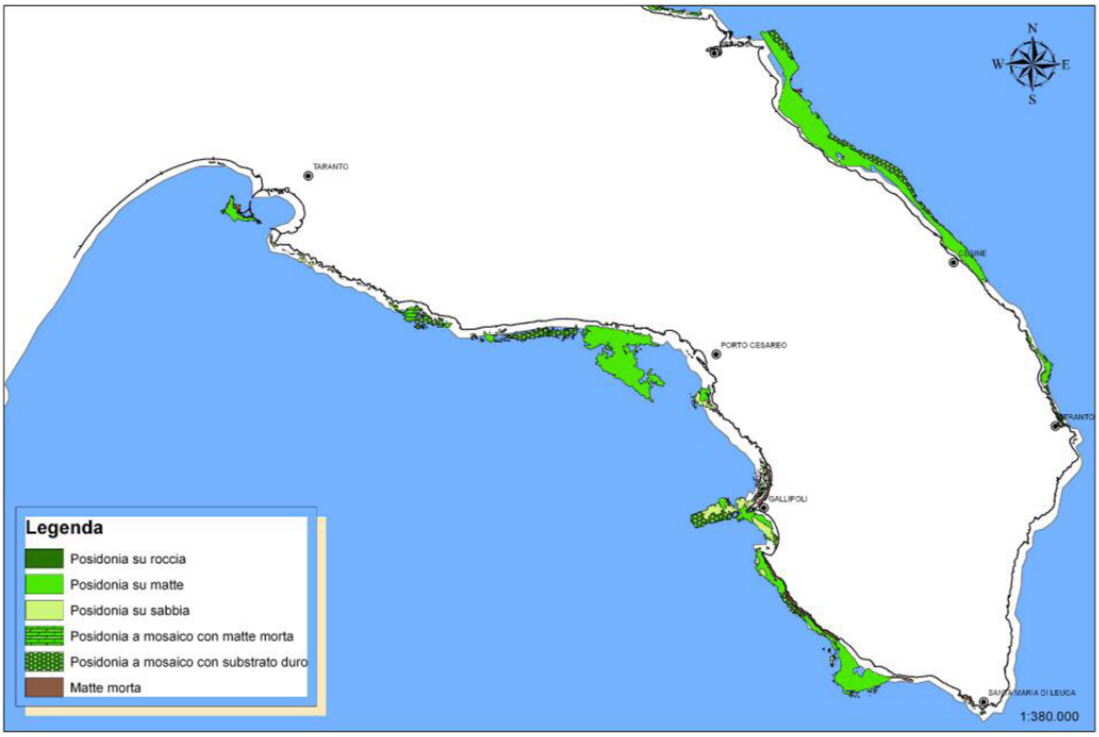

Figure 3-93 *Posidonia oceanica* distribution along south Apulian coasts (Regione Puglia et al.).

3.4.1.5 Invertebrates

The following paragraphs illustrate the status of some relevant bottom fauna invertebrates that are common and/or relevant in the Adriatic area. Information collected is derived from the study redacted by ISPRA (2012) within the process of MSFD implementation in Italy. Species have been selected based on their relevance from an ecological and economic point of view.

<u>Species: *Scyllarides latus*</u>

Scyllarides latus (Latreille, 1803), listed in Appendix 3 of Berne Convention, Appendix 3 of Barcelona Convention, ASPIM Protocol and Appendix V Habitat Directive 42/93, is a typically night species and is one of the biggest crustaceans in the Mediterranean with a length up to 45 cm and a weight of more than 2 kg (Figure 3-94). It belongs to Arthropoda phylum, crustacea subphylum, Malacostraca class and Decapoda order. It can be found from 4 to 300 m depth both on rocky and sandy substratum but also in *Posidonia Oceanica* grasslands.

Figure 3-94 ***Scyllarides latus.***

There is not much information on the species due to difficulties found in its ecology monitoring (the species usually lives in caves) consequently data on spatial distribution are incomplete and still not available. At the moment the species is considered rare and in the Adriatic can be found only in the southern basin. Main cause of its decline is imputable to over fishing with trawling nets, because of its high commercial value. Other pressures derive from coasts modifications due to human disturbance and recreational scuba divers activities.

Species: *Pinna nobilis*

Pinna nobilis Linnaeus, 1758, listed in Appendix 2 of Barcelona Convention and Appendix IV Habitat Directive 42/93, is one of the species whose gathering needs to be regulated. It belongs to Mollusca phylum, bivalvia class and Pterioida order. It is the biggest clam in the Mediterranean Sea, with an average length of 65 cm and can be found both in shallow and in deeper waters until 40 m depth (Figure 3-95).

Figure 3-95 ***Pinna nobilis.***

It can often be found near *Posidonia oceanica* grasslands. The species theoretically has a spatial distribution which covers the entire Adriatic basin but historic data series for identifying different populations don't exist. Data available are mainly derived from literature and are referred only to eastern Adriatic. For this area an average number of 10 individuals per 100 m^2 has been registered; nevertheless this value is actually considered high. Density is however very changeable, as testified by density values gathered in Trieste Gulf with 20 individuals per 100 m^2 or values of 8-10 individuals per 100 m^2 registered in Mljet National Park (Croatia)[27].

At the moment detailed information on species and gathering rates are not available and an exhaustive description of dimension and population conditions can't be given. Main pressures on the species derive from:

- Direct gathering for decorative aims;
- Trawling nets;
- Ships berths and fishing tools.

Species: *Lithophaga litophaga*

Lithophaga litophaga (Linnaeus, 1758), listed in Appendix 2 of Barcelona and Berna Convention and Appendix IV Habitat Directive 42/93, is one of the species which requires strict protection measures. Its consumption, collection and trading are forbidden in all EU countries. It belongs to Mollusca phylum, bivalvia class and Mytiloida order.

The species lives inside calcareous rocks corroding the materials using acid secretions and has a very slow growth (Figure 3-96). It has been estimated that for reaching 5 cm length 15-35 years are required.

Figure 3-96 *Lithophaga litophaga.*

27 http://www.blublog.net/?p=916 last visit 22/11/2012

Lithophaga litophaga can be found in the whole Mediterranean sea; in the Adriatic basin it is distributed mainly along central and southern rocky coast (Figure 3-97). It is however well known that the species is strongly decreasing due to illegal fishing for alimentary purposes.

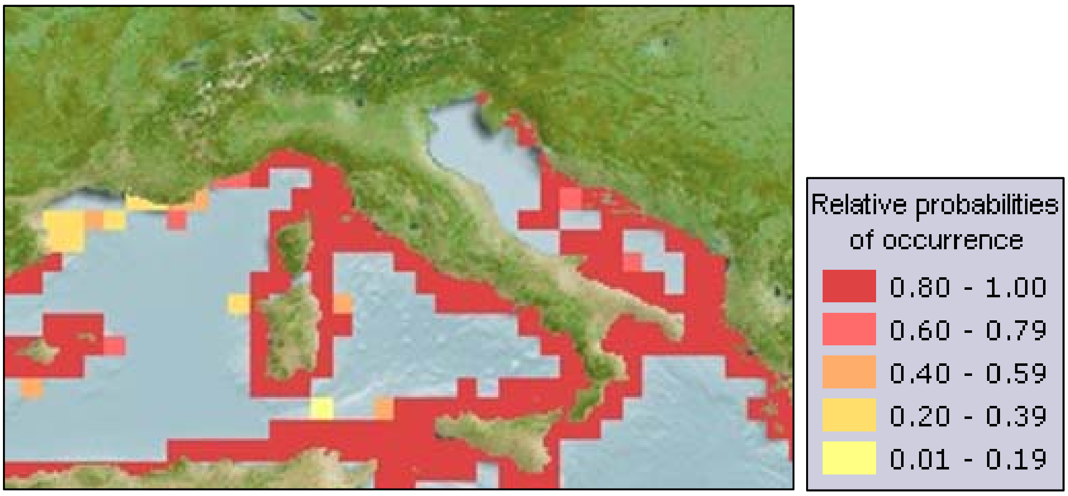

Figure 3-97 Distribution map for Lithophaga lithophaga (Source: www.aquamaps.org, version of August 2010, last visit 28 November 2012).

Species: *Corallium rubrum*

Corallium rubrum (Linnaeus, 1758), listed in Appendix 3 of Barcelona Convention, Appendix 2 of Berna Convention and Appendix IV Habitat Directive 42/93, has a relevant commercial and ecological value and is one of the species whose gathering needs to be regulated. It belongs to Cnidaria phylum, anthozoa class and Alcyonacea order.

It is generally red coloured, but sometimes also white, rose or brown depending on place and depth (Figure 3-98). It has a slow growth rate (3-4 cm per year) and can reach 20-30 cm height; lives in dark places like caves and fissures between 20/30 m and 200 m depth.

Figure 3-98 *Corallium rubrum.*

The species is endemic of the Mediterranean Sea (in particular central and western part of the basin); it lives in colonies and in the Adriatic can be found in the south, especially along Balkans and Apulian coastlines (Filosi, 2006). Figure 3-99 shows coral reef distribution in the Mediterranean.

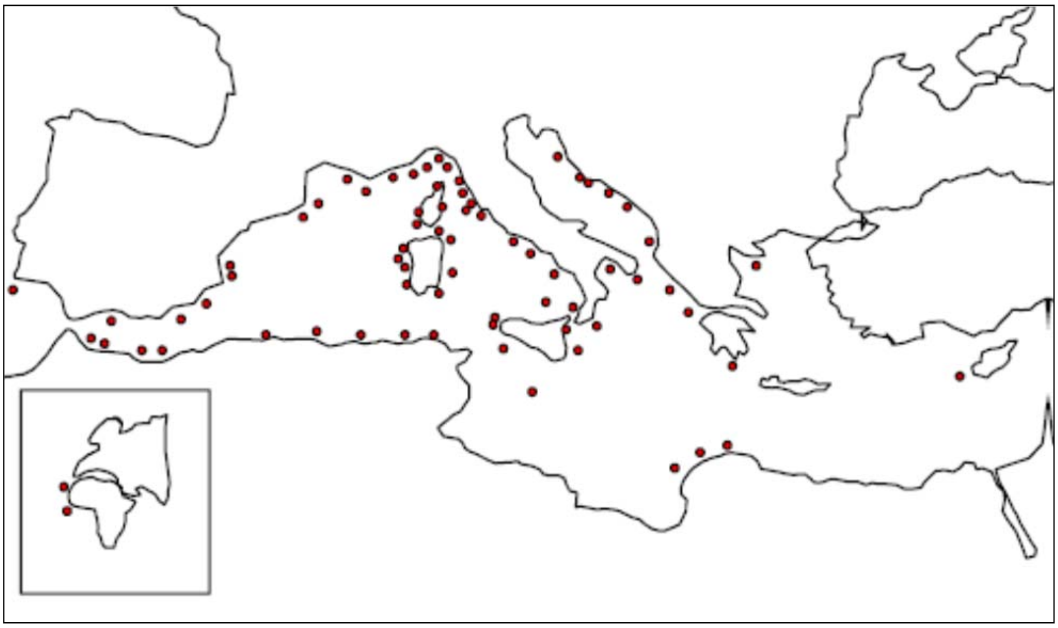

Figure 3-99 *Corallium rubrum* geographic distribution in the Mediterranean basin (Source: Filosi, 2006).

Information on the species living in south Adriatic are very scarce and only referred to Apulian coast lines. Data are partial and could under estimate the actual presence; consideration on spatial distribution and abundance can't be given at the moment. Main pressures on the species derive from:

- Excessive collection for ornamental purposes;
- Habitat destruction due to specific collecting tools that destroy the ocean bottom.

Species: *Centrostephanus longispinus*

Centrostephanus longispinus (Philippi, 1845), listed in Appendix 2 of Berna Convention and Appendix IV Habitat Directive 42/93, is distributed in the whole Mediterranean Sea. It belongs to Echinodermata phylum, Echinoidea class and Diadematoida order. With a shell of 4-5 cm diameter and very long and fine quills black, purplish and whitish coloured, it's a benthonic species which lives in deep waters (40-200 m depth) and tolerates wide salinity variations (Figure 3-100).

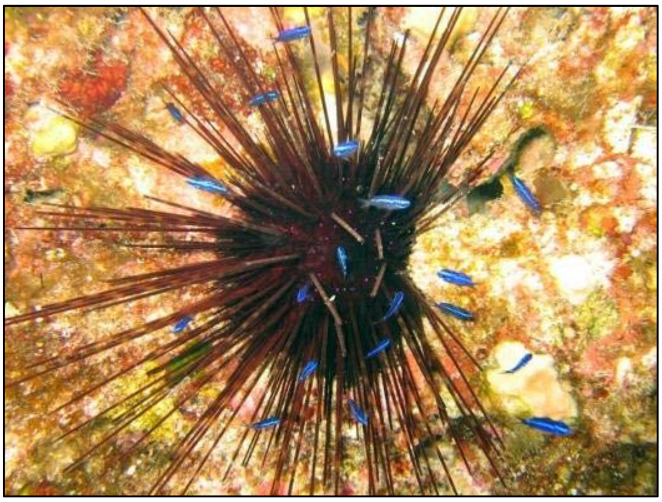

Figure 3-100 ***Centrostephanus longispinus.***

The species can be found on different substratum like *Posidonia oceanica* grasslands, sandy, debris and hard seabed. Even if widespread in the Mediterranean Sea, it's considered rare and guaranteed data on its distribution and abundance don't exist. Main pressures on the species derive from:

- Biological disturbance with collection for ornamental purposes;
- Changes in the thermal regime.

Species: *Nephrops norvegicus*

Nephrops norvegicus (Linnaeus, 1758), also known as scampi, belongs to malacostraca class (Figure 3-101) and has a high economic value. The species reproduces during spring and larvae can be found in the plankton from January to April. It is distributed in deep waters of central Adriatic, in northern Croatian channels and offshore Ancona coastline. High concentrations of juveniles can be found in the Pomo trench in the middle Adriatic. Figure 3-102 summarizes the distribution registered during MEDITS campaign.

Figure 3-101 ***Nephrops norvegicus.***

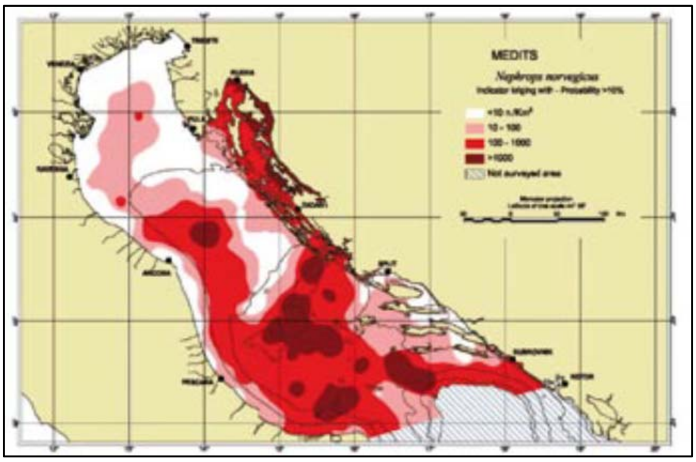

Figure 3-102 *Nephrops norvegicus* distribution in the north and central Adriatic Sea (Source: Regione Marche and Zara County, 2008).

<u>Species: *Eledone cirrhosa*</u>

Eledone cirrhosa (Lamarck, 1798), whose common name is curled octopus, belongs to cephalopoda class (Figure 3-103) and is a species with relevant commercial value.

It has a biological cycle of 18-24 months with reproductive period between spring and early summer. It can be found in the central part of the Adriatic with juveniles' distribution which is the same of the adult species. Figure 3-104 summarizes the distribution registered during MEDITS campaign (Regione Marche and Zara County, 2008).

Figure 3-103 *Eledone cirrhosa.*

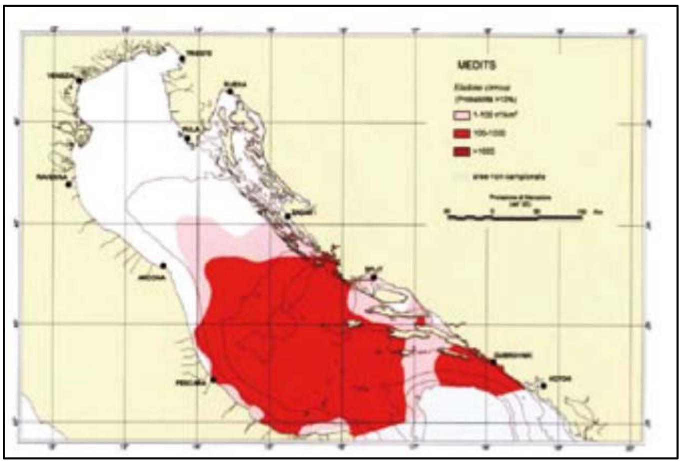

Figure 3-104 *Eledone cirrhosa* distribution in the north and central Adriatic Sea (Source: Regione Marche and Zara County, 2008).

Species: *Eledone moschata*

Eledone moschata (Lamarck, 1798), whose common name is musky octopus, belongs to cephalopoda class (Figure 3-105) and is a species with relevant commercial value. It can be found until 200 m depth with a quite broad reproductive period from winter to late spring. In the Adriatic it is distributed in the northern part of the basin and along Croatian channels in the central Adriatic, with a distribution linked to residual and clayish sands and complementary to *Eledone cirrhosa*. Juveniles cover the same distribution area of the species. Figure 3-106 summarizes the distribution registered during MEDITS campaign.

Figure 3-105 *Eledone moschata.*

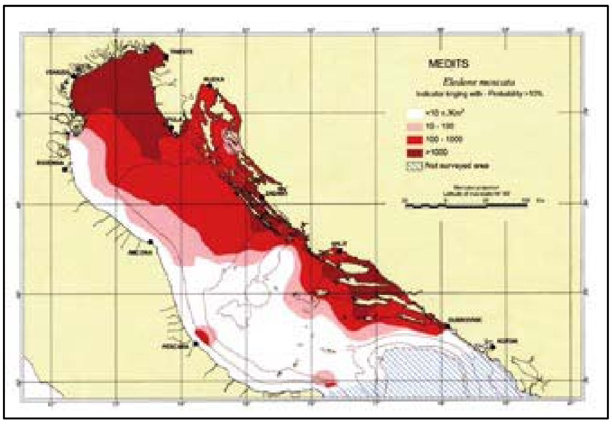

Figure 3-106 *Eledone moschata* distribution in the north and central Adriatic Sea (Source: Regione Marche and Zara County, 2008).

<u>Species: *Loligo vulgaris*</u>

Loligo vulgaris (Lamarck, 1798), also known as common squid, belongs to cephalopoda class (Figure 3-107) and is a species with relevant commercial value.

The species has a short biological cycle of approximately 1-2 years, with a reproductive period extended during the whole year but with a peak in spring. It is distributed in the entire north and central Adriatic with the exception of deeper waters. During the summer high concentrations of juvenile can be found along Italian coastal areas and in the Croatian channels of the middle Adriatic. Figure 3-108 summarizes the distribution registered during MEDITS campaign.

Figure 3-107 L*oligo vulgaris.*

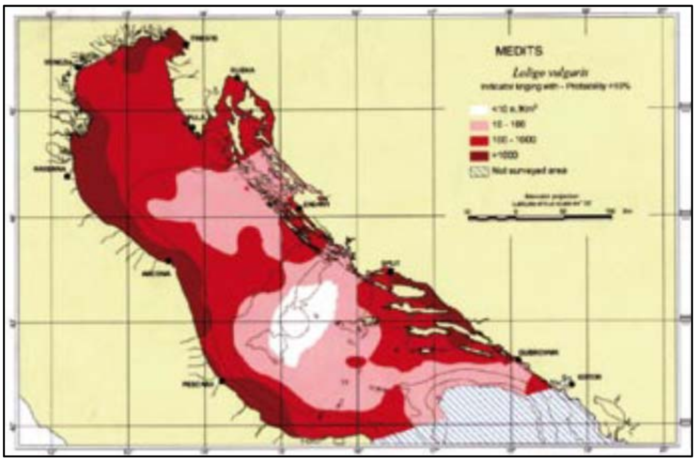

Figure 3-108 *Loligo vulgaris* distribution in the north and central Adriatic Sea (Source: Regione Marche and Zara County, 2008).

Invertebrates in the north Adriatic

North Adriatic is characterized by sandy coasts with changeable granulometry depending on hydrodynamics, high nutrient concentrations and low depths. All these peculiarities strongly influence fauna living in the area. Besides of the sandy seabed, of particular interest from the biologic point of view are also specific small areas called “tegnue” (see also paragraph 3.3.2) with rocky outcrops distributed offshore North West Adriatic coasts, which host many type of invertebrates.

In particular these areas, some of which are also protected (“Tegnùe di Chioggia” and “Tegnùe Porto Falconera, see paragraph 3.3.2) are a concentration of biological diversity with more than 300 *taxa,* mostly animal species, belonging to 11 *phyla* recorded (Anellida, Bryozoa, Crustacea, Polychaeta, Cnidaria, Echinodermata, Mollusca, Porifera, Sipunculida, Tunicata, Nemertina and Nematoda). It should be noted that important differences exist between outcrops from the biological (as for example different organisms living nearby or on the outcrops) and morphological (as for example different origin of the rocks) point of view (ARPAV, SELC, Thetis, 2007).

Data on species abundance is not available and depends on different factors like depth, nutrient concentration, sediment granulometry and composition, pollutant concentration.

Some of the most important invertebrates, divided per *phyla* that can be found in the area are:

- Mollusca: *Lithophaga litophaga, Pinna nobilis, Pecten. Jacobeus, Chlamys glabra, Ostrea edulis, Mytilus galloprovincialis, Nassarius mutabilis, Hexaplex trunculus, Bolinus brandaris, Callista chione, Patella cerulean, Tapes decussatus. Ostrea edulis* and *Mytilus galloprovincialis* in particular are very common with high biomass values (more than 10 kg/m^2) and have a significant economic relevance;
- Porifera: *Geodia cydonium, Tethya aurantium, Tethya citrine, Hippospongia communis, Spongia officinalis;*
- Crustacea: *Carcinus aestuarii, Palaemon adspersus, Palaemon elegans, Liocarcinus vernalis, Maja crispata, Maja squinado, Hommarus gammarus, Eriphia verrucosa, Pachygrapsus marmoratus*;

- Echinodermata: *Ophiotrix fragilis, Oloturia tubulosa, Paracentrotus lividus, Asterina gibbosa;*
- Cnidaria: *Actinia equina, Anemonia sulcata*, *Anemonia viridis, Cladocora caespitosa*;
- Anellida: *Serpula concharum, Serpula vermicularis, Pomatoceros triqueter, Protula tubularia;*
- Tunicata: *Polycitor adriaticus.*

3.4.2 Population dynamics, natural and actual range and status of species of fishes

At the moment the Adriatic fish population structure is constituted by a total of 418 fish species, representing 120 families which amounts to 72% of the known species and subspecies of the Mediterranean (in total about 581 species and subspecies) (Dulčić et al., 2005). Species and subspecies can be grouped into 2 classes, 26 orders and 120 families; of the total number of families, 21 belong to the class of cartilaginous fish (Selachii or Chondrichthyes), the rest, to the class of bony fish (Osteichtyes).

Most species and subspecies of Adriatic fish, apart from some endemic species and subspecies, belong to the Mediterranean and Mediterranean-Atlantic biogeographical region.

Only some fish families in the Adriatic can be considered as having numerous genera and/or species. Among the Chondrichthyes this is true only of the Rajidae family, including one genus (*Raja*), 4 subgenera (*Raja, Dipturus, Leucoraja, Rostroraja*) and 11 species. The most numerous family of the Osteichthyes is the Gobiidae with 18 genera. 45 species and one subspecies. The genera with the largest number of species are the *Gobius* and *Pomatoschistus*. Also the following families are numerous: Labridae (8 genera, 2 subgenera and 18 species), Sparidae (9 genera, 3 subgenera and 18 species), Blennidae (5 genera and 17 species and subspecies), etc.

The following paragraphs, derived from ISPRA (2012), SIBM (2010), Regione Marche and Zara County (2008), Cataudella and Spagnolo (2011) and Adriamed database[28], illustrate the distribution of some Adriatic fish species, relevant from an economic and biological point of view or because threatened, during the past years. In most cases data gathering is actually insufficient for giving a complete spatial and temporal distribution framework.

The complete list of species can be found in the SIBM database (http://www.sibm.it/CHECKLIST/menu%20checklist%20II.htm).

<u>Species: *Mustelus mustelus*</u>

Mustelus mustelus (Linnaeus, 1758), belonging to Chondrichthyes class and elasmobranch subclass (Figure 3-109), is considered to be particularly vulnerable to fishing activities and coastal environment degradation and consequently threatened. Mustelus mustelus is an extreme mobile species and can be found in all the Adriatic Sea. Preliminary data from “by catch project” on density (number of individuals per km^2), focused on northern Adriatic during the pe-

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[28] http://www.faoadriamed.org/html/country_p/CroCProfile.html, last access 18 June 2013

riod 2006-2010, show higher presence values in the areas located northern river Po mouth (Figure 3-110).

Figure 3-109 *Mustelus mustelus.*

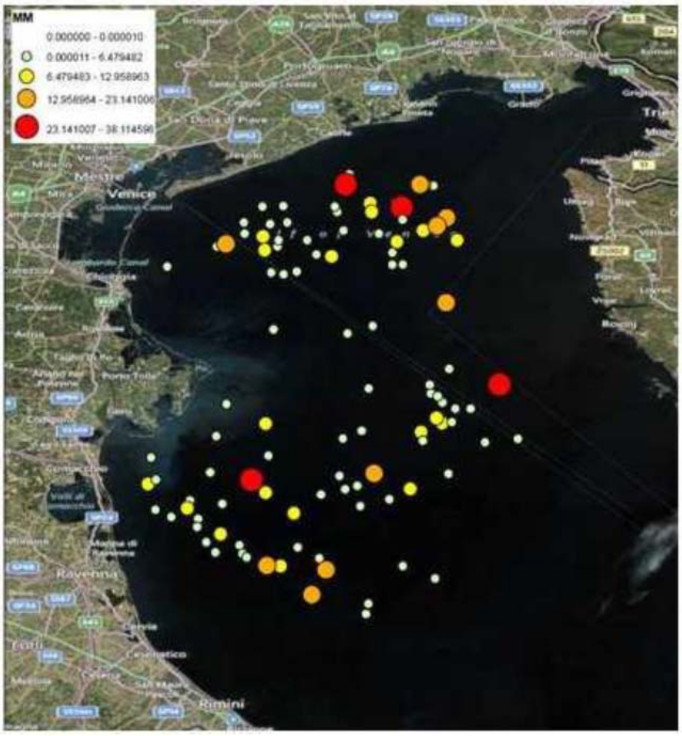

Figure 3-110 *Mustelus mustelus* population density in north Adriatic (Source: ISPRA, 2012).

The distribution in the whole Adriatic is instead summarized in Figure 3-111, confirming high occurrence probabilities in the north Adriatic, decreasing going towards south, with minimum values along central Croatian coasts. Species is still abundant but, due to significant temporal series lacking, it’s not possible to trace a trend.

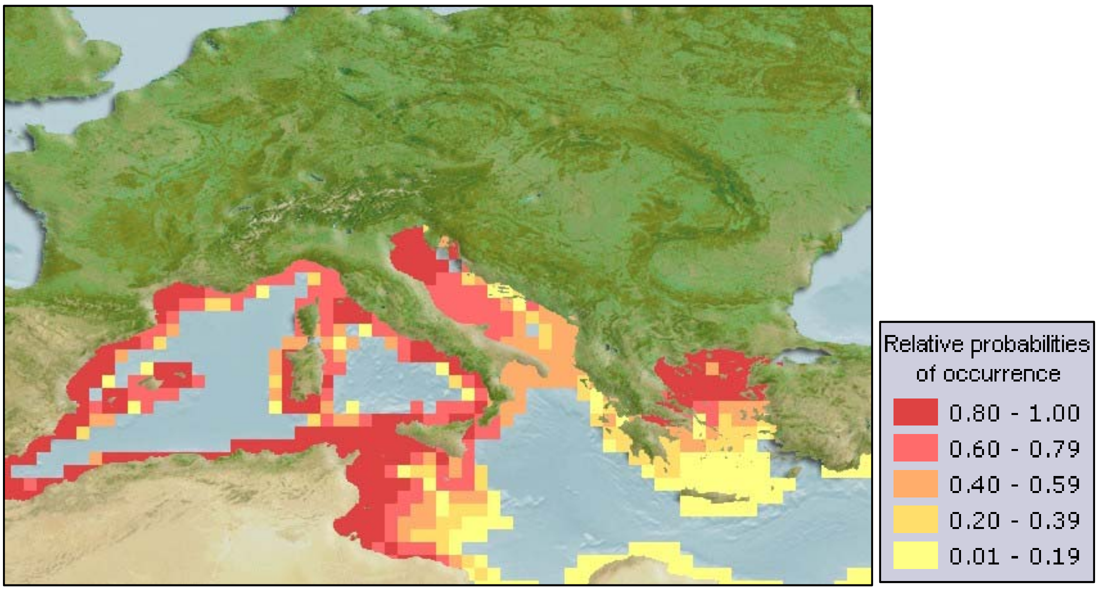

Figure 3-111 Distribution map for *Mustelus mustelus* (Source: www.aquamaps.org, version of August 2010, last access 26 November 2012).

Species: *Myliobatis Aquila*

Myliobatis Aquila (Linnaeus, 1758), also called common eagle ray, belonging to Chondrichthyes class and elasmobranch subclass (Figure 3-112), is characterized by a slow growth with long life (more than 60-70 years) and is considered to be particularly vulnerable to fishing activities realized with pelagic tools.

Myliobatis Aquila is an extreme mobile species and can be found in all the Adriatic Sea. Preliminary data from "by catch project" on density (number of individuals per km^2), for northern Adriatic during the period 2006-2010, show higher presence values in the areas located northern river Po mouth (Figure 3-113).

Figure 3-112 *Myliobatis Aquila.*

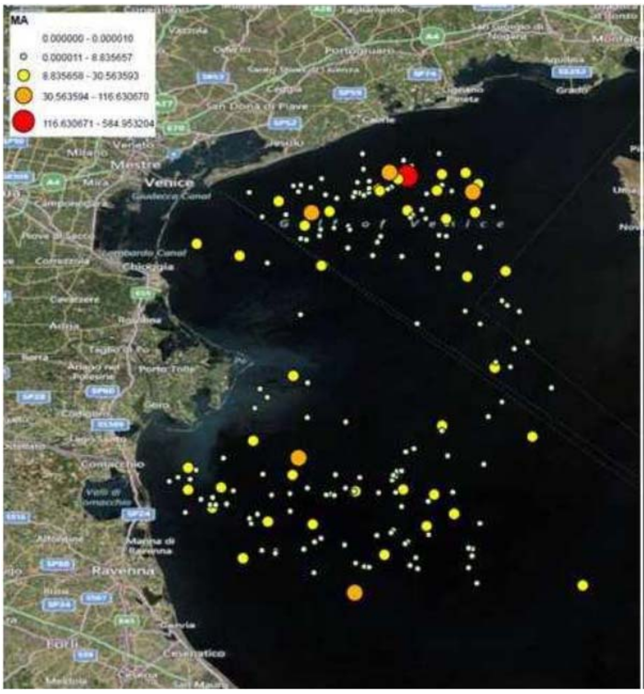

Figure 3-113 *Myliobatis Aquila* population density in north Adriatic (Source: ISPRA, 2012).

The distribution in the whole Adriatic is instead summarized in Figure 3-114; the species is abundant in the whole basin, particularly in the north and central part. Even if *Myliobatis Aquila* has not commercial value, the main pressure on the species derives from accidental catching, followed by coastal habitat loss, essential for reproduction and for nursery areas. Species is still abundant but, due to significant temporal series lacking, it's not possible to trace a trend.

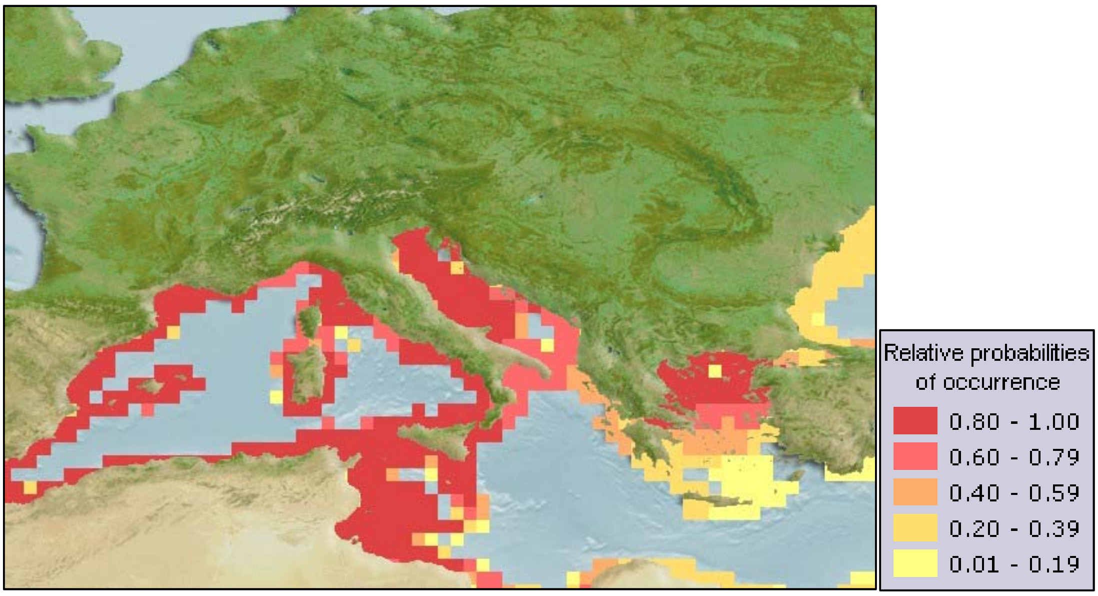

Figure 3-114 Distribution map for Myliobatis Aquila (Source: www.aquamaps.org, version of August 2010, last access 26 November 2012).

<u>Species: *Pteromylaeus bovinus*</u>

Pteromylaeus bovinus (Geoffroy St. Hilaire, 1817), also called bull ray, belonging to Chondrichthyes class and elasmobranch subclass, has been found in the whole Adriatic and is considered to be particularly vulnerable to coastal environment degradation (Figure 3-115).

It is an extreme mobile species and can be found in all the Adriatic Sea. Preliminary data from "by catch project" on density (number of individuals per km^2), for northern Adriatic during the period 2006-2010, show higher presence values in the areas located northern river Po mouth (Figure 3-116) and in the marine area in front of Ravenna and Comacchio.

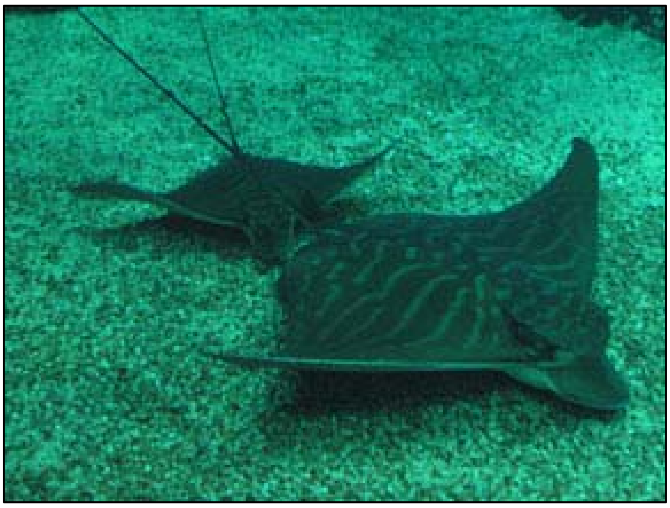

Figure 3-115 *Pteromylaeus bovinus.*

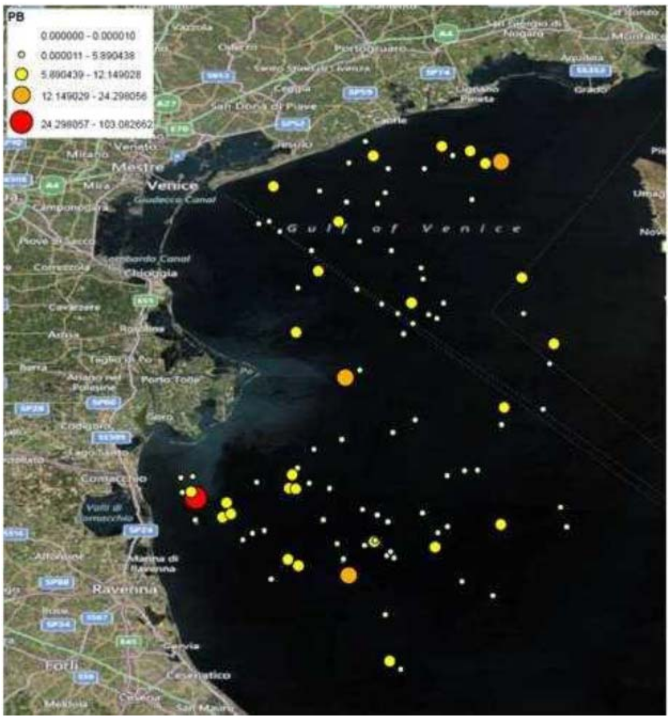

Figure 3-116 *Pteromylaeus bovinus* population density in north Adriatic (Source: ISPRA, 2012).

The distribution in the whole Adriatic is instead summarized in Figure 3-117; in the central Adriatic medium-high occurrence probabilities are registered, while in the south the species is still common but with lower densities values. Even if *Pteromylaeus bovinus* has not commercial value, the main pressure on the species derives from accidental catching, followed by coastal habitat loss, essential for reproduction and for nursery areas. The species is still quite abundant but, due to significant temporal series lacking, it's not possible to trace a trend.

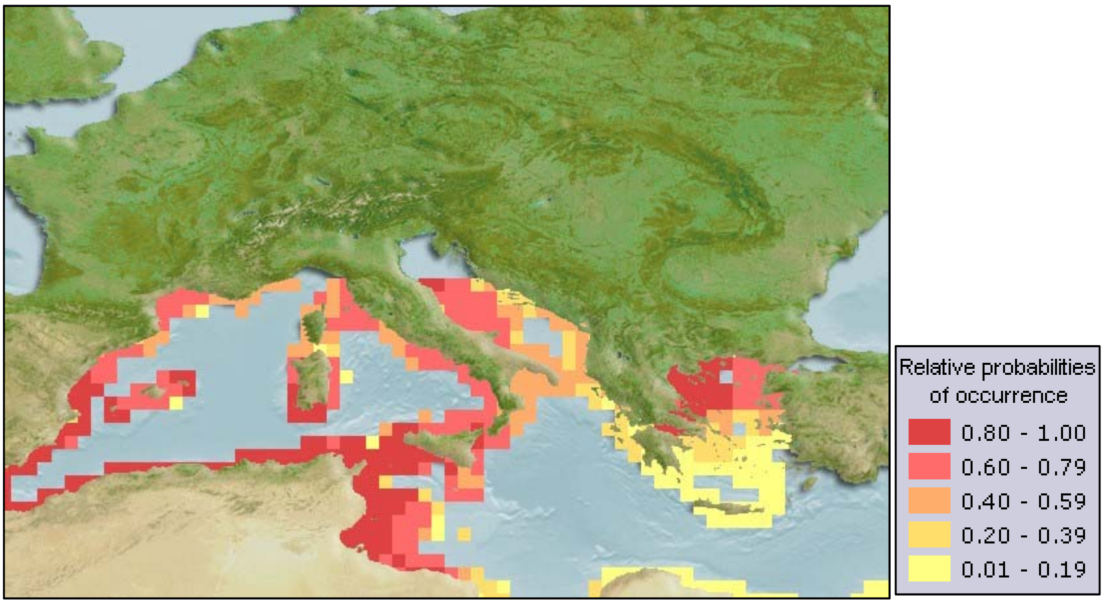

Figure 3-117 Distribution map for *Pteromylaeus bovinus* (Source: www.aquamaps.org, version of August 2010, last visit 26 November 2012).

Species: *Pteroplatytrygon violacea*

Pteroplatytrygon violacea (Bonaparte, 1832), belonging to Chondrichthyes class and elasmobranch subclass, is considered to be strictly affected by fishing activities with pelagic long lines (Figure 3-118). It is an extreme mobile species and can be found in all the Adriatic Sea (is included into the Convention on migratory species list). Preliminary data from "by catch project" on density (number of individuals per km^2), for northern Adriatic during the period 2006-2010, show higher presence values in the areas located northern river Po mouth and in the marine area in front of Ravenna and Comacchio (Figure 3-119).

Figure 3-118 *Pteroplatytrygon violacea.*

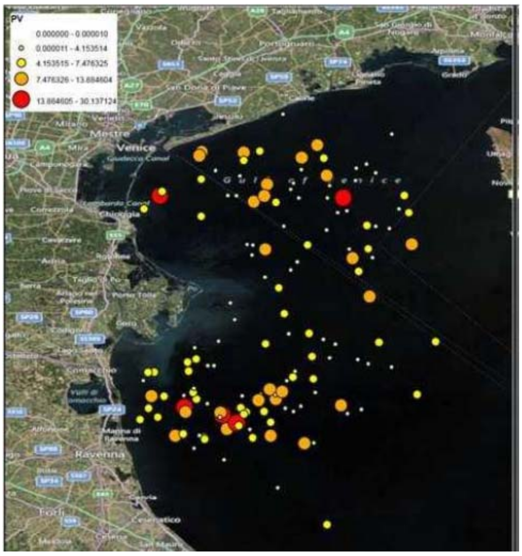

Figure 3-119 *Pteroplatytrygon violacea* population density in north Adriatic (Source: ISPRA, 2012).

The distribution in the whole Adriatic is instead summarized in Figure 3-120; decreasing occurrence probabilities are registered going from the north to the south Adriatic.

Even if *Pteroplatytrygon violacea* has not commercial value. The main pressure on the species derives from accidental catching, followed by coastal habitat loss, essential for reproduction and for nursery areas. Species is still quite abundant but, due to significant temporal series lacking, it's not possible to trace a trend. Moreover at the moment there aren't data on central and south Adriatic areas and consequently it's not possible to give an exhaustive distribution, dimension and condition evaluation of the species.

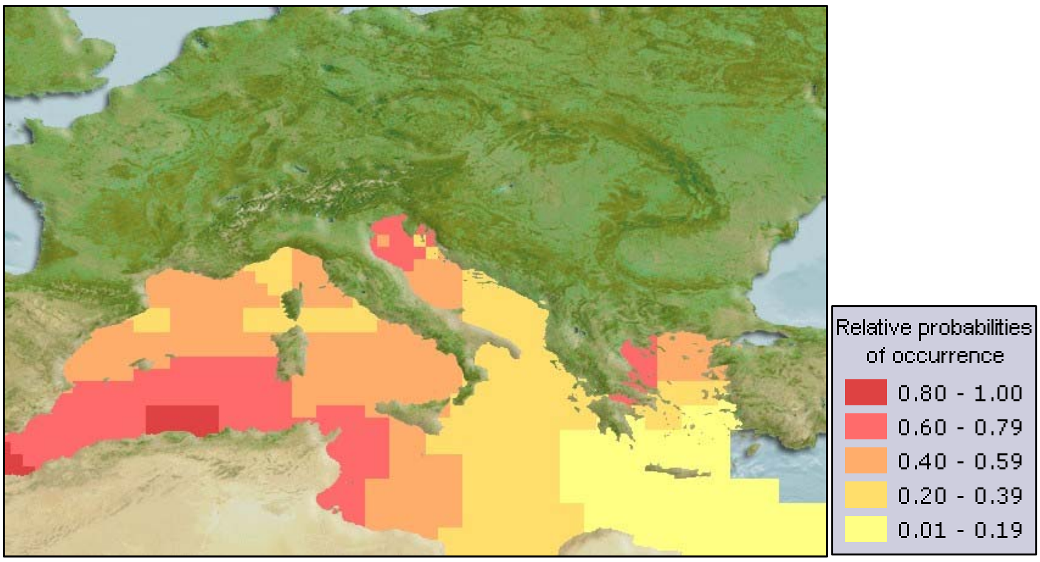

Figure 3-120 Distribution map for *Pteroplatytrygon violacea* (Source: www.aquamaps.org, version of August2010, last access 26 November 2012).

Species: *Squalus acanthias*

Squalus acanthias, Linnaeus, 1758, belonging to Chondrichthyes class is considered particularly vulnerable to fishing activities and coastal environment degradation (Figure 3-121).

Its stock is also declining in many areas of the world and the species is consequently endangered. It is an extreme mobile species and can be found in all the Adriatic Sea (is included into the Convention on migratory species list). Preliminary data from by catch project on density (number of individuals per km^2), for northern Adriatic during the period 2006-2010, show higher presence values in the areas located northern river Po mouth and in the open marine area offshore Ravenna and Comacchio (Figure 3-122).

Figure 3-121 *Squalus acanthias.*

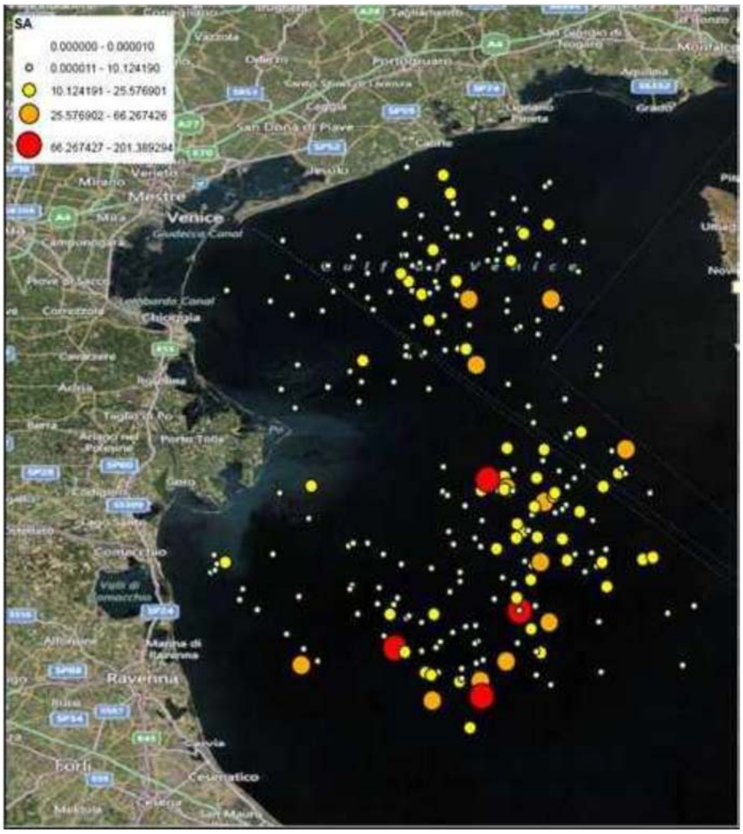

Figure 3-122 *Squalus acanthias* population density in north Adriatic (Source: ISPRA, 2012).

The native distribution in the whole Adriatic is instead summarized in Figure 3-123; low occurrence probabilities are registered in the middle Adriatic, while in the south no information is available. The species has a commercial value; consequently the main pressure derives from catching, realized mainly with pulling fishing nets and drift nets. Another important pressure is coastal habitat loss, essential for reproduction and for nursery areas.

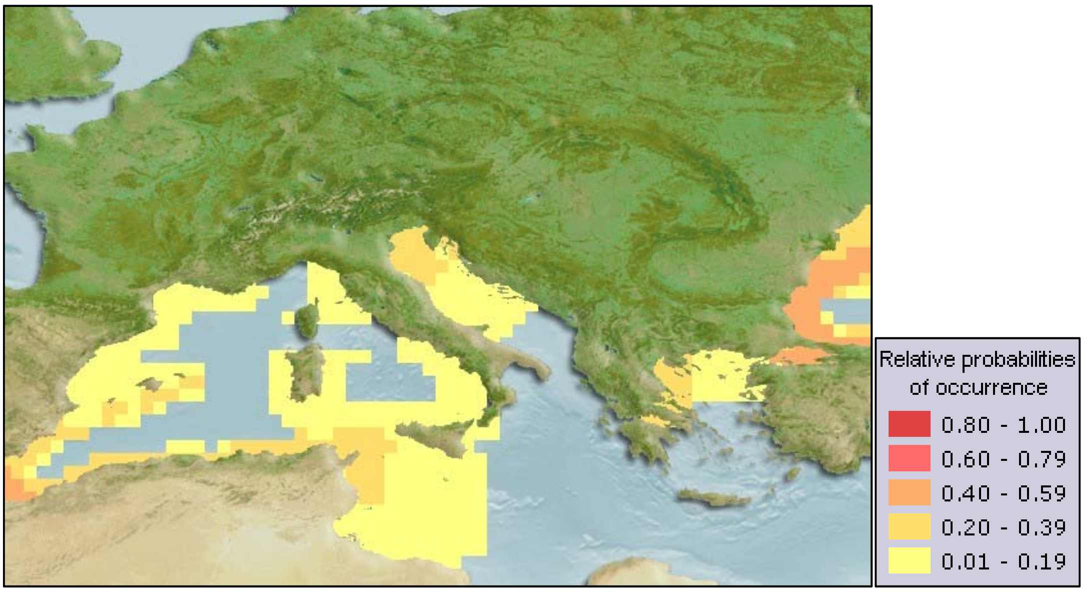

Figure 3-123 Reviewed native distribution map for *Squalus acanthias* (Source: www.aquamaps.org, version of August 2010, last access 26 November 2012).

<u>Species: *Carcharodon carcharias*</u>

Carcharodon carcharias (Linnaeus, 1758), also called great white shark, belonging to Elasmobranchii class and Lamnidae family (Figure 3-124), is considered endangered and is listed in Appendix 2 of Berne Convention, Appendix 2 of Barcelona Convention and CITES Appendix II. It's a predator collocated at the top of the food chain and is a mobile species that can be found in the Adriatic and in the whole Mediterranean Sea. The species is accidentally caught during sword fish and tuna fishing and trawling (ISPRA, 2012).

Figure 3-124 *Carcharodon carcharias.*

Regarding its native distribution, following figure shows that high occurrence probabilities can be found in the north Adriatic, while in the central basin it is quite rare; no data are available for the south Adriatic.

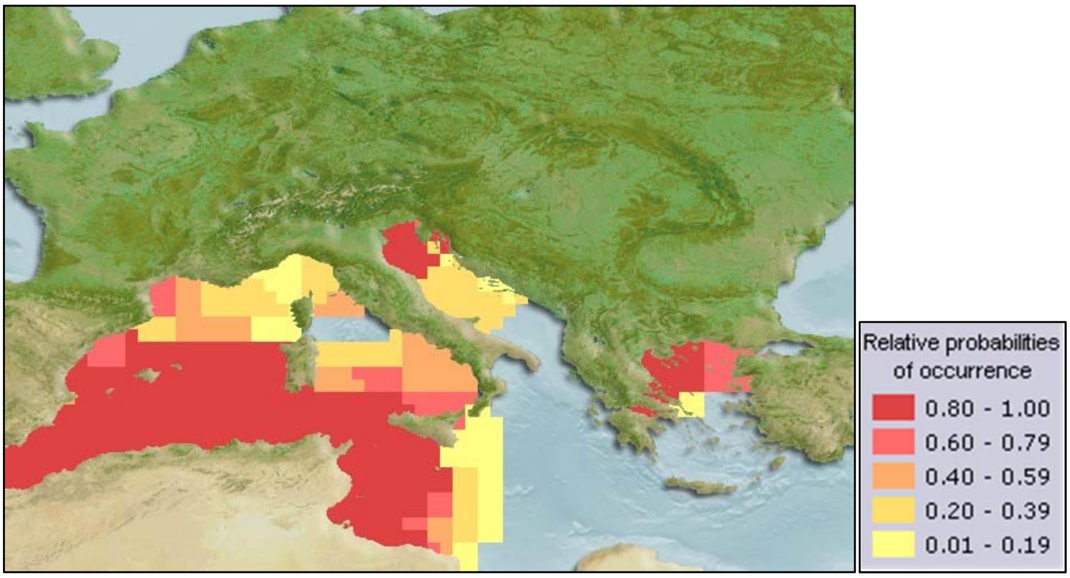

Figure 3-125 Reviewed native distribution map for *Carcharodon carcharias* (Source: www.aquamaps.org, version of August 2010, last access 26 November 2012).

<u>Species: *Lamna nasus*</u>

Lamna nasus (Bonnaterre, 1788), also called porbeagle, belonging to Elasmobranchii class and Lamnidae family (Figure 3-126), is listed in SPA/BD Protocol Appendix 3 of Barcelona Convention.

Figure 3-126 *Lamna nasus.*

It's an extremely mobile predator distributed in the whole Mediterranean and with high commercial value. Main pressure on the species derives from fishing and accidental catching during tuna and swordfish fishing activities. Regarding its native distribution, following figure shows that it is common in the middle Adriatic, while is quite rare along north-central western coasts of Italy.

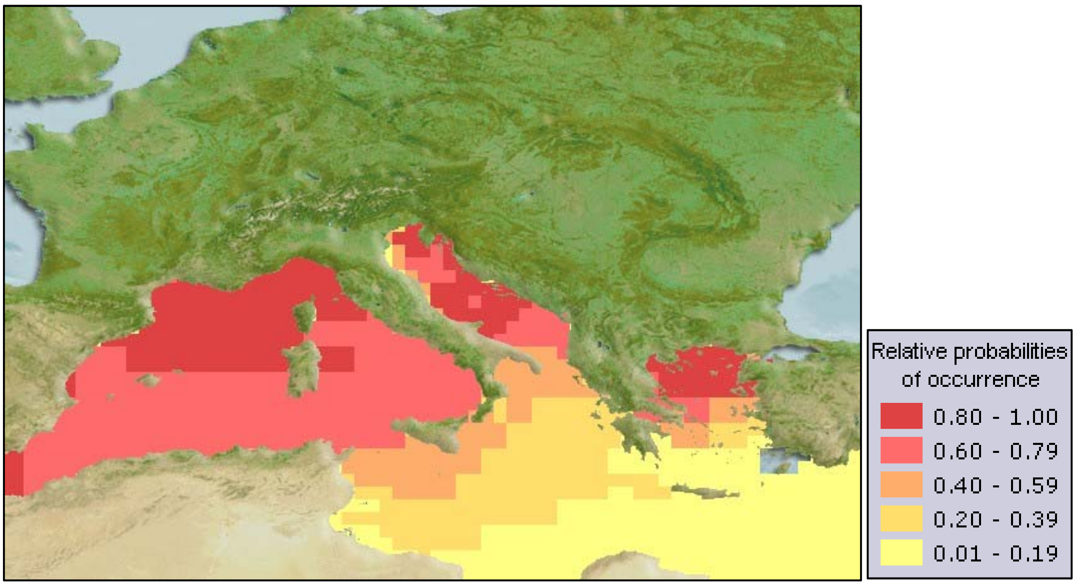

Figure 3-127 Reviewed native distribution map for *Lamna nasus* (Source: www.aquamaps.org, version of August 2010, last access 26 November 2012).

Species: *Prionace glauca*

Prionace glauca (Linnaeus, 1758), called also blue shark, belonging to Elasmobranchii class and Carcharhinidae family (Figure 3-128) is listed in SPA/BD Protocol Appendix 3 of Barcelona Convention.

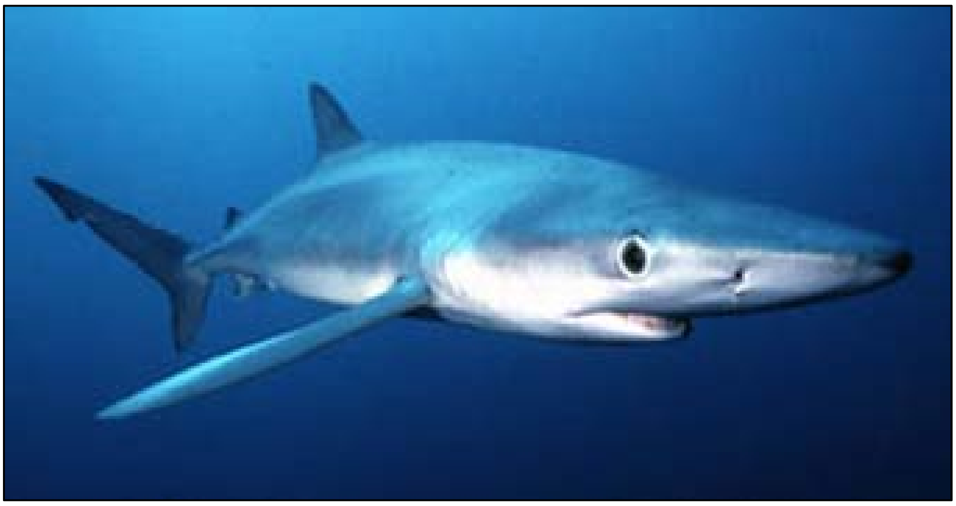

Figure 3-128 *Prionace glauca.*

It is an extremely mobile predator distributed in the whole Mediterranean; main pressure on the species derives from accidental catching during tuna and swordfish fishing activities. Regarding its native distribution, in the Adriatic is not common with the exception of the areas offshore Istria peninsula, where occurrence probabilities are higher.

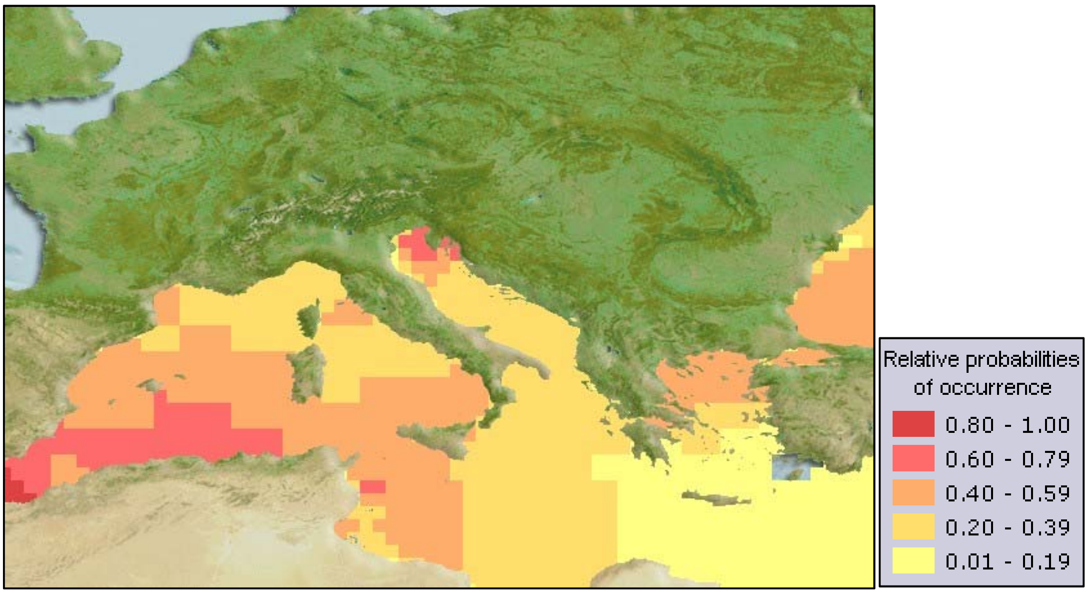

Figure 3-129 Reviewed native distribution map for *Prionace glauca* (Source: www.aquamaps.org, version of August 2010, last access 26 November 2012).

Species: *Cetorhinus maximus*

Cetorhinus maximus (Gunnerus, 1765), also called elephant shark, belongs to Cetorhinidae family (Figure 3-130), is inserted in SPA/BD Protocol Appendix 2 of Barcelona Convention and is considered threatened. It's a big dimension mobile species which feeds of plankton and that can be found in the whole Mediterranean Sea.

Figure 3-130 *Cetorhinus maximus.*

The species is accidentally caught with coastal nets, which constitute the main pressure for the species. Regarding its native distribution, it is common in the whole Adriatic, and particularly in the north and central part of the basin (Figure 3-131).

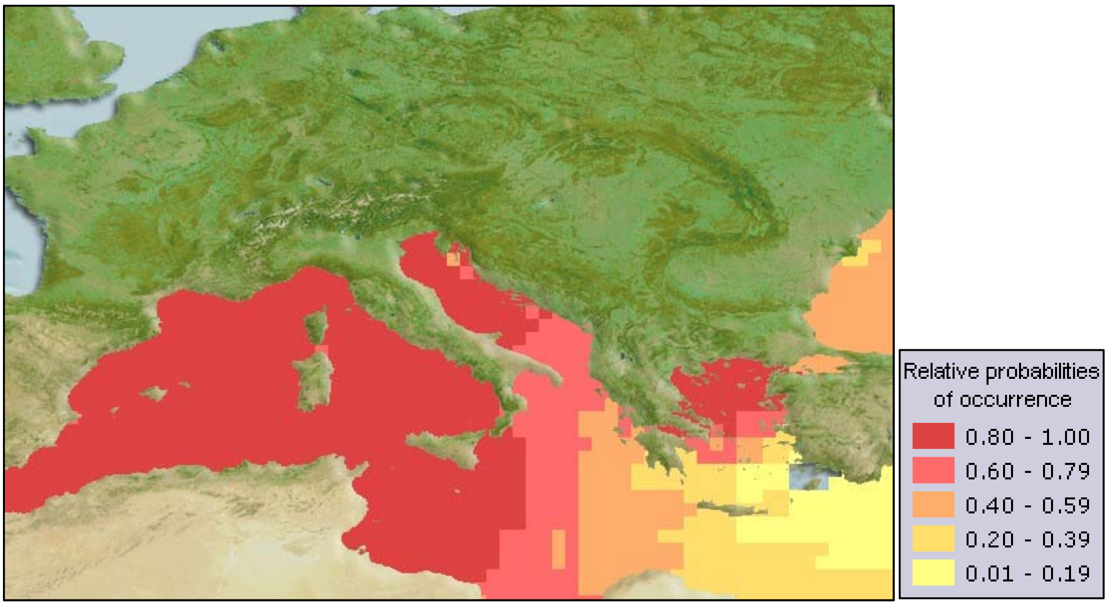

Figure 3-131 Reviewed native distribution map for *Cetorhinus maximus* (Source: www.aquamaps.org, version of August 2010, last access 26 November 2012).

<u>Species: *Mobula mobular*</u>

Mobula mobular (Bonnaterre, 1788), belonging to Chondrichthyes class and Mobulidae family (Figure 3-132), is considered endangered and is listed in Appendix 2 of Berna Convention and Appendix 2 of Barcelona Convention.

Figure 3-132 *Mobula mobular.*

At the moment it is not possible to give a complete description of species distribution, dimension and population condition. An analysis on data gathered during 2010 campaign can nevertheless give a preliminary distribution and summer abundance of the species in the Adriatic sea (ISPRA, 2012) (Figure 3-133). The species appears to be distributed mainly in the medium-south Adriatic in deep waters, even if in some cases it has been registered also in shallow waters near coastal areas. The main pressure derives from accidental catching with trawl nets during fishing activities.

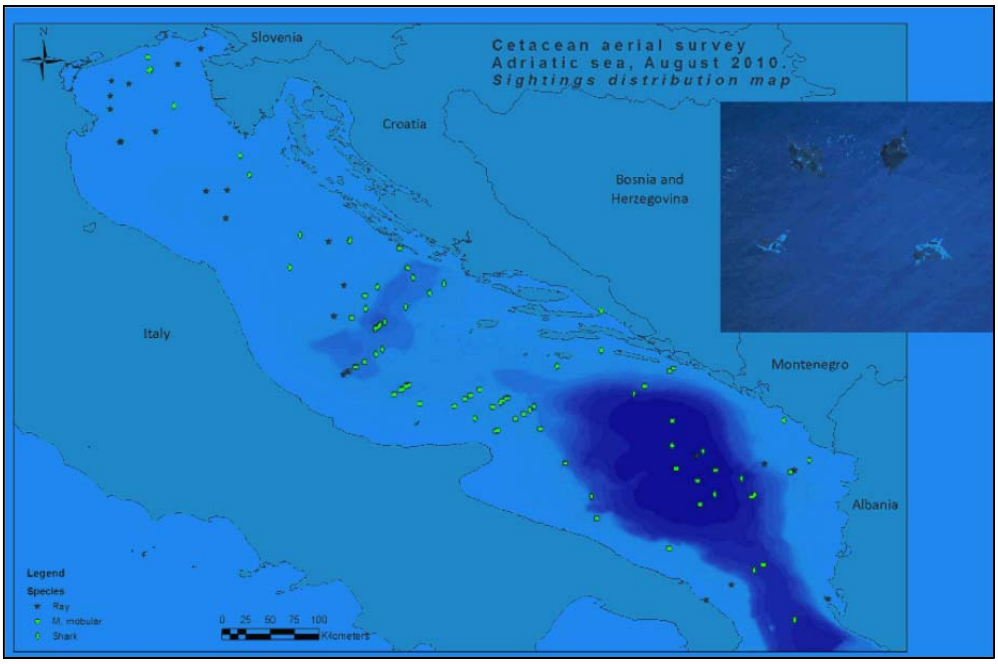

Figure 3-133 *Mobula mobular* distribution in the Adriatic Sea (Source: ISPRA, 2012).

<u>Species: *Merluccius merluccius*</u>

Merluccius merluccius (Linnaeus, 1758) whose common name is European hake belongs to Actinopterygii class (Figure 3-134) and gives a relevant contribute to economic fishing activities. It is mainly fished with bottom trawl nets, but long-lines and trammel-net are also used.

Figure 3-134 *Merluccius merluccius.*

It has a very long reproductive period with a peak during winter months, lives more than 20 years and can be found in the whole Adriatic with the exception of some areas northern Po mouth. Figure 3-135 summarizes the distribution registered during MEDITS campaign[29] realized in a period of three years.

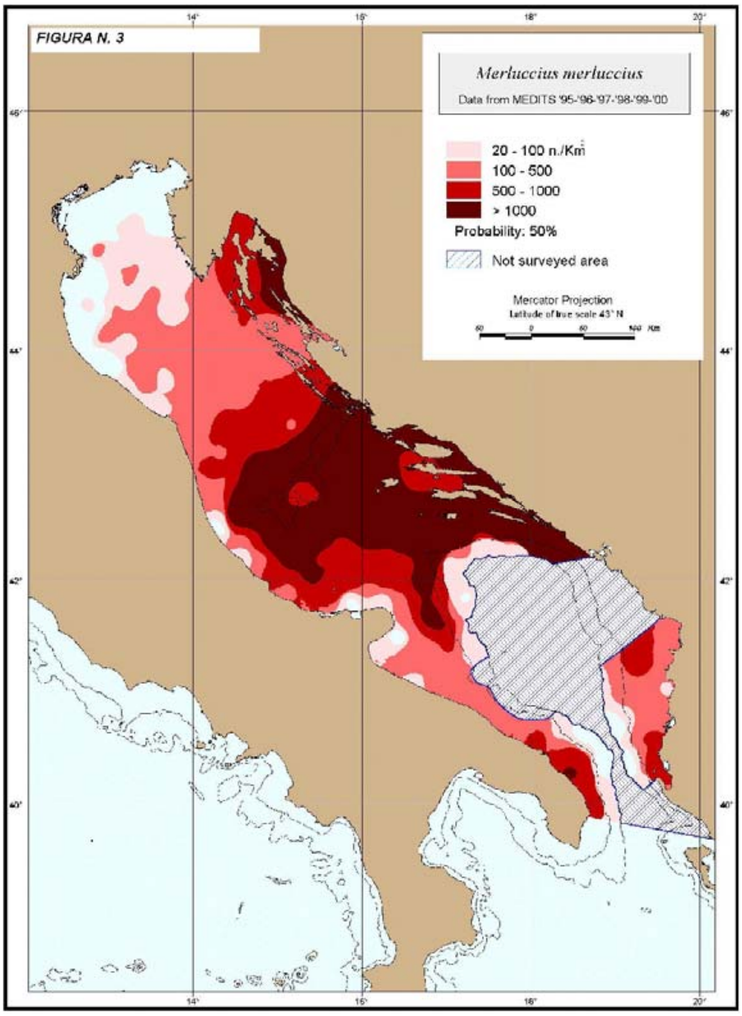

Figure 3-135 *Merluccius merluccius* distribution in the Adriatic Sea (Source: FAO ADRIAMED http://www.faoadriamed.org/Italy/html/Species/MerlucciusMerluccius.html, last access 18 June 2013).

In the northern Adriatic juvenile specimens concentrate in a specific area located along Croatian channels near Fiume, near mud seabed at more than 100 m depth where they can find small crustaceans. They stay in deep waters until a 12-15 cm is reached (approximately one year old); after they move towards shallower waters. In the areas located northern Po river they are almost absent. In the southern Adriatic instead the most relevant nursery areas are

29 http://www.faoadriamed.org/Italy/html/Species/MerlucciusMerluccius.html last visit 22/11/2012

located near the Gargano zone, Manfredonia gulf and near Egnatia canyon, in front of Monopoli coastline (Figure 3-136).

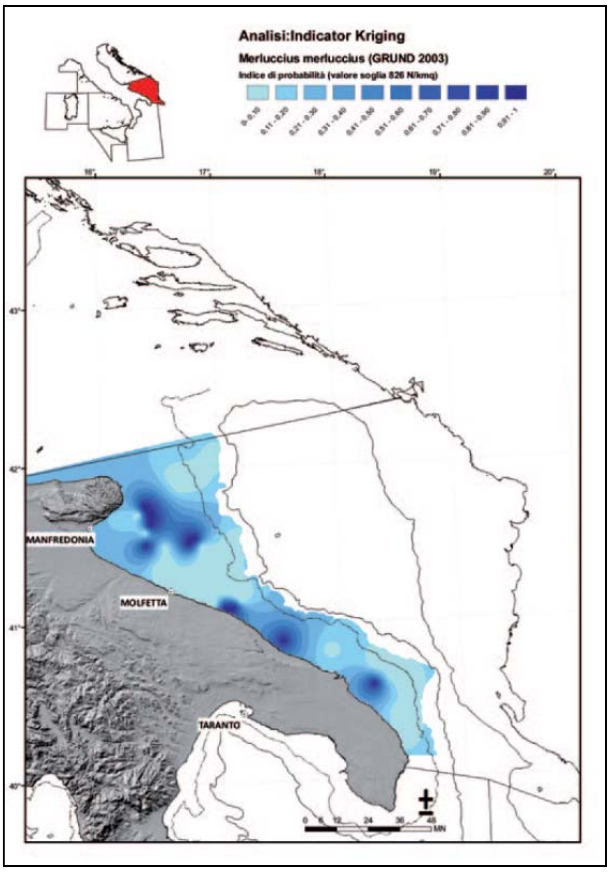

Figure 3-136 *Merluccius merluccius* nursery areas (Source: Cataudella and Spagnolo, 2011).

Regarding their abundance (number of individuals per km^2 and biomass per km^2) during the years 1994-2010 the situation. divided into north and south Adriatic. is summarized in the following figures.

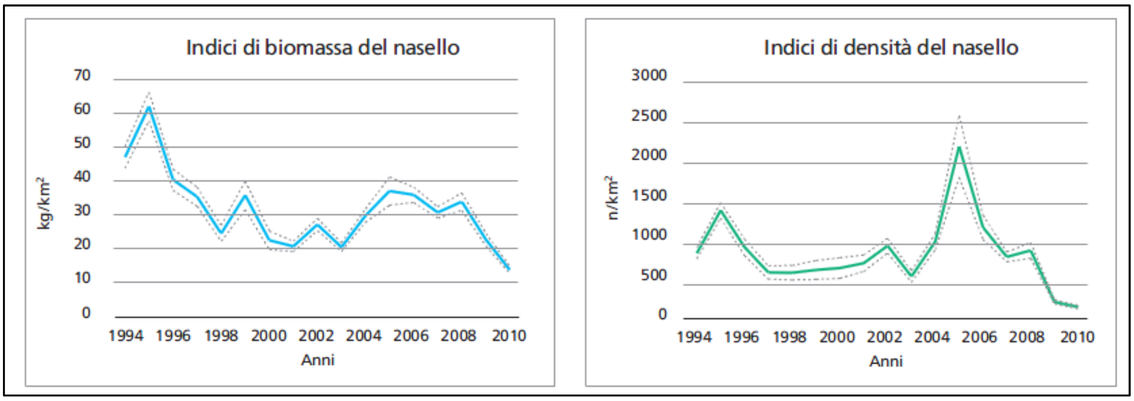

Figure 3-137 *Merluccius merluccius* biomass and density indexes trends in northern Adriatic (Source: Cataudella and Spagnolo, 2011).

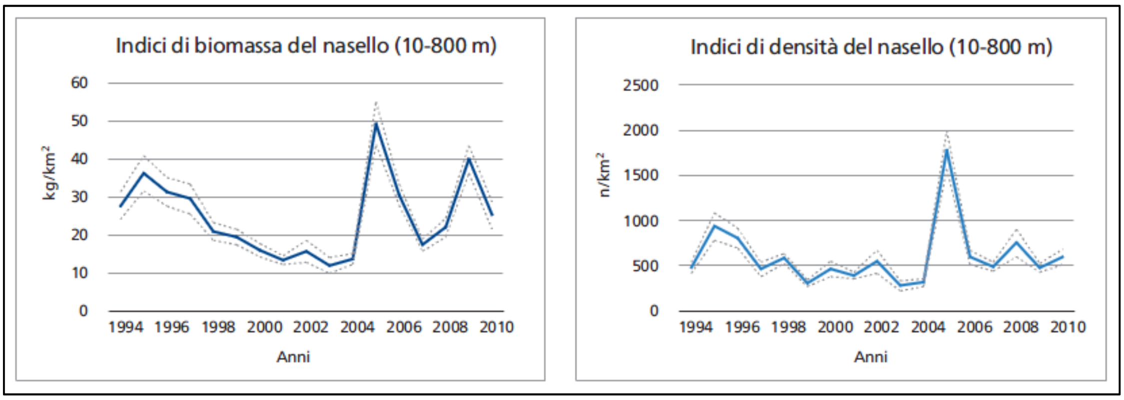

Figure 3-138 *Merluccius merluccius* biomass and density indexes trends in southern Adriatic (Source: Cataudella Spagnolo, 2011).

In the northern Adriatic a reduction of *Merluccius merluccius* biomass has been registered during years with a minimum in 2010; the decrease can be seen also looking at the density index, with the exception of year 2005. In southern Adriatic the situation is instead quite different: during the period considered in fact the two indexes, even if evidence important fluctuations (see for example year 2005), nevertheless don't show a specific tendency.

<u>Species: *Lophius budegassa*</u>

Lophius budegassa (Spinola, 1807), also known as black-bellied angler, belongs to Actinopterygii class (Figure 3-139). The species reproduces during late spring and early summer and is widely distributed in the whole central Adriatic and in the Croatian channels of the north Adriatic. Juveniles show a distribution similar to adults with higher densities registered in the central part of middle Adriatic. Figure 3-140 summarizes the distribution registered during MEDITS campaign.

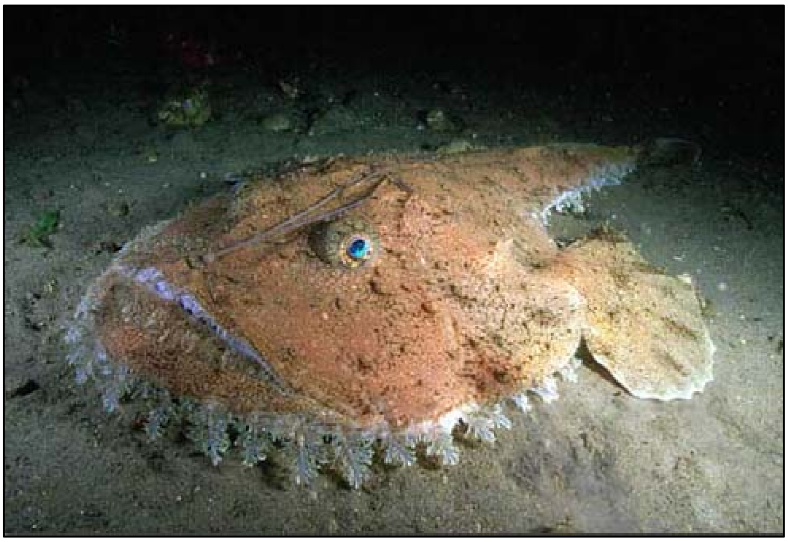

Figure 3-139 *Lophius budegassa*.

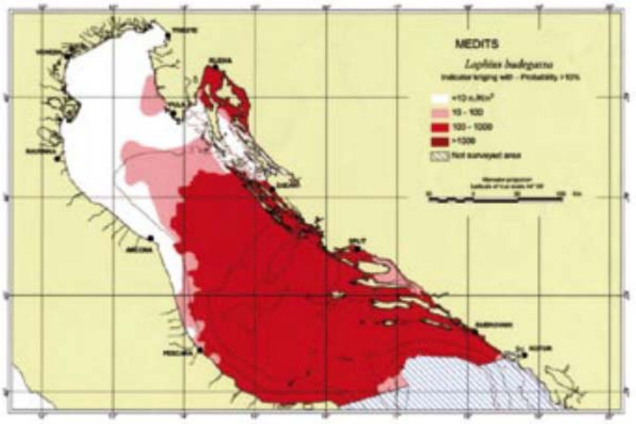

Figure 3-140 *Lophius budegassa* distribution in the north and central Adriatic Sea (Source: Regione Marche and Zara County, 2008).

Species: *Pagellus erythrinus*

Pagellus erythrinus (Linnaeus, 1758), called also pandora fish, belongs to Actinopterygii class (Figure 3-141). The species typically measures 10-30 cm, but it can reach as much as 50 cm in length. It is omnivorous, but mainly feeds on smaller fish and benthic invertebrates. Eggs are laid once a year during spring and summer. It is common in the north and central Adriatic until 100 m depth with higher abundances in Croatian channels with respect to open sea. Figure 3-142 summarizes the distribution registered during MEDITS campaign.

Figure 3-141 *Pagellus erythrinus.*

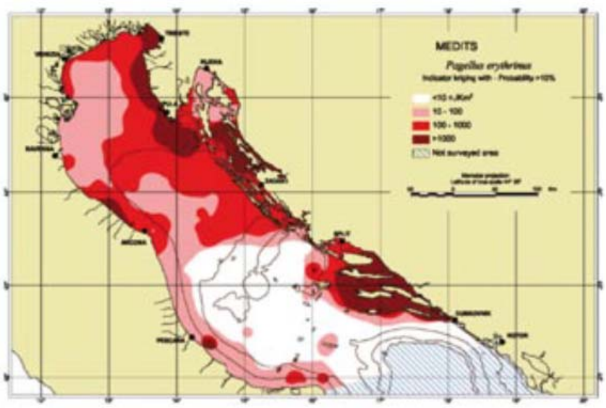

Figure 3-142 *Pagellus erythrinus* distribution in the north and central Adriatic Sea (Source: Regione Marche and Zara County, 2008).

A global view of the species distribution in the Adriatic is provided by Figure 3-143, evidencing that, even if caught for commercial purposes, it is nevertheless abundant in the whole basin, with the exception of deep depressions of south Adriatic.

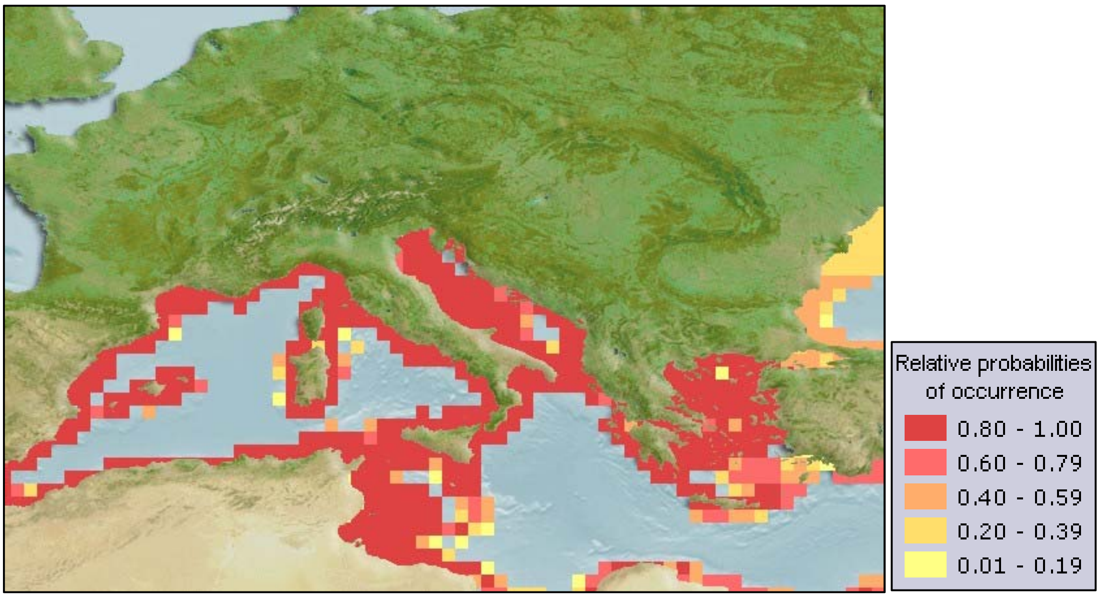

Figure 3-143 Distribution map for *Pagellus erythrinus* (Source: www.aquamaps.org, version of August 2010, last access 27 November 2012).

Species: *Mullus barbatus*

Mullus barbatus Linnaeus, 1758, whose common name is red mullet. belongs to Actinopterygii class (Figure 3-144) and gives a relevant contribute to economic fishing activities. It is almost exclusively fished with bottom trawl nets but smaller quantities are fished with trammel-nets as well.

Figure 3-144 *Mullus barbatus.*

The reproductive period depend on the fish size and varies from May-June for small-medium size to September-October for bigger ones. The species is distributed in the whole basin but is absent in deeper waters of middle Adriatic. In the northern and central Adriatic juvenile specimens concentrate along the coastline; young specimens grow in the warmer and more productive shallow waters and, after they have reached a size of approximately 12 cm (usually at the end of October when water temperature decreases), they leave coastal areas and move to deeper waters towards Croatia. The distribution in the north and central Adriatic, derived from MEDITS campaign, is shown in Figure 3-145. In southern Adriatic the species is abundant and nursery areas are mainly located in front of Garganos headland and along Molfetta coastline (Figure 3-146).

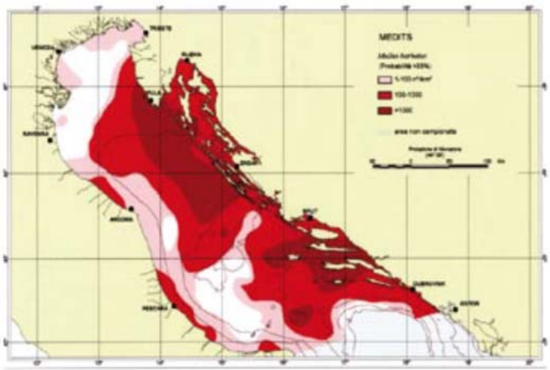

Figure 3-145 *Mullus barbatus* distribution in the north and central Adriatic Sea (Source: Regione Marche and Zara County, 2008).

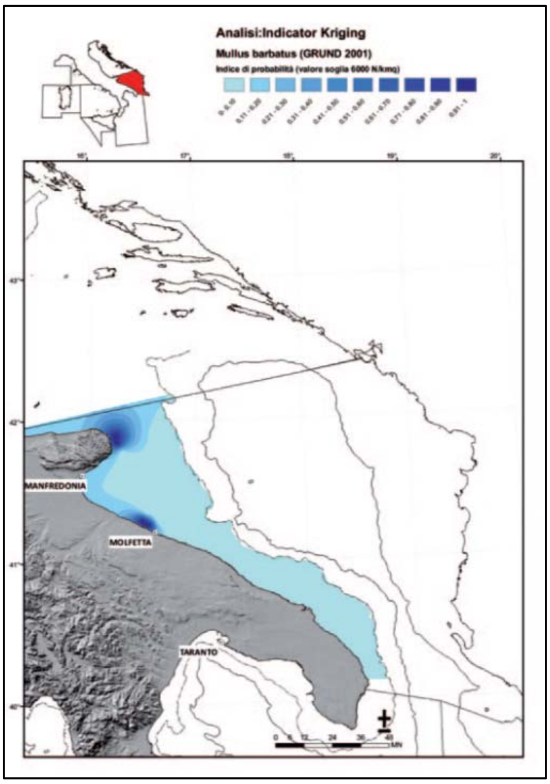

Figure 3-146 *Mullus barbatus* nursery areas in the south Adriatic (Source: Cataudella Spagnolo, 2011).

Regarding their abundance (number of individuals per km^2 and biomass per km^2) during the years 1994-2010 the situation, divided into northern and southern Adriatic, is summarized in the following figures.

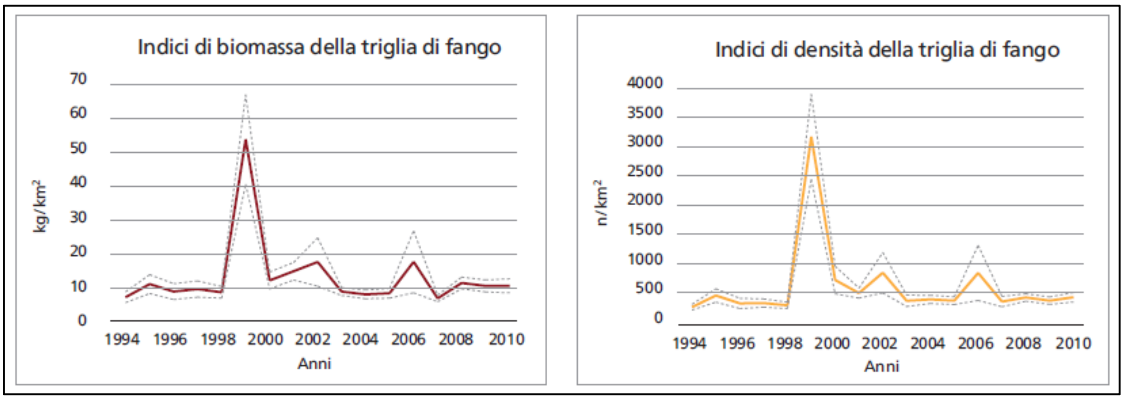

Figure 3-147 *Mullus barbatus* biomass and density indexes trends in the north Adriatic (Source: Cataudella Spagnolo, 2011).

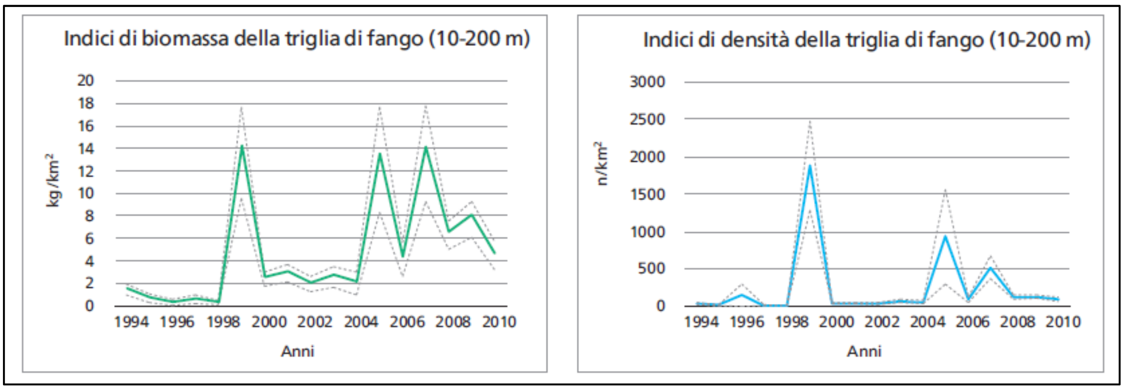

Figure 3-148 *Mullus barbatus* biomass and density indexes trends in south Adriatic (Source: Cataudella Spagnolo, 2011).

For northern Adriatic the biomass and density indexes trend during the period considered is quite constant, with the exception of year 1999 which shows a peak due to a late sampling realized at the end of the summer. In the southern Adriatic instead relevant positive variations during years have been registered. Causes of these fluctuations are still not well known but it seems reliable that main causes derive from ecological factors and pressures rather than fishing activities.

Species: *Thunnus thynnus*

Thunnus thynnus (Linnaeus, 1758), whose common name is red tuna, belongs to Scombridae family (Figure 3-149) and is inserted in SPA/BD Protocol Appendix 3 of Barcelona Convention. It's a mobile predator that can be found in the Adriatic and in the whole Mediterranean sea.

Figure 3-149 *Thunnus thynnus.*

The most relevant pressure is surely caused by fishing activities, made with long lines and specific nets, being tuna one of the most important commercial species. Also environmental pollution can be an important pressure for the species. Regarding its native distribution, following figure shows that the species is present in all the Adriatic, with higher densities in the north and central part of the basin.

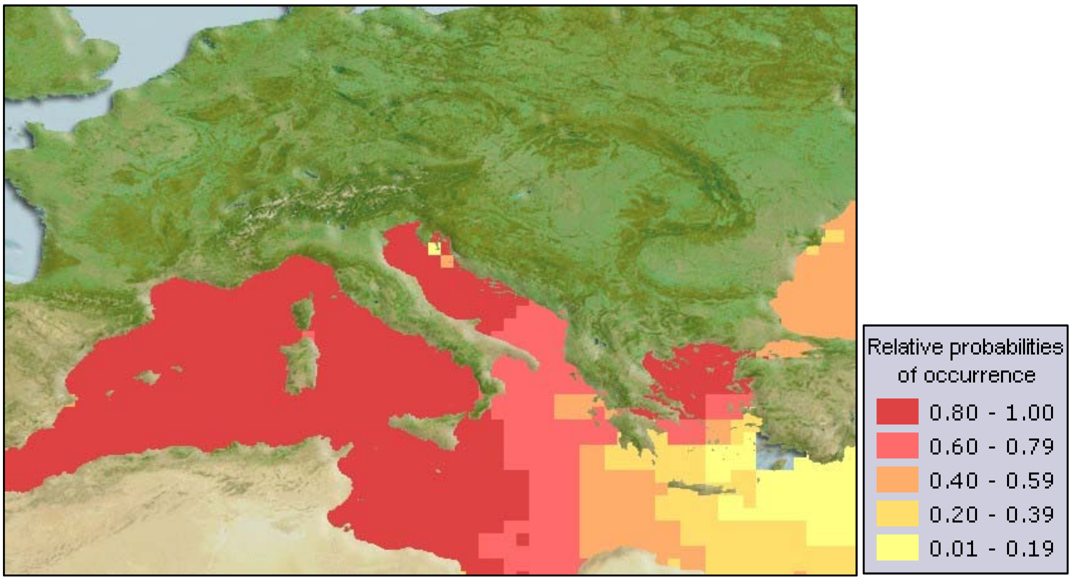

Figure 3-150 Reviewed native distribution map for *Thunnus thynnus* (Northern bluefin tuna) (Source: www.aquamaps.org, version of August 2010, last access 27 November 2012).

Species: *Xiphias gladius*

Xiphias gladius (Linnaeus, 1758), also called swordfish, belongs to Xiphiidae family (Figure 3-151) and is inserted in SPA/BD Protocol Appendix 3 of Barcelona Convention. It's a mobile pelagic predator and migrant that can be found in the Adriatic and in the whole Mediterranean sea.

Figure 3-151 *Xiphias gladius.*

The most relevant pressure is surely caused by fishing activities, made with long lines and seine nets, being swordfish one of the most important commercial species. Also environmental pollution can be an important pressure for the species. Regarding its native distribution, following figure shows medium densities in the north Adriatic, with higher values offshore Croatian coasts and lower densities in the rest of the basin.

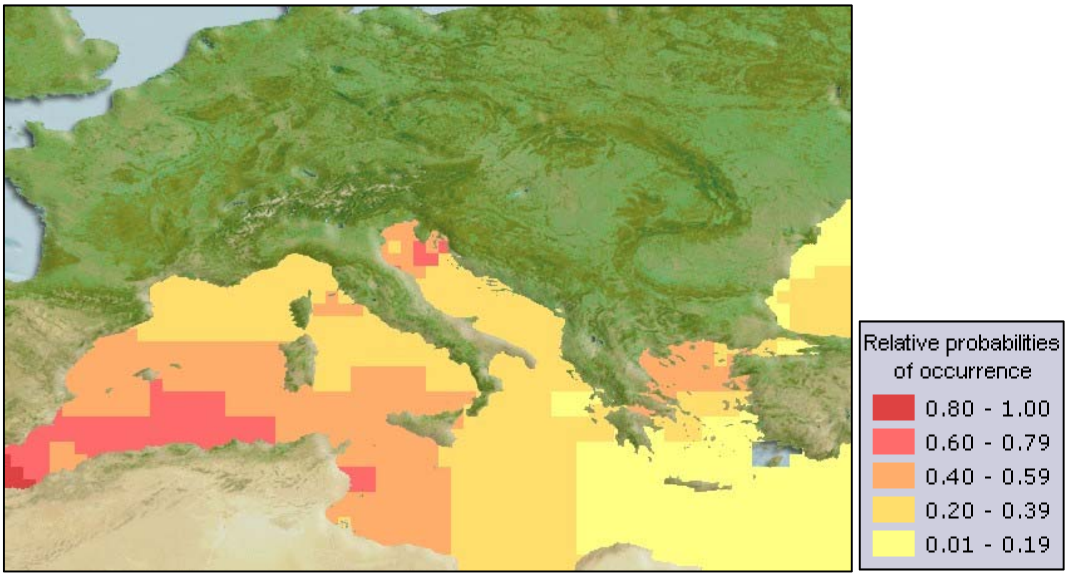

Figure 3-152 Reviewed native distribution map for *Xiphias gladius* (Source: www.aquamaps.org, version of August 2010, last access 27 November 2012).

3.4.3 Population dynamics, natural and actual range and status of species of marine mammals and reptiles

The Adriatic sea is considered an important feeding and nursery area for many marine mammals and sea turtles. The following paragraphs, divided per single species, illustrate the status of some relevant marine mammals and reptiles in the area, giving a framework of density population, species distribution and population condition, considering also external pressures.

For marine mammals. where information is available, the following indicators have been developed:

- Distribution set (number of individual sighting per kilometre using cells of 100 km^2 and stranding observations);
- Population abundance (using plane surveys with the sapling method);
- Population genetic structure considering the relation between population dimension and genetic variability.

Results are derived from specific studies developed by ISPRA (2012), within the process of MSFD implementation in Italy. In some cases data gathering is nevertheless actually insufficient for giving a complete spatial and temporal distribution framework. The complete list of species is reported in the following table.

Table 3-23 List of marine reptiles and mammals found in the Adriatic (Source: Società Italiana di Biologia Marina SIBM[30]).

Order	Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Reptile	*Caretta caretta*	(Linnaeus, 1758)	X	X	X	Threatened
Reptile	*Chelonia mydas*	(Linnaeus, 1758)	X	X	X	Threatened, not frequent
Reptile	*Dermochelys coriacea*	(Vandelli, 1761)	X	X	X	Threatened, not frequent
Mammalia	*Eubalaena glacialis*	(Müller, 1776)			X	Threatened, accidental
Mammalia	*Balaenoptera acutorostrata*	Lacépède, 1804			X	Threatened, occasional
Mammalia	*Balaenoptera physalus*	Lacépède, 1804	X	X	X	Threatened
Mammalia	*Megaptera novaeangliae*	(Borowski, 1781)		X		Threatened, accidental
Mammalia	*Physeter macrocephalus*	Linnaeus, 1758	X	X	X	Threatened
Mammalia	*Ziphius cavirostris*	Cuvier 1823		X	X	Threatened

30 http://www.sibm.it/CHECKLIST/menu%20checklist%20II.htm , last access 18 June 2013.

Order	Species	Author	North Adriatic	Central Adriatic	South Adriatic	Notes
Mammalia	*Delphinus delphis*	Linnaeus, 1758	X	X	X	Threatened, less regular than in the past
Mammalia	*Globicephala melas*	(Traill, 1809)			X	Threatened, not frequent
Mammalia	*Grampus griseus*	(Cuvier,1812)	X	X	X	Threatened
Mammalia	*Pseudorca crassidens*	(Owen, 1846)	X			Threatened, occasional
Mammalia	*Stenella coeruleoalba*	(Meyen, 1833)		X	X	Threatened
Mammalia	*Tursiops truncatus*	(Montagu,1821)	X	X	X	Threatened
Mammalia	*Monachus monachus*	(Hermann, 1779)			X	Threatened, occasional

Species: *Caretta caretta*

Caretta caretta Linnaeus 1758 (Figure 3-153), which belongs to chelonidae family, is the most common sea turtle in the Mediterranean Sea.

Figure 3-153 *Caretta caretta.*

An adult can reach a dimension of 80-140 cm with a mass of 100-160 kg. It's a very mobile species which lives in the open sea and come to the seashore just for eggs lying. It can be found in the whole Adriatic Sea: south Adriatic is in particular considered a strategic area for juveniles' growth of the species while north Adriatic is an important zone for young during the neritic phase.

Data collection realized by ISPRA in summer 2010 with the "By catch" project (ISPRA, 2012), in collaboration with scientific institutions of Slovenia, Croatia, Montenegro and Albania, enabled the realization of the species census using linear path by plane (distance sampling technique). Results emerged confirms that the summer presence of the species is spread in all Adriatic; with a high density in the north for a total of 25,692 sightings.

Regarding genetic variability, data on nuclear DNA analysis confirms that most of the individuals derive from Greek and Cypriot reproductive areas (85%), while a small part from Turkish areas (3%) The sampling has been made during a specific period. Consequently it's not possible to give more details on seasonal and inter-annual distribution differences.

Caretta caretta is considered an endangered species, threatened mainly by trawling fishing and "volante" fishing. It has been estimated that in the north Adriatic with the first technique an average of 4,273 of turtles are yearly captured with a mortality of approximately 2,000 individuals per year; with the latter instead an average of 863 individuals are captured with 1% mortality rate. Other causes of death or injury are related to collisions with boats and ships.

In order to protect the species and save individuals injured, in Italy along the Adriatic coasts many rehabilitation centres have been created; most important ones are[31]:

- Marine Turtle Rescue Centre Policoro (Matera);
- WWF Oasis Policoro Herakleia (Matera);
- Fondazione Cetacea (Riccione);
- Ferrara ARCHE' (Ferrara);
- Riserva Naturale Marina di Miramare (Grignano);
- Centro di Primo Soccorso Tartarughe Marine (Lesina and Foggia);
- Centro Recupero Tartarughe Marine Museo di Calimera (Calimera);
- Centro Recupero Tartarughe Marine Manfredonia – Legambiente (Manfredonia);
- WWF centre Molfetta;
- Facoltà Medicina Veterinaria Università di Bari (Bari).

<u>Species: *Tursiops truncatus*</u>

Tursiops truncatus (Montagu, 1821), also called bottlenose dolphin, extends all around the world, lives in shoals, can reach a length of 2-4 meters with a weight of 150-650 kg (Figure 3-154) and is mainly distributed in continental platform waters. It's very adaptable and can be also found in deteriorated areas.

[31] http://www.tartaclubitalia.it/centri-recupero-marine, last access 17 June 2013

Figure 3-154 ***Tursiops truncatus.***

Its distribution in the Adriatic Sea is aligned with physical, geographical and climatic characteristics; data gathered estimate a population of minimum 5,772 individuals in the Adriatic Sea for year 2010. Moreover projection trends of the species based on demographic parameters registered in the Adriatic, confirm that the species should maintain a good conservation status (ISPRA, 2012). In the north Adriatic in particular it is the only cetacean species regularly reported in the area at the present time. This species survives at low population densities and in small groups, but faces challenges that range from prey depletion to contamination by xenobiotic pollutants (Bearzi et al., 2004).

Information on *Tursiops truncatus* distribution can be derived both from number of individuals detected and number of individuals stranded. The following figure shows the meeting rate per km per cell; for the Adriatic results of 2010 summer campaign evidence that sightings are mainly concentrated in the northern area. White cells indicate that no observations have been registered even if a positive research effort has been made.

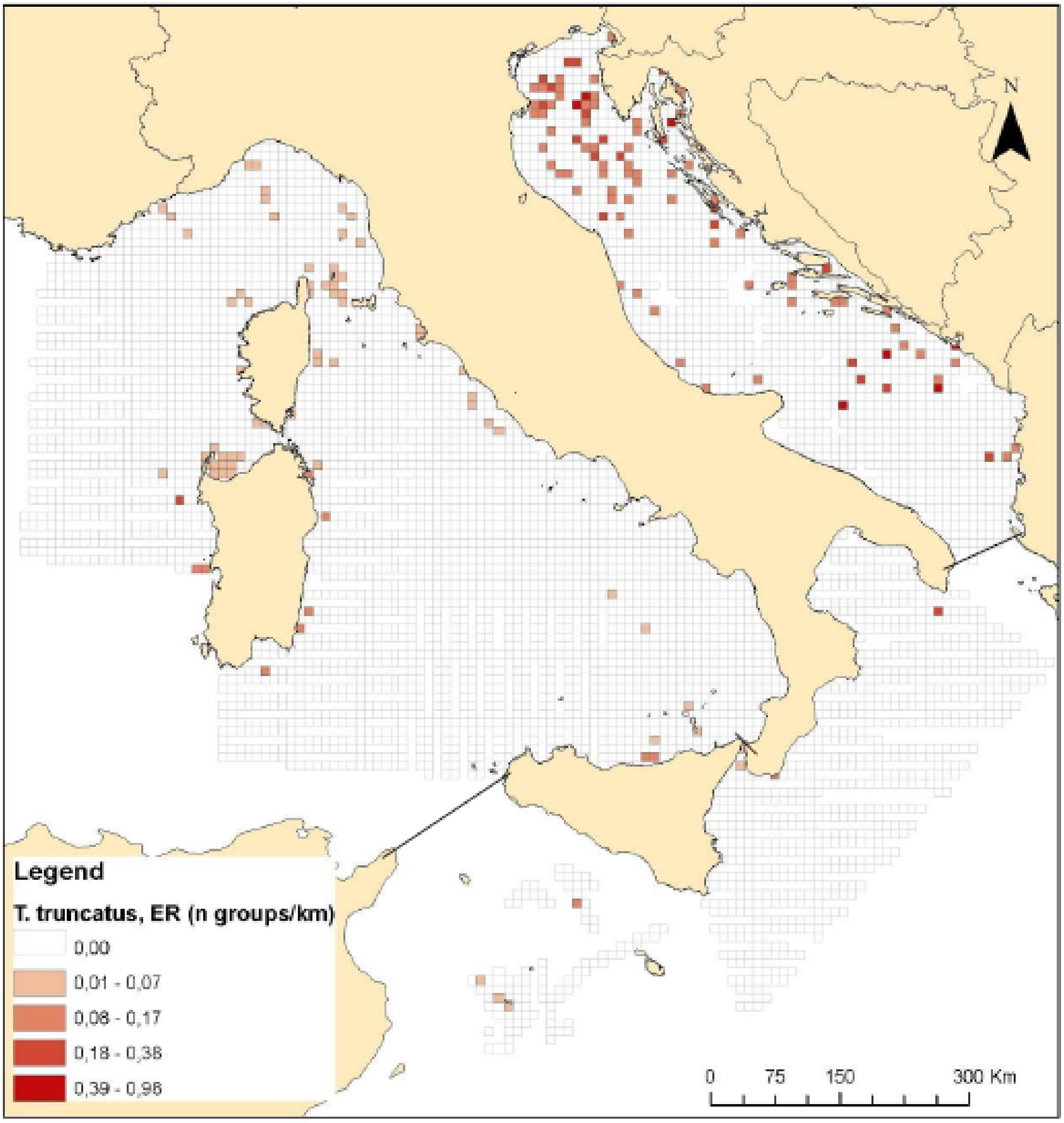

Figure 3-155 *Tursiops truncates* distribution (Source: ISPRA, 2012).

Figure 3-156 illustrates instead the number of individuals stranded during a period of 25 years. The left side of the figure refers to 1986-2000 period, with a total of 263 individuals stranded in the whole Adriatic, while the right side refers to 2001-2011 period with a total of 226 individuals stranded.

Observations on the north Adriatic area for 2006-2011 years confirm that the species doesn't show relevant seasonal variation with relative density indexes very similar each other during the whole year (Figure 3-157).

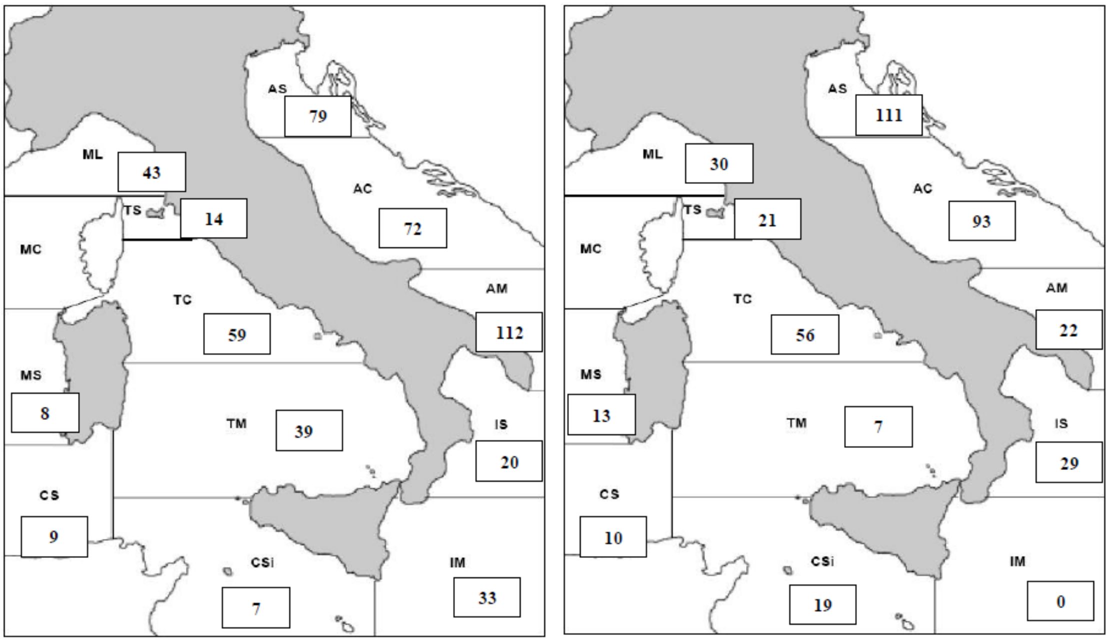

Figure 3-156 stranded *Tursiops truncatus* distribution during period 1986-2011 (Source: ISPRA, 2012).

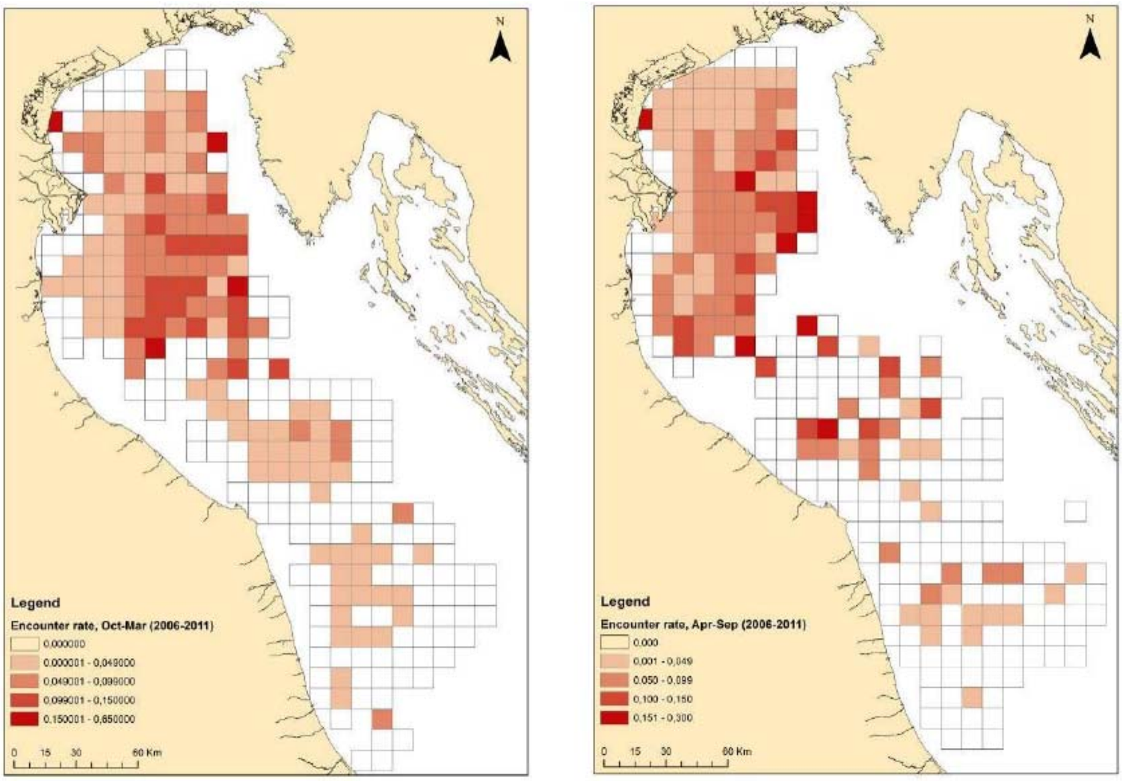

Figure 3-157 comparison between number of individuals observed per km during winter season (October-March. left side of the figure) and summer season (April-September right side of the figure) years 2006-2011 (Source: ISPRA, 2012).

Regarding the genetic aspects, recent studies found evidence that there are at least two distinct different populations with different genetic structure living in the Adriatic. The most relevant pressure on the species derives from:

- Fishing activities; due to data lacking on interaction between various fishing systems and *Tursiops truncates*, at the moment it's not possible to evaluate global effects deriving from accidental captures. The only information available regards pelagic trawling which, in north and central Adriatic, on average records 19 deaths per year;
- Chemicals pollution (impact unknown);
- Overexploitation of floor fish resources.

Species: *Delphinus delphis*

Delphinus delphis Linnaeus, 1758 lives in pelagic waters near scarps, feeds on squids and reaches on average 1.5-2.7 m length with 200 kg weight (Figure 3-158). *Delphinus delphis* has been included by IUCN in the so called "Red list" of the species endangered. In Adriatic the species is rare as testified by 2010 summer survey plane campaign that didn't register any sighting (Figure 3-159).

Some information on species distribution in the Adriatic can also derive from the number of individuals stranded in the past 25 years (Figure 3-160). The left side of the figure refers to 1986-2000 period, with 6 stranded in the whole Adriatic, while the right side refers to 2001-2011 period with no individuals stranded.

Figure 3-158 *Delphinus delphis.*

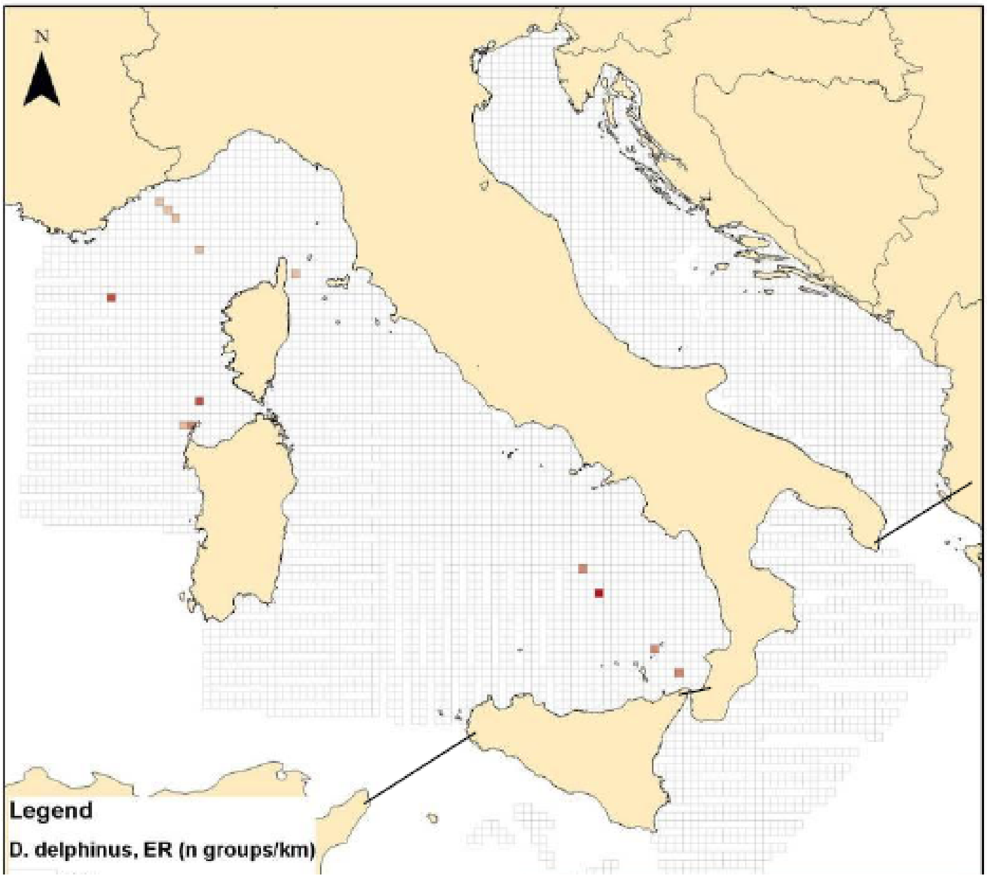

Figure 3-159 ***Delphinus delphis*** **distribution (Source: ISPRA, 2012).**

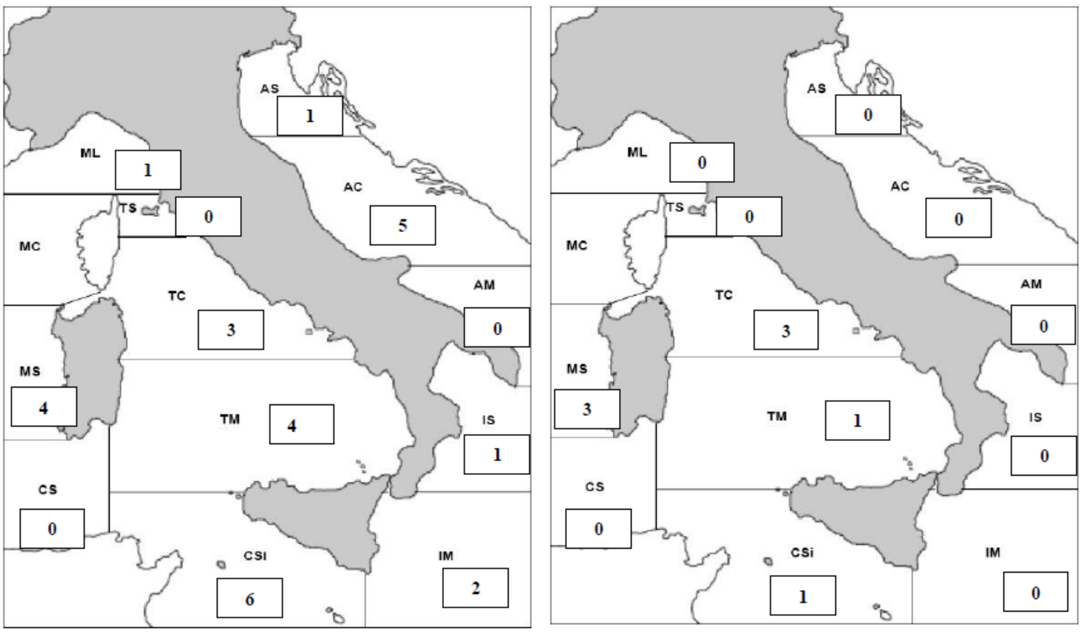

Figure 3-160 stranded ***Delphinus delphis*** **distribution during period 1986-2011 (Source: ISPRA, 2012).**

Pressures on the species are determined by:

- Accidental captures during fishing activities (high impact);
- Chemicals pollution (impact unknown).

Regarding northern Adriatic, as testified by Bearzi et al. 2004, the combination of habitat degradation (e.g. diminished carrying capacity due to overfishing, presence of noxious xenobiotics in the trophic web, etc.) and intensive culling, which may have been particularly penalizing for these populations, represent valid explanations for the species decline in the region.

<u>Species: *Stenella coeruleoalba*</u>

Stenella coeruleoalba (Meyen, 1833) is the most common cetacean in the Mediterranean basin, lives in pelagic waters with high productivity and can reach a length of 2.5 m with a weight of 160 kg (Figure 3-161).

In Adriatic the species is common (there are at least 15,343 individuals) especially in the southern pelagic part, as testified by 2010 summer campaign. Figure 3-162 shows the meeting rate per km per cell; white cells indicate that no observations have been registered even if a positive research effort has been made.

Information on species distribution in the Adriatic can also be derived from the number of individuals stranded in the past 25 years (Figure 3-163).The left side of the figure refers to 1986-2000 period, with a total of 135 individuals stranded in the whole Adriatic, while the right side refers to 2001-2011 period with 38 individuals stranded.

Figure 3-161 *Stenella coeruleoalba.*

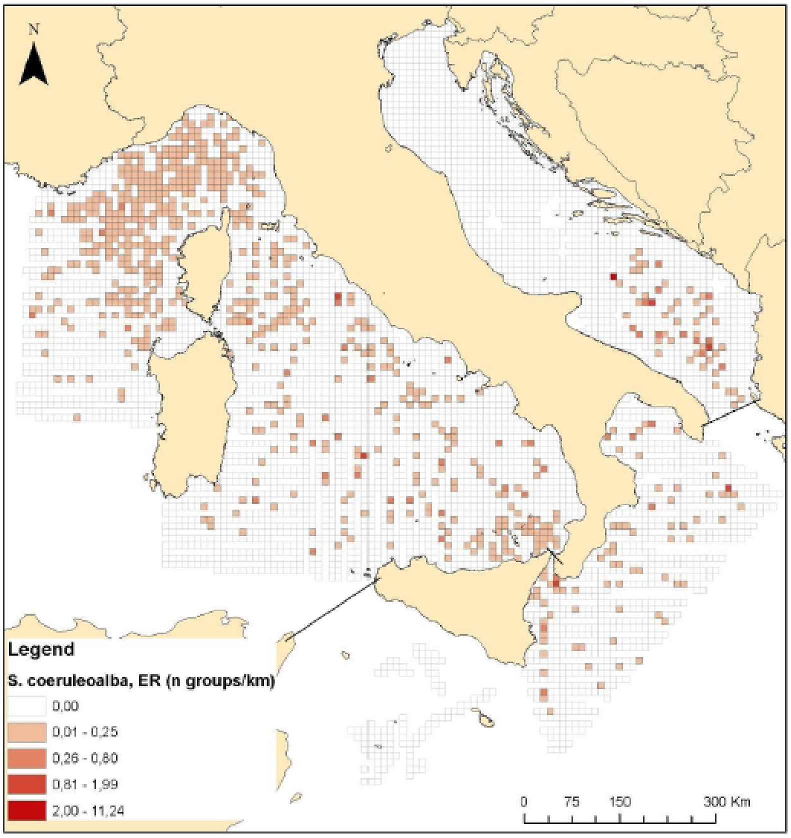

Figure 3-162 ***Stenella coeruleoalba*** **distribution (Source: ISPRA, 2012).**

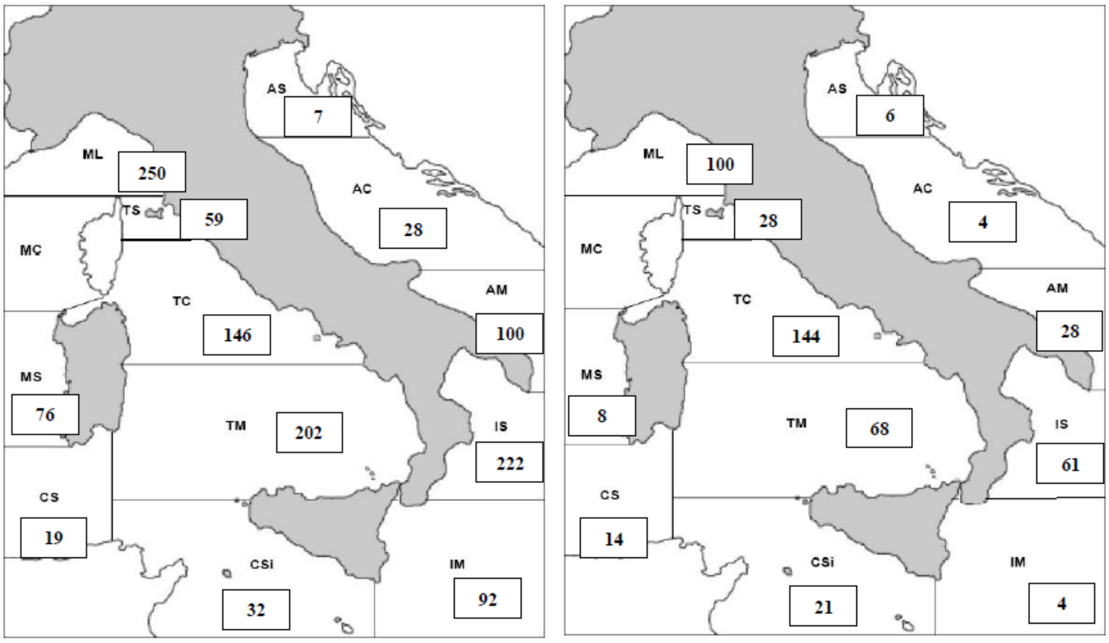

Figure 3-163 stranded ***Stenella coeruleoalba*** **distribution during period 1986-2011 (Source: ISPRA, 2012).**

Genetic studies confirm that a small difference between population living in Adriatic and Mediterranean exists. Regarding pressures affecting the population the main causes are:

- Accidental captures during fishing activities, in particular with pelagic nets for swordfish (impact unknown);
- Chemicals pollution; in particular analysis confirm high levels of DDT and PCB in the tissues exceeding threshold are associated to harmful effects onset.

Experts from IUCN/ACCOBAMS estimate that the combined interaction of impacts on the species could have caused a 30% population reduction in a period of 60 years (ISPRA, 2012).

Species: *Ziphius cavirostris*

Ziphius cavirostris Cuvier 1823, also called Cuvier's beaked whale, lives in deep waters (more than 600 m) near canyons and scarps, is cryptic, feeds on squids and can reach 7 m length with 2-3 weight tons (Figure 3-164).

It is the known to regularly occur throughout the entire Mediterranean Sea (Holcer et al. 2007). In Adriatic the species can be found in the southern pelagic part, as testified by 2010 summer campaign. Figure 3-165 shows the meeting rate per km per cell with a hot spot in the south Adriatic; white cells indicate that no observations have been registered even if a positive research effort has been made. Nevertheless observation with plane surveys is not the best way to evaluate distribution and abundance because *Ziphius cavirostris* mainly lives in deep waters.

Information on species distribution in the Adriatic can also be derived from the number of individuals stranded in the past 25 years (Figure 3-166).The left side of the figure refers to 1986-2000 period, with a total of 2 individuals stranded in the whole Adriatic, while the right side refers to 2001-2011 period with 4 individuals stranded.

Figure 3-164 *Ziphius cavirostris.*

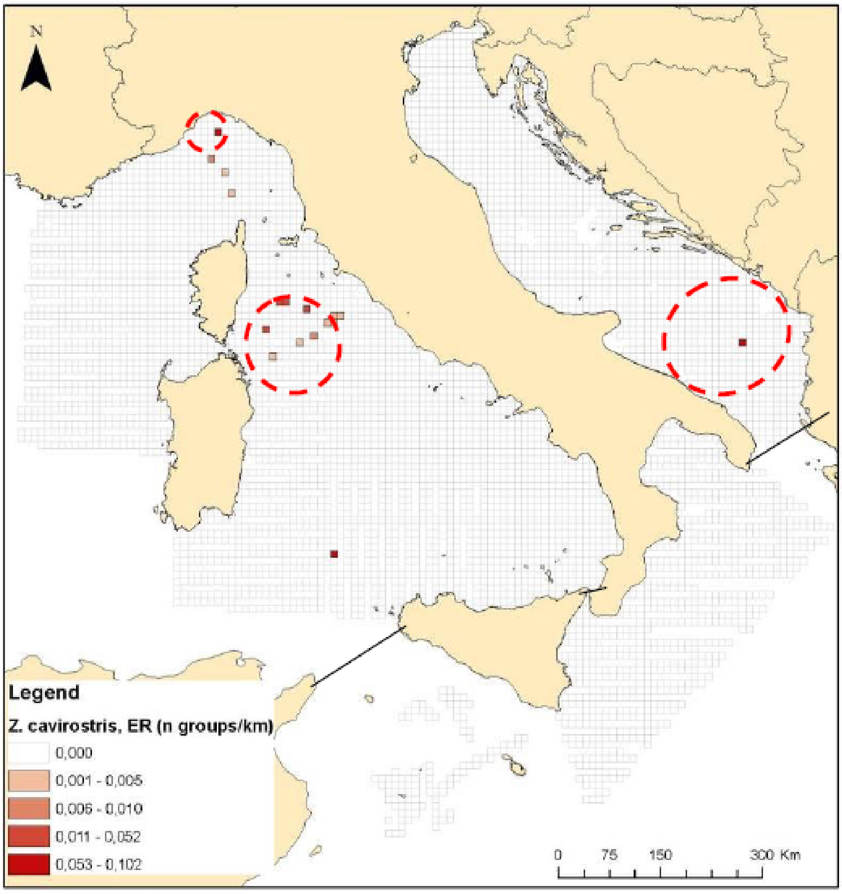

Figure 3-165 ***Ziphius cavirostris*** **distribution (Source: ISPRA, 2012).**

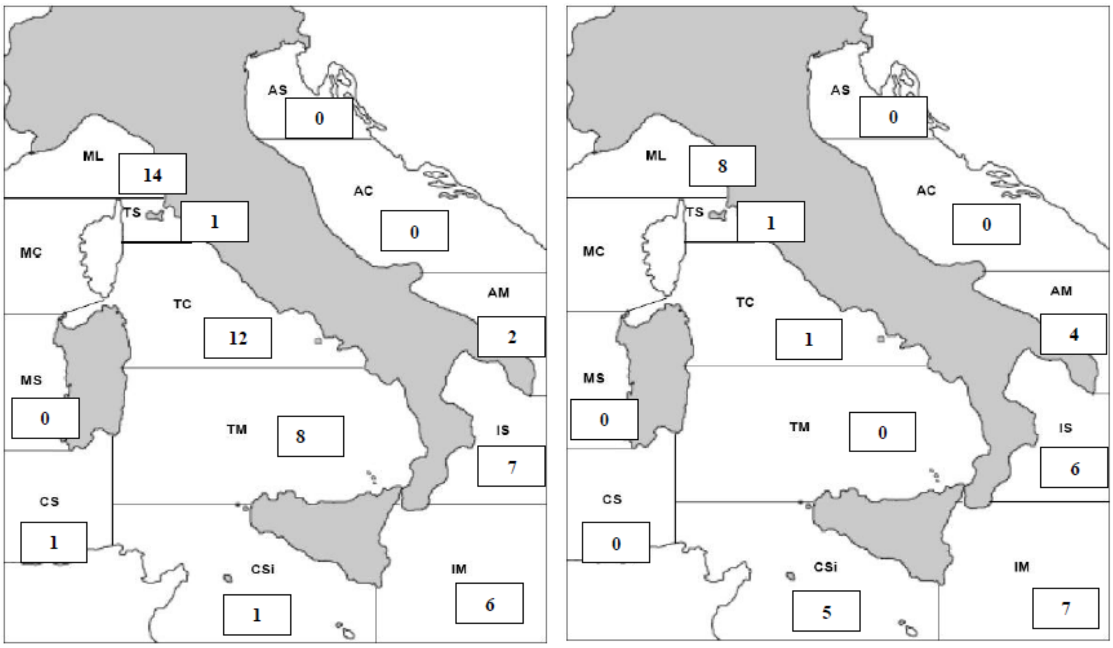

Figure 3-166 stranded ***Ziphius cavirostris*** **distribution during period 1986-2011 (Source: ISPRA, 2012).**

Even though the known occurrences of *Ziphius cavirostris* strandings in the southern Adriatic could appear small, they represent approximately 3% of the entire Mediterranean stranding record. This percentage increases up to about 5% if considering only data collected after 1975. Considering that the southern Adriatic represents approximately 3% of the Mediterranean surface. the proportion of occurrences of the total number of stranded *Ziphius cavirostris* in this small area ranges from average to almost double of that of the entire Mediterranean Sea. Therefore. the southern Adriatic Sea should be considered as a potentially relevant habitat of *Ziphius cavirostris* (Holcer et al. 2007). Main pressures for the species derive from:

- Acoustic pollution; it has been demonstrated a relationships between atypical stranded groups and military drills (impact detected);
- Chemicals pollution (impact unknown);
- Pollution derived from debris and plastic bags; for unknown reasons the species is in fact famous for swallowing wastes (impact unknown).

Species: *Grampus griseus*

Grampus griseus (Cuvier,1812), also called Risso's dolphin, lives in pelagic waters near scarps, feeds of squids and reaches on average 2.5-4 m length with 600-700 kg weight (Figure 3-167).

In the Mediterranean Sea the species is one of eight cetacean species considered to be regular inhabitants (Bearzi et al. 2010). In Adriatic the species is not very common. as testified by 2010 summer survey plane campaign and concentrates in the south Adriatic (Figure 3-168). Data available suggests an estimation of minimum 510 individuals.

Some information on species distribution in the Adriatic can also derive from the number of individuals stranded in the past 25 years (Figure 3-169).The left side of the figure refers to 1986-2000 period, with 13 stranded in the whole Adriatic, while the right side refers to 2001-2011 period with 8 individuals stranded.

Figure 3-167: *Grampus griseus.*

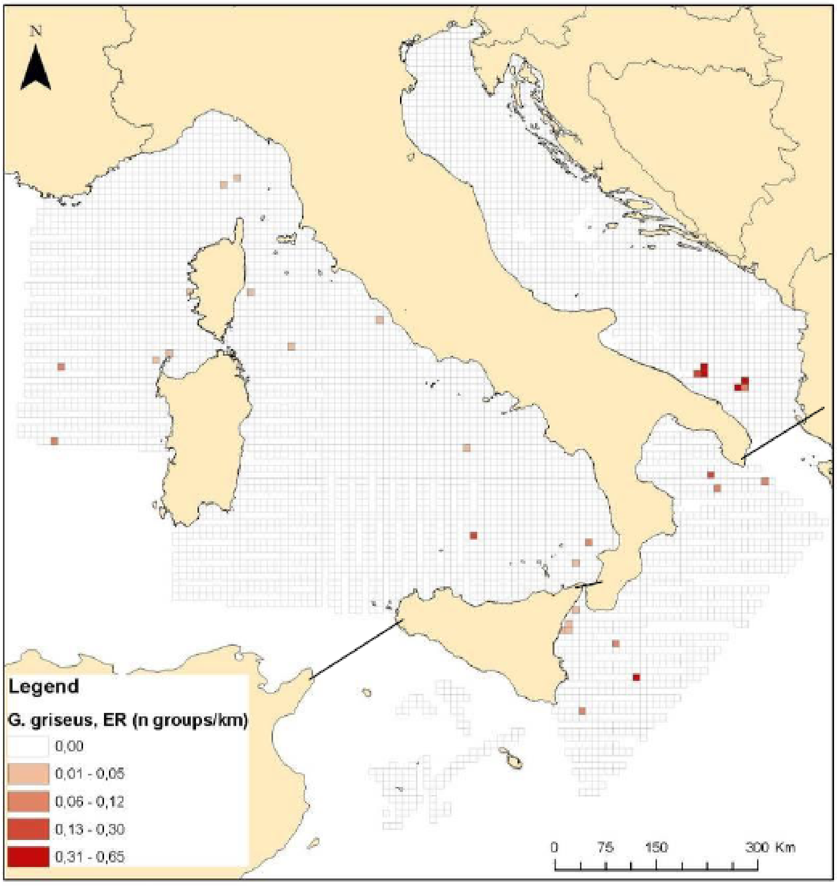

Figure 3-168 *Grampus griseus* distribution (Source: ISPRA, 2012).

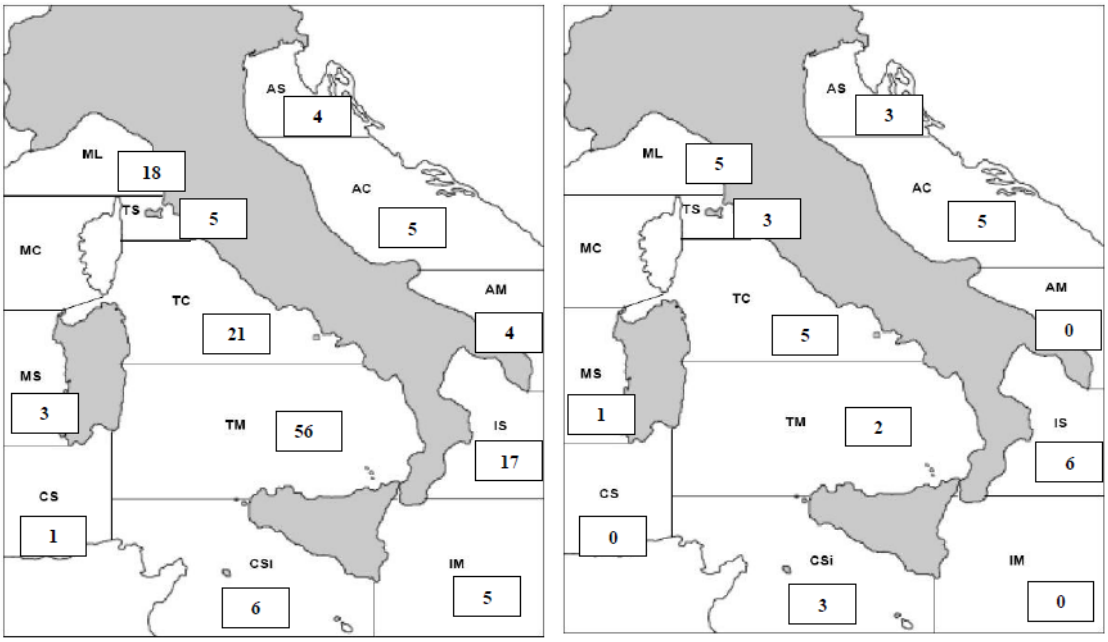

Figure 3-169 stranded *Grampus griseus* distribution during period 1986-2011 (Source: ISPRA, 2012).

Main pressures on the species derive from:

- Accidental captures during fishing activities, in particular with pelagic nets for sword-fish (pelagic gillnets also called driftnets);
- Chemicals pollution;
- Pollution derived from debris and plastic bags; for unknown reasons the species is in fact famous for swallowing wastes.

The following figure summarizes possible threats for the species.

Threat	Quality of information	Impact at the population level	Rationale behind assessment/Notes
Incidental mortality and injury in fisheries (bycatch). Mortality or injury from accidental entanglement in gear of various types including passive and active nets, longlines, traps and discarded or lost nets and lines and illegal fishing practices (e.g. use of dynamite)	Good	High	Occurrence of stranded animals showing evidence of bycatch in fishing gear
Acoustic pollution (noise). Mortality, injury or chronic disturbance from exposure to man-made sounds	Poor	Uncertain	Although exposed to considerable anthropogenic noise, including high-intensity sonars, no evidence of trauma or behavioural disruption reported so far
Ingestion of solid debris. Mortality or injury from the ingestion of foreign objects and materials, such as plastic, wood, textiles etc. (obstructing part of the digestive tract)	Poor	Moderate	Plastic and other debris found in stomachs of several animals, but limited evidence that this was a direct cause of mortality
Chemical contamination. Accumulation in the body tissues (mostly through the food web) of chemicals known to adversely affect mammalian functions and health	Poor	Moderate	Cause–effect relations not demonstrated for most chemicals and for this species, but high levels of some trace metals are a cause for concern
Disturbance. Behavioural disruption through intentional or non-intentional approaches, likely or proven to induce long-term effects on dolphin populations	Poor	Possibly minor, with important exceptions (see relevant section in text)	Inference based on distribution, occurrence of disturbance in those areas, and behaviour shown by the animals
Prey depletion. Depletion of food resources caused directly or indirectly by fishing	Poor	Possibly minor	Inference based on diet and degree of exploitation of key prey; impact may increase in the future
Ecosystem change. Reduced habitat quality due to effects of coastal development (e.g. eutrophication, harmful algal blooms, prey depletion, alien species invasions)	Fair	Minor, except possibly in Risso's dolphin hotspots situated near shore	Inference based on Risso's dolphin distribution and habitat use
Intentional and direct takes. Killing or capture to obtain products for human consumption and shark bait, live capture for display facilities, acts of retaliation for actual or perceived damage to fish catches or gear, and shooting for 'sport'	Fair	Minor	Infrequent observation of relevant wounds on animals found stranded or adrift
Vessel strikes. Accidental mortality or injury from contact with a vessel, particularly the hull or propeller	Fair	Minor	Infrequent observation of relevant wounds or amputations on animals found stranded or adrift
Climate change. Changes in prey availability (abundance or distribution), shifts in distribution of competitors, exposure to novel diseases etc.	Poor	Unknown	No evidence

Figure 3-170 Overview of threats to *Grampus griseus* in the Mediterranean Sea. quality information to characterize those threats. and their suspected or inferred impacts at the population level (Source: Bearzi .G. et al 2010).

Species: *Globicephala melas*

Globicephala melas (Traill, 1809) lives in pelagic waters and reaches on average 6-7 m length with 2 weight tons (Figure 3-171).

In Adriatic the species is very rare as testified by 2010 summer survey plane campaign that didn't register any sighting (Figure 3-172). Some information on species rarity in the Adriatic can also derive from the number of individuals stranded in the past 25 years (Figure 3-173).The left side of the figure refers to 1986-2000 period, with no individual stranded in the whole Adriatic, while the right side refers to 2001-2011 period with one individual stranded. The main pressure on the species. whose impact is unknown, derives from chemicals pollution.

Figure 3-171 *Globicephala melas*.

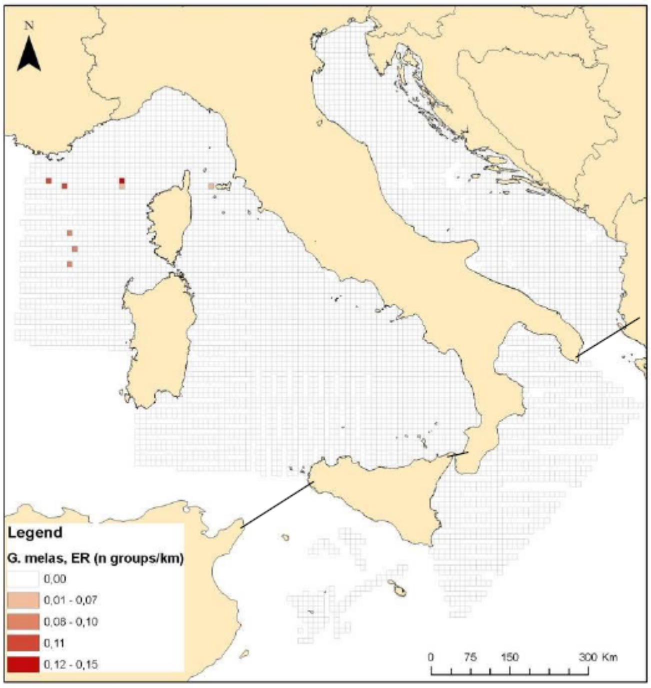

Figure 3-172 *Globicephala melas* distribution (Source: ISPRA, 2012).

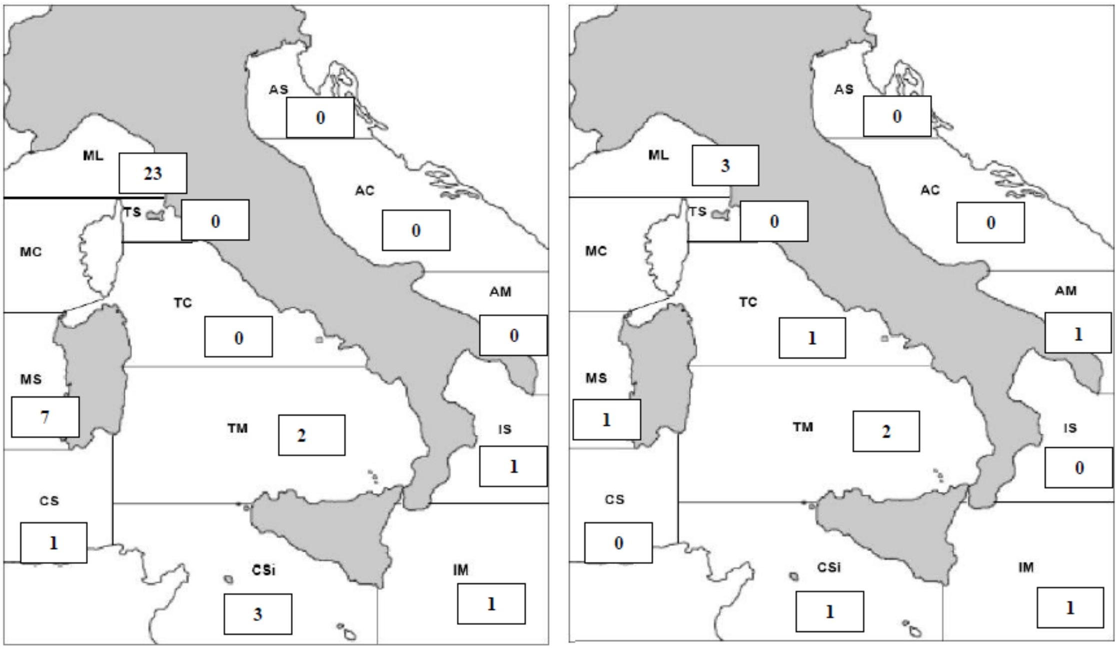

Figure 3-173 stranded *Globicephala melas* distribution during period 1986-2011 (Source: ISPRA, 2012).

Species: *Balaenoptera physalus*

Balaenoptera physalus Lacépède, 1804 extends all around the world. is pelagic, lives in small groups in deep sea and can reach a length of 18-25 meters with a weight of 30-80 tons (Figure 3-174).

Figure 3-174 *Balaenoptera physalus.*

It's present in all Mediterranean, mostly in deep offshore waters of the western portion of the basin (Notarbartolo di Sciara and Birkun, 2010). Depending on food needs it can moves northern or southern Mediterranean basin.

In Adriatic the species is rare and is classified as threatened; there aren't information on population abundance in the area, while is more common in north Tyrrhenian and Liguria sea, as testified by 2010 summer campaign. Figure 3-175 shows the meeting rate per km per cell; white cells indicate that no observations have been registered even if a positive research effort has been made.

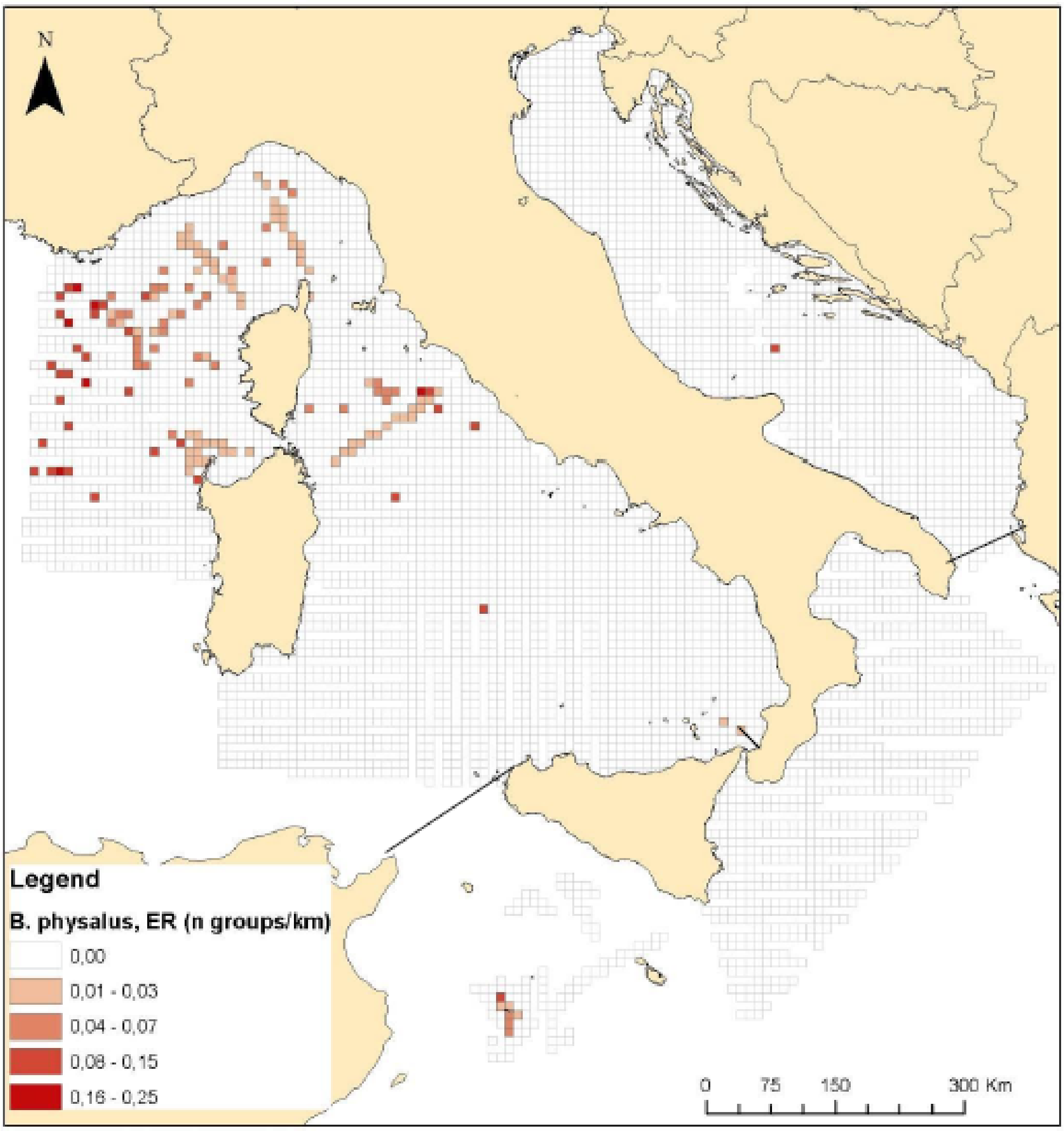

Figure 3-175 *Balaenoptera physalus* distribution (Source: ISPRA, 2012).

The rarity of the species in the Adriatic is also confirmed by the number of individuals stranded in the past 25 years (Figure 3-176).The left side of the figure refers to 1986-2000 period, with a total of 4 individuals stranded in the whole Adriatic, while the right side refers to 2001-2011 period with only one individual stranded.

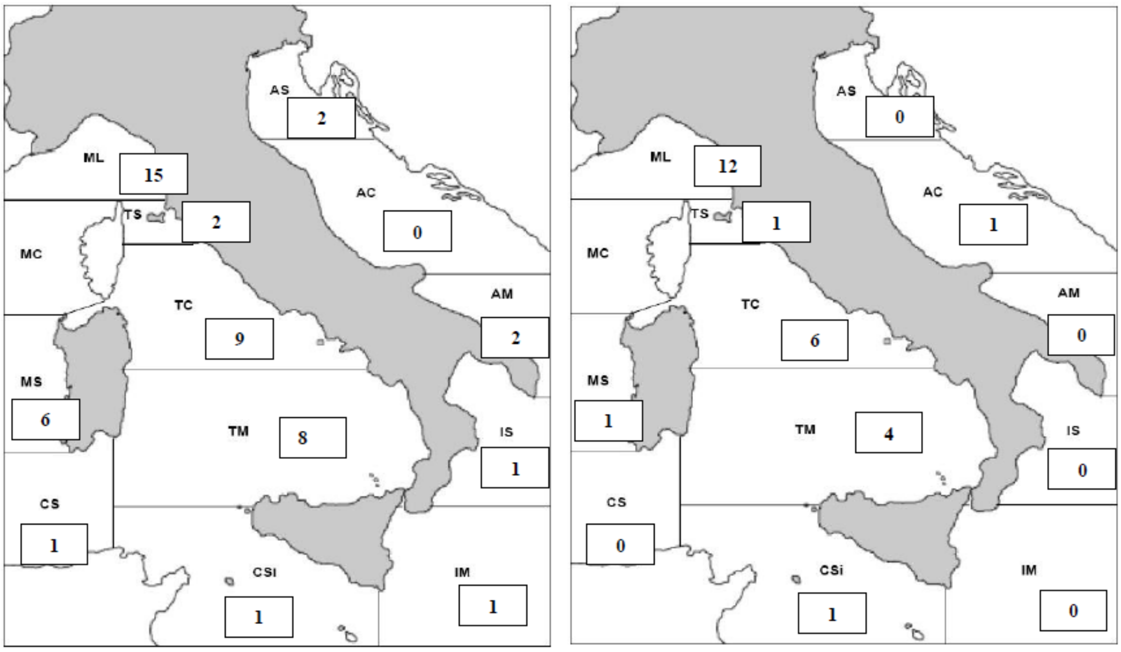

Figure 3-176 stranded *Balaenoptera physalus* distribution during period 1986-2011 (Source: ISPRA, 2012).

Main pressures on the species derive from the following causes:

- Collisions against ships (cumulative impact unknown);
- Acoustic pollution; strong acoustic emissions set displacement with consequences on reproduction and/or on feeding (impact unknown);
- Chemical substances pollution which can determinate a high toxicological stress (impact unknown).

<u>Species: *Physeter macrocephalus*</u>

Physeter macrocephalus, Linnaeus 1758 lives in pelagic waters, is cryptic, feeds on squids and reaches on average 18 m length with 52 weight tons (Figure 3-177).

In Adriatic the species is rare and classified as threatened, as testified by 2010 summer survey plane campaign that didn't register any sighting (Figure 3-178). Nevertheless observation with plane surveys is not the best way to evaluate distribution and abundance because *Physeter macrocephalus* mainly lives in deep waters.

More information on species distribution in the Adriatic can derive from the number of individuals stranded in the past 25 years (Figure 3-179).The left side of the figure refers to 1986-2000 period, with no individuals stranded in the whole Adriatic, while the right side refers to 2001-2011 period with 8 individuals stranded.

Figure 3-177 ***Physeter macrocephalus.***

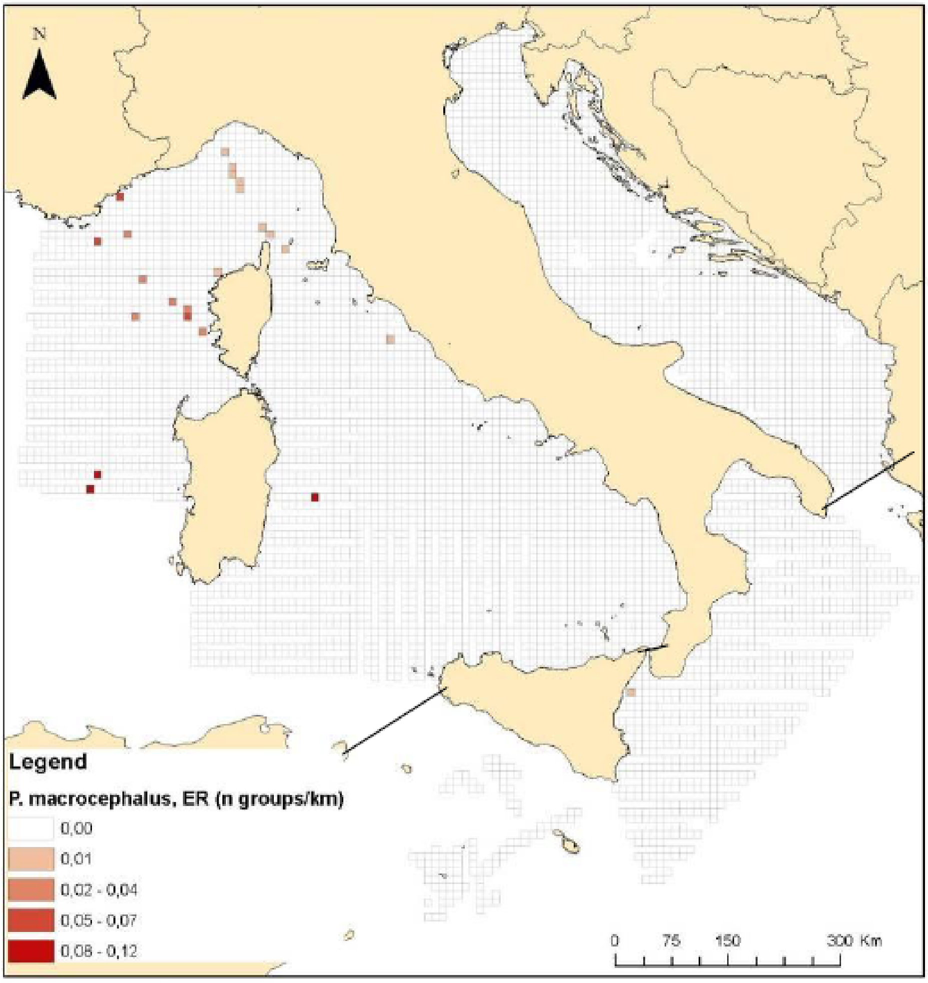

Figure 3-178 *Physeter macrocephalus* distribution (Source: ISPRA, 2012).

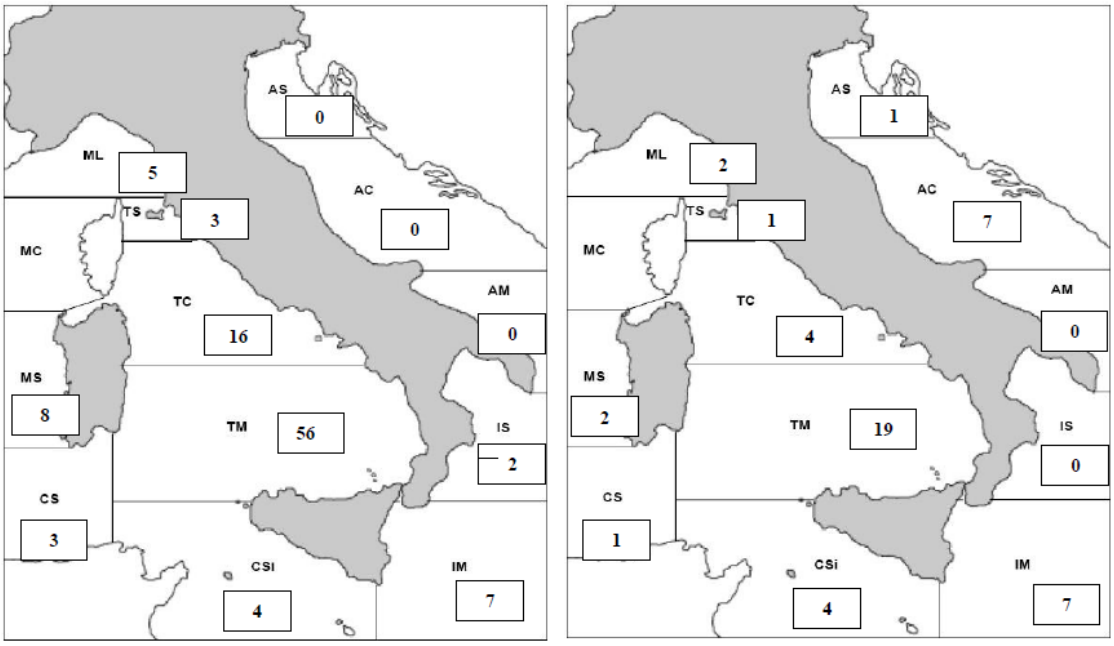

Figure 3-179 stranded *Physeter macrocephalus* distribution during period 1986-2011 (Source: ISPRA, 2012).

Main pressures on the species derive from:

- Accidental captures during fishing activities, in particular with pelagic nets for sword-fish (impact unknown);
- Acoustic pollution (impact detected);
- Collisions against ships (impact unknown).

<u>Species: *Monachus monachus*</u>

Monachus monachus (Hermann, 1779), also called monk seal, lives mainly in water during non-reproductive periods feeding mainly of octopus and cuttlefishes and stays near the coast during reproductive period; adults can reach on average 80-240 cm length with 320 kg weight (Figure 3-180).

Listed in Annex II of the SPA/BD Protocol of the Barcelona Convention, it is also included by IUCN in the so called “Red list” of the species endangered. The whole population has been estimated to be made up of 300-400 individuals divided into two groups (the Atlantic population in Morocco, Mauritania, Madeira island and the Mediterranean population in Greece, Turkey and eastern Mediterranean) while elsewhere there are only errant individuals or small groups.

Main pressure on the species derives from:

- Accidental killing;
- Accidental catching with fishing tools;
- anthropic stress along coastlines.

Figure 3-180 ***Monachus monachus.***

At the moment Italian coastlines don't host a permanent colony of the species but only errant individuals have been registered. The following figure show sightings (years and number of sightings) along Italian coastline during 1998-2010. In the Adriatic Italian coastline the species has been seen only twice, in 2000 and 2003, and always in the south Adriatic.

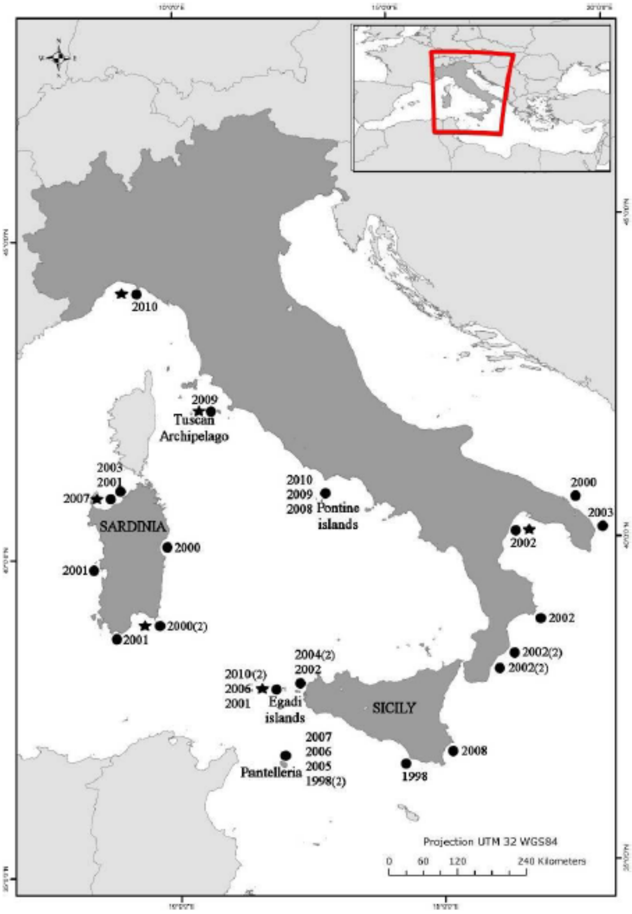

Figure 3-181 ***monachus monachus*** **sightings (Source: ISPRA, 2012).**

According to IUCN data, the Mediterranean monk seal is considered to be possibly extinct in Croatian waters, while according to the Red Book of Mammals of Croatia from 2006, it has the status of a regionally extinct species. Nevertheless over the past 15 years, there have been several reports of sightings of adult Mediterranean monk seals in the Croatian waters of the Adriatic. In recent years the intensive of sighting reports has substantially increased with more reports documented. Sightings are regular in different parts of the Adriatic, especially along the eastern coast of Istria and western coast of the island of Cres and Losinj. Despite this, considered that there isn't a systematic research on the species in the Adriatic, it is difficult to say with any certainty that it also reproduces in the Adriatic. Therefore it's necessary to begin with special monitoring at sites with frequent sightings.

3.4.4 Population dynamics, natural and actual range and status of sea-birds

Mediterranean basin hosts many different species of pelagic and coastal seabirds. Even if they have great importance from the ecological point of view, there are many risk factors that can affect their survival. The most important threats are surely sea pollution, mainly due to aquaculture activities, urban and industrial wastewaters, accidental oil spills, accidental catches during fishing activities, nests anthropic disturb and introduction of new species that can negatively affect nests. Consequently some Important Bird Areas (IBA) are going to be defined by the Italian government (LIPU, 2009) and by other countries overlooking Adriatic sea.

IBA is not a synonym of protected area but of an area worthy of some legal protection because of its outstanding natural values. Therefore, all IBAs should be afforded an adequate legal status that will guarantee the preservation of its qualities and of the essential biological processes. An IBA is a site providing essential habitat to one or more species of breeding, wintering, and/or migrating birds, with the following primary goals[32]:

- To identify, nominate, and designate key sites that contribute to the preservation of significant bird populations or communities;
- To provide information that will help land managers evaluate areas for habitat management and/or land acquisition;
- To activate public and private participation in bird conservation efforts;
- To provide public education and community outreach opportunities.

The following paragraphs summarize the distribution and population of some important marine seabird species that are considered stable or migratory in nations overlooking the Adriatic sea. Species not directly linked to marine environment but which can be found in coastal zones like lagoons or ponds as *Haematopus ostralegus, Himantopus himantopus, Phoenicopterus ruber, Egretta alba, Grus grus, Egretta garzetta, Ardea purpurea, Ciconia ciconia*, etc. have not been considered.

Not for all species and for all countries considered data on densities are available.

32 http://www.massaudubon.org/Birds_and_Birding/IBAs/, last access 18 June 2012

Species: *Calonectris diomedea*

Included in Annex I of the European Union Directive on the conservation of wild birds (79/409/EEC), in Annex III (Protected Fauna Species) of the Bern Convention and covered by the European Union Regulation laying down certain technical measures for the conservation of fishery resources in the Mediterranean (1626/94 (EC) 1994) (UNEP-MAP RAC/SPA, 2003), it's a typical pelagic species which usually stays in open sea and comes back to dry land only during reproductive period (Figure 3-182).

Figure 3-182 *Calonectris diomedea.*

Calonectris diomedea breeds in sea-cliffs, on rocky islands and islets, nesting in natural crevices, amongst boulders, screes, as well as under vegetation, It has a long breeding season and the majority of the population migrates outside the Mediterranean. Only one egg is laid, sit on for 51 days. In early October young birds start to leave the nest and by the third week of the month the colonies are deserted. It has been estimated that the whole European population amounts to less than 270,000 pairs (76,000 in the Mediterranean basin) while for Adriatic countries data collected show that (UNEP, MAP, RAC/SPA, 2006):(i) In Italy there are approximately 15-18,000 pairs with more than 30 colonies; (ii) Croatia hosts 800-1,000 pairs. Results on density emerged from a study conducted by LIPU on *Calonectris diomedea* visual observation along specific transects along Italian Adriatic coastline are shown in Figure 3-183.

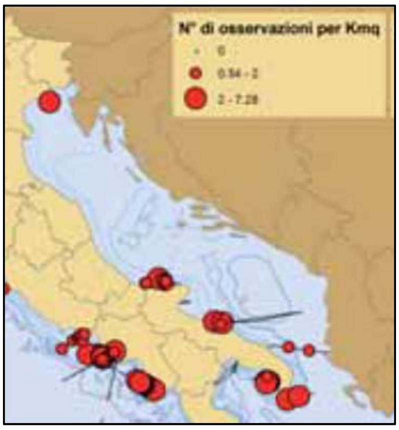

Figure 3-183 *Calonectris diomedea* densities along transects in the Adriatic sea (Source: LIPU, 2009).

Population is strongly declining because of the presence of mammals like rats introduced by human beings and stray dogs. The species is also threatened by sea pollution and anthropic development near nesting colonies.

Species: *Puffinus yelkouan*

Inserted in Annex I of the European Union Directive on the conservation of wild birds (79/409/EEC), in Annex II (Strictly Protected Species) of the Convention on the Conservation of European Wildlife and Natural Habitats (1979), and covered by the European Union Regulation laying down certain technical measures for the conservation of fishery resources in the Mediterranean (1626/94 (EC) 1994) (UNEP-MAP-RAC/SPA, 2003), it's a typical pelagic species which usually stays in open sea and comes back to dry land only during reproductive period nesting in colonies (Figure 3-184).

Figure 3-184 *Puffinus yelkouan.*

Restricted mainly to central and eastern Mediterranean. *Puffinus yelkouan* breeds in caves, crevices and burrows in sea cliffs and on offshore islands. The first birds arrive at the colonies in October, but egg laying starts in the last week of February and continues until the first ten days of March. A single egg is laid inside a deep crevice and incubation lasts about 50-52 days with both partners alternating in brooding. Juvenile individuals start flying after 60-68 days. It has been estimated that the whole European population amounts to less than 33,000 pairs while for Adriatic countries data collected show that (UNEP, MAP, RAC/SPA, 2006):

- Albania hosts 1-10 breeding pairs;
- In Italy there are approximately 7.000-14,000 breeding pairs;
- Croatia hosts 50-100 breeding pairs.

Results on density emerged from a study conducted by LIPU on *Puffinus yelkouan* visual observation along specific transects along Italian Adriatic coastline are shown in Figure 3-185.

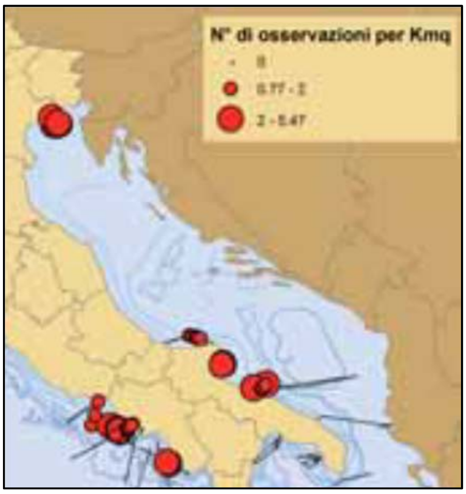

Figure 3-185 *Puffinus yelkouan* densities along transects in the Adriatic sea (Source: LIPU, 2009).

Population is stable at the moment. Nevertheless the species is threatened because of the presence of mammals like rats introduced by human beings, stray dogs and cats, sea pollution and anthropic development near nesting colonies.

Species: *Hydrobates pelagicus*

Included in Annex I of the European Union Directive on the conservation of wild birds (79/409/EEC), in Annex II (Strictly Protected Species) of the Convention on the Conservation of European Wildlife and Natural Habitats (1979), and covered by the European Union Regulation laying down certain technical measures for the conservation of fishery resources in the Mediterranean (1626/94 (EC) 1994) (UNEP-MAP-RAC/SPA, 2003), it's a typical pelagic species which usually stays in open sea and comes back to dry land only during reproductive period nesting in colonies (Figure 3-186).

Figure 3-186 *Hydrobates pelagicus.*

Hydrobates pelagicus breeds on rocky islands and islets and nests in natural crevices, fissures in rocks and cliff faces, amongst and under stones and boulders, in burrows and in caves. The egg-laying period spans a period of four months, from April to July. The single white egg is laid in a fissure, under a boulder, or deep among the stones. Incubation is carried out by both sexes and it lasts about 40 days. The young is also fed by both parents and after a period of about 70 days it is ready to fledge.

It has been estimated that the whole European population amounts to more than 430,000 pairs. It's distributed in the Mediterranean basin and Atlantic ocean, sub species *Hydrobates pelagicus melitensis* is instead endemic of the Mediterranean sea.

Population data collected (UNEP, MAP, RAC/SPA, 2006) for Croatia suggest that there are 1-10 breeding pairs; for Italy instead specific breeding surveys for the Adriatic are totally lacking, while at national level 1,700-2,500 breeding pairs have been counted in Sicily and Sardinia. Population is stable at the moment. Nevertheless the species is threatened because of the presence of mammals like rats and natural predators, habitat loss, sea pollution and anthropic development near nesting colonies.

Species: *Phalacrocorax aristotelis*

Included in Annex 1 of the Bird Directive (Directive 79/409/CEE), it's a sedentary species which nests in colonies nearby rocky coastal areas, normally far from land (Figure 3-187).

Figure 3-187 *Phalacrocorax aristotelis.*

During the breeding season it forms sparse colonies, nesting in crevices or caves, on ledges or amongst boulders, often a few meters above the sea level. The nest is built with a variety of vegetal materials, and is frequently reused in successive seasons. Two or three eggs are laid between middle of December and May; sit on for 30-31 days. Juvenile individuals start flying after 53 days.

It has been estimated that the whole European population amounts to less than 81,000 pairs (less than 10,000 in the Mediterranean). It's distributed in the Mediterranean basin and Atlantic ocean; sub species *Phalacrocorax aristotelis desmarestii* is instead endemic of the Mediterranean sea.

For some Adriatic countries data collected show that:

- Albania hosts 5-10 pairs;
- Croatia hosts 250-300 pairs;
- Italy hosts approximately 1,600-2,200 pairs with more than 30 colonies;
- Former Yugoslavia hosts 1,500-2,000 pairs with more than 30 colonies.

For Italy nevertheless results on density emerged from a study conducted by LIPU on *Phalacrocorax aristotelis* visual observation during march-November 2008 along specific transects in Italian Adriatic coastline don't show this evidence (Figure 3-188) probably because the period considered is too short. Results from e new campaign on the number of individual observed in the Adriatic sea will be soon available.

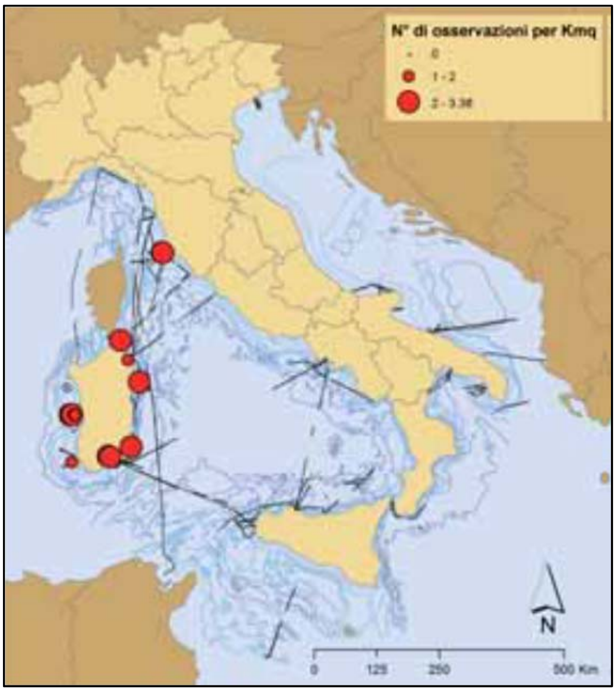

Figure 3-188 *Phalacrocorax aristotelis* densities along transects of Italian coast (Source: LIPU, 2009).

Population is stable at the moment. Nevertheless the species is threatened because of fishing near colonies, nautical disturb, hooks and nets presence in the feeding areas, habitat loss, sea pollution and anthropic development near nesting colonies.

<u>Species: *Larus melanocephalus*</u>

Included in Annex 1 of the Bird Directive (Directive 79/409/EEC), it's mostly distributed in eastern Mediterranean basin and Black sea. *Larus melanocephalus* nests in colonies in coastal brackish environments like lagoons (Figure 3-189).

Figure 3-189 *Larus melanocephalus.*

The nest is made on the ground near low vegetation. Two or three eggs are laid between May and July and after a period of about 35-40 days juveniles are ready for flying.

It has been estimated that the whole European population amounts to more than 120,000 pairs with approximately 2,000 in Italy (LIPU, MATTM, DPN, 2009), concentrated mainly in Puglia, north Adriatic and the Venice lagoon (in this last case figure doesn't show the presence of the species in the lagoon probably because no samplings have been made in the area). Results on density emerged from a study conducted by LIPU on *Larus melanocephalus* visual observation along specific transects in the Mediterranean are shown in Figure 3-190.

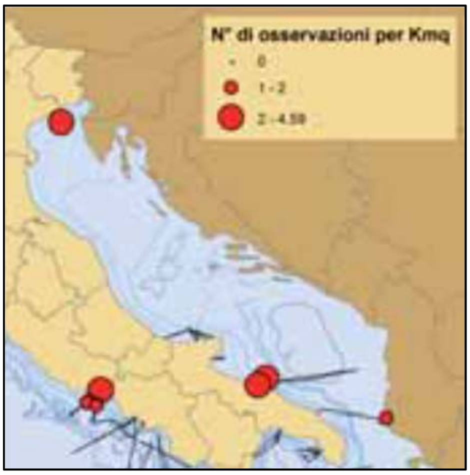

Figure 3-190 *Larus melanocephalus* densities along transects in the Adriatic sea (Source: LIPU 2009).

Population is stable at the moment. Nevertheless the species is threatened because of habitat loss, pesticide pollution, sea storms during nesting period and anthropic disturbance near nesting colonies.

Species: *Larus genei*

Included in Annex 1 of the Bird Directive (Directive 79/409/EEC), it's mostly distributed in eastern Mediterranean basin and Black sea. *Larus genei* nests in colonies in coastal brackish environments like lagoons and ponds (Figure 3-191).

Figure 3-191 *Larus genei.*

The nest is made on the ground. often near water. Two or three eggs are laid between end of April and June and after a period of about 30-37 days juveniles are ready for flying. It has been estimated that the whole European population amounts to less than 56,000 pairs with approximately 3,350 in Italy (LIPU, MATTM, DPN, 2009). In the Adriatic important colonies are located along Veneto and Puglia coastlines. Population is at the moment stable but localized. Nevertheless the species is threatened because of habitat loss, water level variation during nesting period, heavy metal pollution and anthropic disturbance near nesting colonies.

<u>Species: *Larus audouinii*</u>

Included in Annex 1 of the Bird Directive (Directive 79/409/EEC), it is endemic of the Mediterranean. *Larus audouinii* is a typical pelagic species, which nests in colonies on sea cliffs with rocks and herbaceous covering with the nest made on the ground (Figure 3-192).

Figure 3-192 *Larus audouinii.*

Two or three eggs are laid between April and May; 35-40 days after hatching juveniles are ready for flying.

It has been estimated that the whole European population amounts to less than 19,000 pairs (90% of total is concentrated in 10 specific sites) with approximately 500-900 in Italy (LIPU, MATTM, DPN, 2009). In Italy the colonies are localized in a few areas (Sardinia. Campania and Puglia) and along Adriatic coast it is absent (Figure 3-193). Currently the population is growing, even if localized. In the other Adriatic countries data collected evidence the presence of 60-70 breeding pairs in Croatia, while in Montenegro the species may occur but has never been recorded due to lack of monitoring at sea (UNEP, MAP, RAC/SPA, 2006).

Figure 3-193 *Larus audouinii* densities along transects of Italian coast (Source: LIPU, 2009).

Species: *Sterna sandvicensis*

Included in Annex 1 of the Bird Directive (Directive 79/409/EEC), it has a large distribution range (Figure 3-194).

Figure 3-194 *Sterna sandvicensis.*

Sterna sandvicensis nests in colonies located in open lagoons or small flat islands, totally or partially covered by vegetation with nests lay on the ground generally nearby water.

One or two eggs are laid between end of April and half June; 30-35 days after hatching, juveniles are ready for flying. It has been estimated that the whole European population amounts to less than 130,000 pairs with approximately 800 in Italy (LIPU, MATTM, DPN, 2009). Along the Italian Adriatic coastal zones the species nests since 1979 and the colonies are localized in Veneto and Emilia Romagna (mainly Venice lagoon, Po delta and Valli di Comacchio) and Puglia (Figure 3-195). The population is slightly decreasing due to habitat destruction and transformation, anthropic disturbance near nesting colonies, sea storm during nesting period.

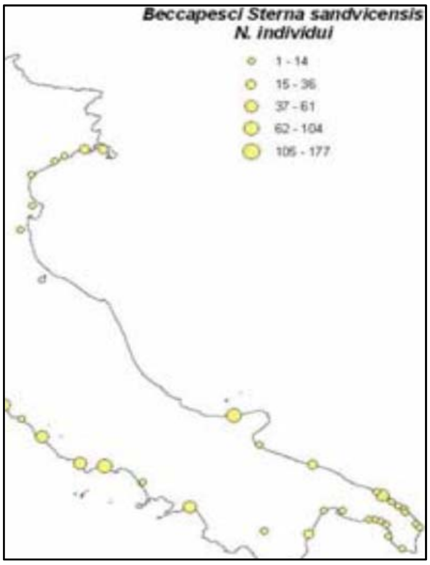

Figure 3-195 sites with maximum values registered of *sterna sandvicensis* years 1998-2003 (Source: LIPU, 2009).

Regarding other countries overlooking Adriatic sea data collected (UNEP, MAP, RAC/SPA, 2006) show that:

- In Slovenia 34 individuals have been registered during winter season, while in summer the number goes down to 15-20 individuals;
- In Montenegro up to 180 individuals have been registered during winter season at the mouth of the Bojana river in the Adriatic sea, while in summer the number goes down to 60 individuals;
- In Croatia 500-800 individuals have been registered during winter season.

Species: *Sterna hirundo*

Included in Annex 1 of the Bird Directive (Directive 79/409/EEC), it has an oloarctic distribution (Figure 3-196).

Sterna hirundo nests in colonies located in coastal brackish wetlands and more rarely in internal fresh waters, with nests laid on the ground generally nearby water or low vegetation.

Two or three eggs are laid between April and half July; 25-26 days after hatching juveniles are ready for flying. It has been estimated that the whole European population amounts to more than 270,000 pairs with approximately 4,000-5,000 in Italy. In the Adriatic important nesting colonies are located along Veneto, Emilia Romagna and Friuli Venezia Giulia coastlines. Population is at the moment stable. Nevertheless the species is threatened because of habitat loss, water level variation during nesting period, heavy metal and chloride hydrocarbons pollution, anthropic disturbance near nesting colonies.

Figure 3-196 *Sterna hirundo.*

Species: *Sterna albifrons*

Included in Annex 1 of the Bird Directive (Directive 79/409/EEC), it has a cosmopolitan distribution (Figure 3-197).

Figure 3-197 *Sterna albifrons.*

Sterna albifrons nests in colonies located in coastal brackish wetlands and also in internal fresh waters (for example rivers with wide bed with islands) with nests laid on the ground.

Two or three eggs are laid from May to July; 19-20 days after hatching juveniles are ready for flying.

It has been estimated that the whole European population amounts to less than 55,000 pairs with approximately 2,000-3,500 in Italy (LIPU, MATTM, DPN, 2009). Along the Italian Adriatic coastal zones the colonies are localized in Veneto and Emilia Romagna (mainly Venice lagoon, Po delta and Valli di Comacchio) and Puglia (Gargano) (Figure 3-198). The population is decreasing especially at north Adriatic sites due to reproductive habitat destruction and transformation, anthropic disturbance near nesting colonies, heavy metals and chloride hydrocarbons pollution, water level fluctuation during reproductive period, nests plundering by rats, stray dogs and cats, seagulls.

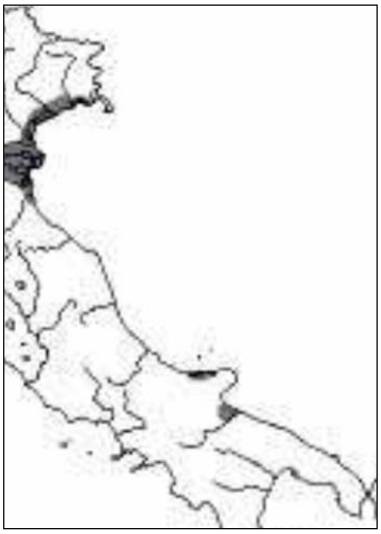

Figure 3-198 *Sterna albifrons* distribution along Italian Adriatic coastline (source: LIPU, 2009; http://www.uccellidaproteggere.it/; last access 22 November 2012).

Regarding other countries overlooking Adriatic sea data collected (UNEP, MAP, RAC/SPA, 2006) show that:

- In Croatia 60-75 breeding pairs have been registered;
- In Montenegro 90 breeding pairs have been registered;
- In Slovenia 26 breeding pairs have been registered;
- In Bosnia the species has been seen in the past but at the moment any sighting has been recorded.

3.4.5 Population dynamics, natural and actual range and status of non-indigenous, exotic species

It has been estimated that over half the whole Mediterranean marine species are native of the Atlantic Ocean, 4% are considered "relic", testimony of times way back in history when the Mediterranean had a tropical climate, 17% have come from the Red Sea and the rest are endemic (UNEP, 2009).

Non indigenous species (NIS) presence in the Adriatic basin is becoming a relevant element because they:

- Are often invasive;
- Can easily substitute local species.
- Can be dangerous for local species and also for human health.

Non-indigenous species (also known as alien, exotic, non-native or allochthonous species), are species, subspecies or lower taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential. They encompass also invasive alien species, defined broadly as 'species whose introduction and/or spread threaten biological diversity or have other unforeseen consequences' (e.g. adverse effects on ecosystem functioning, socio-economic values and/or human health in invaded regions) (SEC (2008) 2886 Commission Staff Working Document).

A recent draft study produced by ISPRA (2012), has detected a list of NIS species found in the Adriatic sea, belonging to eight main taxa:

- plantae;
- polychaeta;
- cnidaria;
- bryozoa;
- ascidiacea;
- mollusca;
- pisces;
- crustacea decapoda.

Lacking information on NIS intensity and abundance, based on available dataset, data on NIS distribution have been gathered using SIDIMAR database[33].

Following figures show the distribution of NIS found in the Adriatic sea, subdivided by previous identified taxa with a focus on a particularly problematic algae species like *Caulerpa racemosa*. A complete updated list of single alien species is also provided. The situation emerged shows that:

- for algae, molluscs and crustaceans most critical zones are located in the north west part of the basin (Veneto and Emilia Romagna Regions) and Puglia;
- for bryozoa and ascidiacea hot spots are located in the Venice gulf;
- for pisces critical areas are those located along Croatian and Albanian coasts;
- for polychaeta, Venice lagoon, Istria peninsula and south Puglia are critical zones;
- for cnidarian, the whole north and central Adriatic are critical areas both along coasts (Croatia in particular) both in open sea.

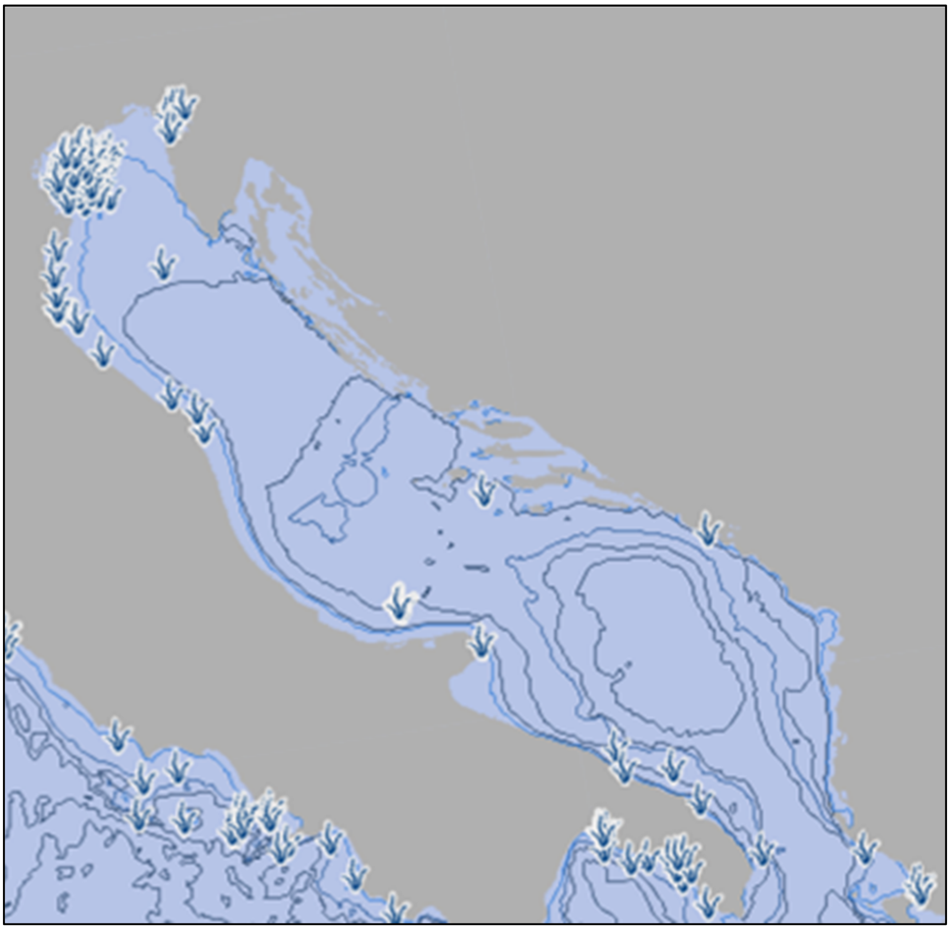

Figure 3-199 non indigenous algae finding (Source: SIDIMAR http://www.tutelamare.it/cocoon/sa/app/it/index.html, last access 22 November 2012).

33 http://www.sidimar.tutelamare.it/ last access 22 November 2012

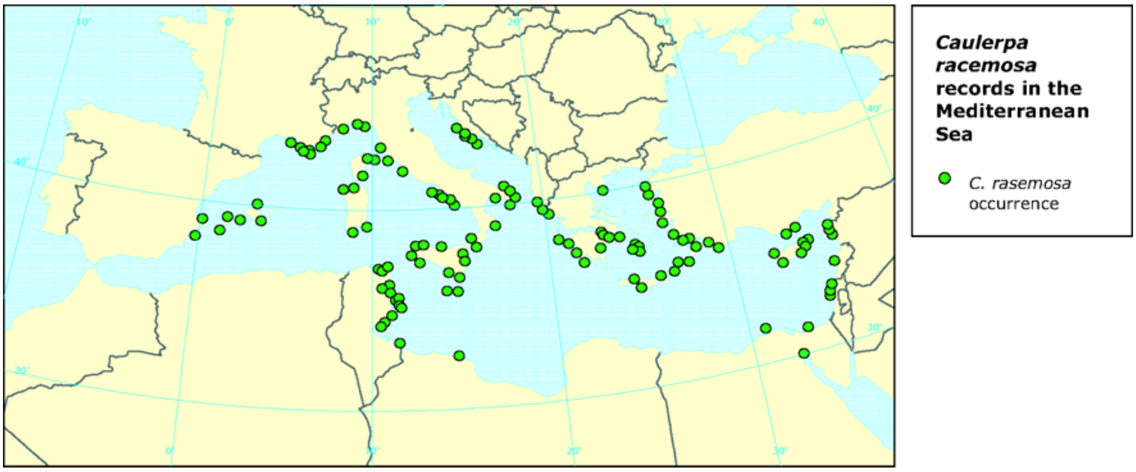

Figure 3-200 ***Caulerpa racemosa*** **distribution in the Mediterranean. year 2005 (source: EEA, http://www.eea.europa.eu/data-and-maps/figures/caulerpa-racemosa-records-in-the-mediterranean-sea, last access 22 November 2012).**

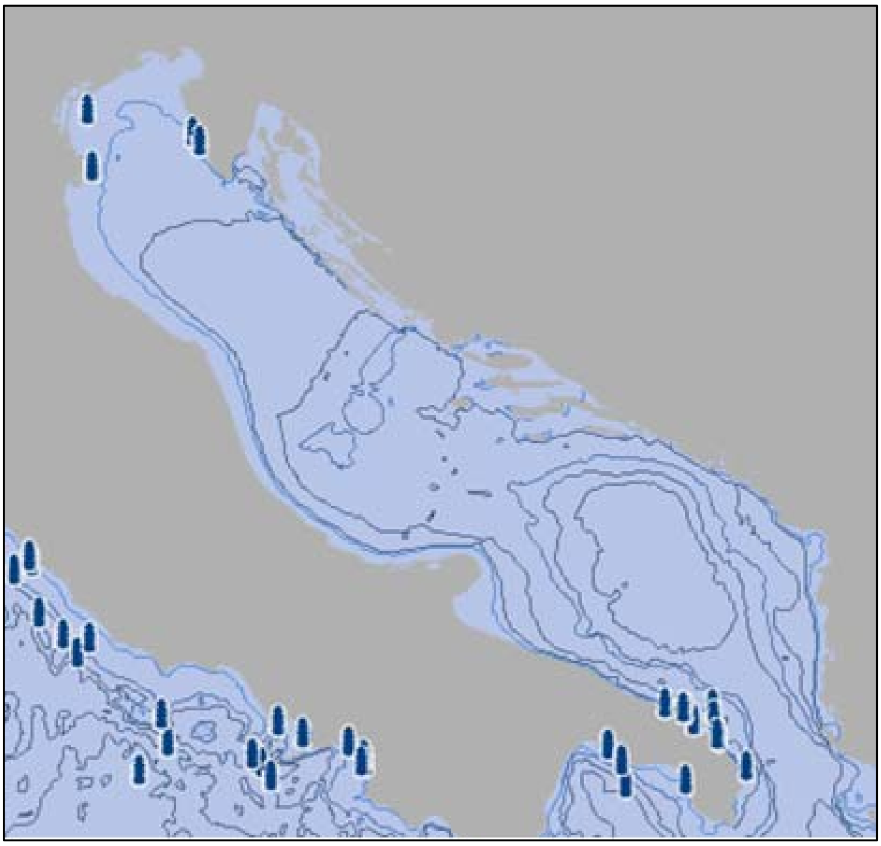

Figure 3-201 non indigenous polychaeta finding (Source: SIDIMAR http://www.tutelamare.it/cocoon/sa/app/it/index.html; last access 22 November 2012).

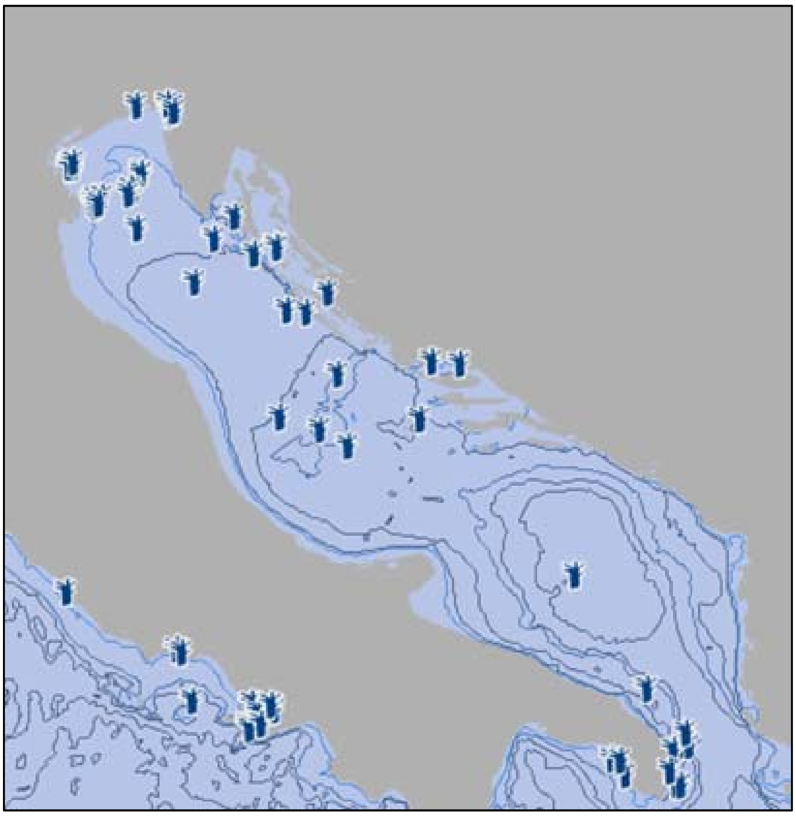

Figure 3-202 non indigenous cnidaria finding (Source: SIDIMAR http://www.tutelamare.it/cocoon/sa/app/it/index.html, last access 22 November 2012).

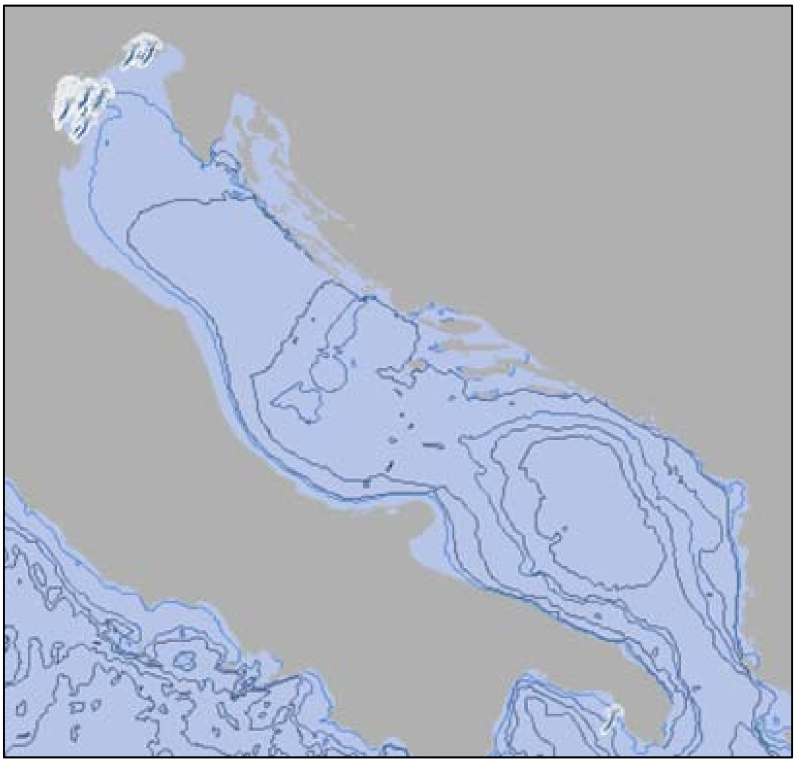

Figure 3-203 non indigenous bryozoa finding (Source: SIDIMAR http://www.tutelamare.it/cocoon/sa/app/it/index.html, last access 22 November 2012).

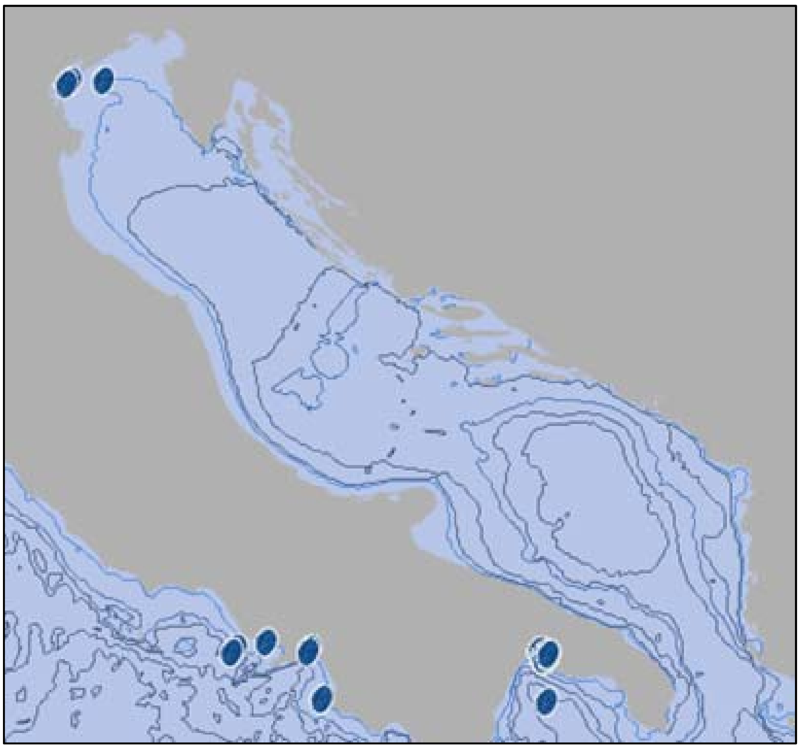

Figure 3-204 non indigenous ascidiacea finding (Source: SIDIMAR http://www.tutelamare.it/cocoon/sa/app/it/index.html, last access 22 November 2012).

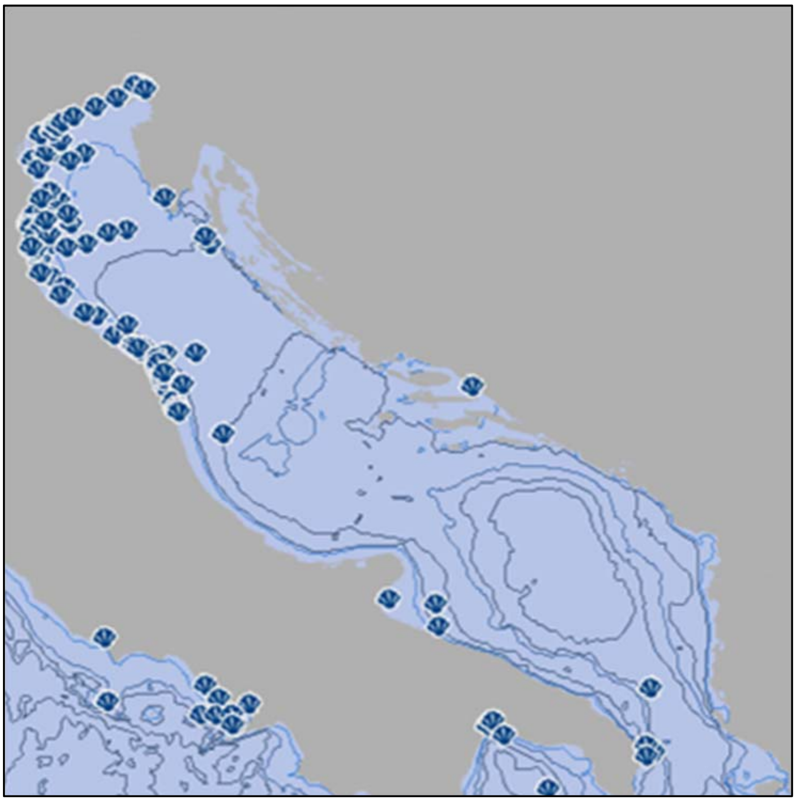

Figure 3-205 non indigenous mollusca finding (Source: SIDIMAR http://www.tutelamare.it/cocoon/sa/app/it/index.html, last access 22 November 2012).

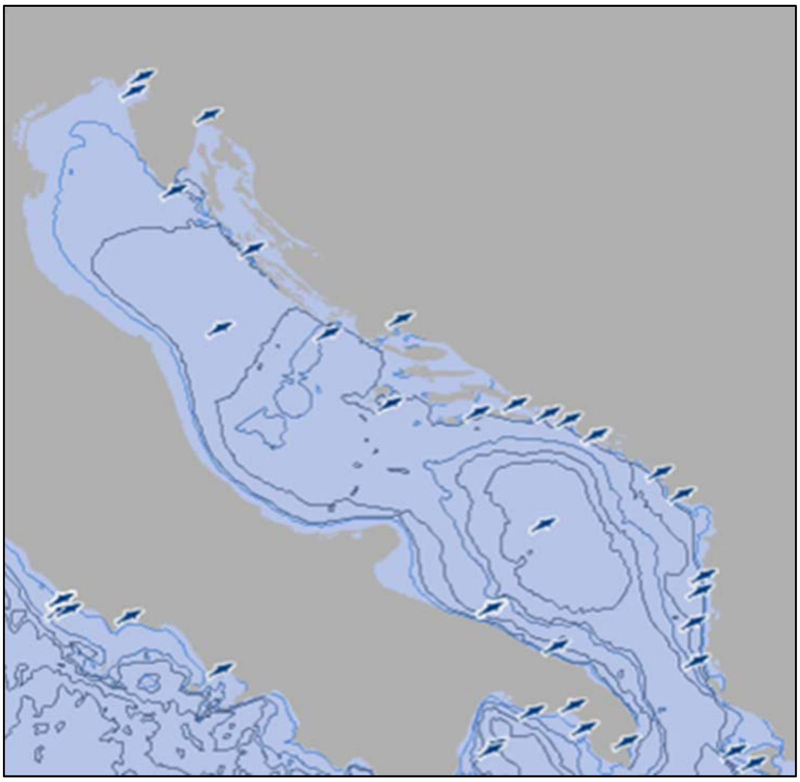

Figure 3-206 non indigenous pisces finding (Source: SIDIMAR http://www.tutelamare.it/cocoon/sa/app/it/index.html, last access 22 November 2012).

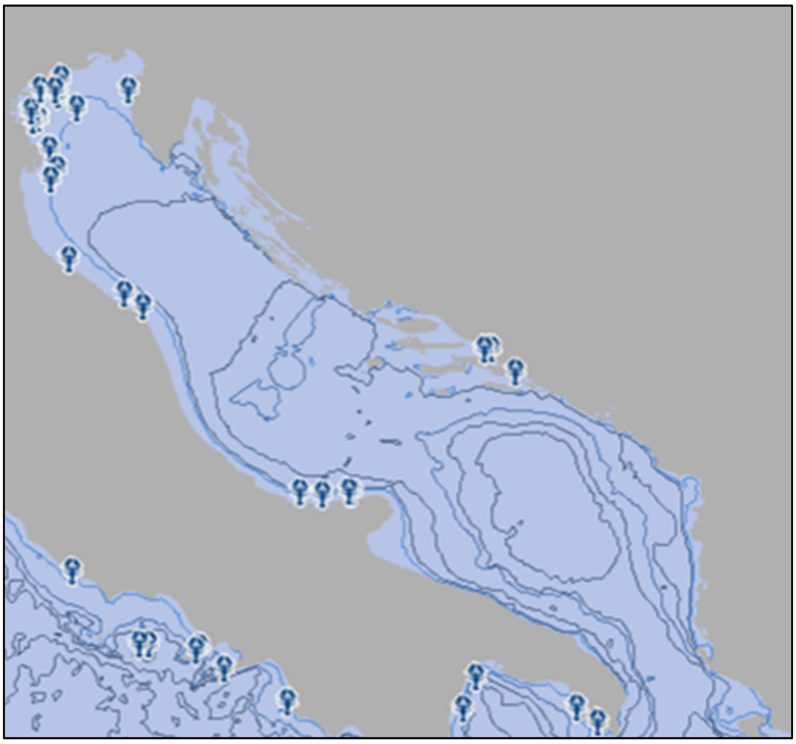

Figure 3-207 non indigenous crustacea finding (Source: SIDIMAR http://www.tutelamare.it/cocoon/sa/app/it/index.html, last access 22 November 2012).

Regarding main causes which generate the spread of NIS, literature data confirms that aquaculture and maritime transport activities (ballast water and fouling) are the most relevant. In the case of Adriatic sea it has been estimated that maritime transport contribute for 28% of total NIS introduced and aquaculture for 18%; other less relevant causes are living bait import and aquarium activities (ISPRA, 2012). The following table summarizes NIS detected in the Adriatic.

Table 3-24 inventory of NIS detected in the Adriatic sea (Source: ISPRA, 2012).

Species	Author	Species	Author
Aglaothamnion feldmanniae	Halos, 1965	*Striatella delicatula*	(Kützing) Grunow ex Van Heurck, 1881
Amphora exigua	Gregory, 1857	*Undaria pinnatifida*	(Harvey) Suringar, 1873
Amphora lineolata	Ehrenberg, 1838	*Womersleyella setacea*	(Hollenberg) R.E.Norris, 1992
Amphora macilenta	Gregory, 1857	*Botrylloides violaceus*	Oka, 1927
Amphora pusio	Cleve, 1896	*Perophora viridis*	Verrill, 1871
Antithamnion hubbsii	E.Y.Dawson, 1962	*Celleporella carolinensis*	Ryland, 1979
Bonnemaisonia hamifera	Hariot, 1891	*Tricellaria inopinata*	d'Hondt & Occhipinti Ambrogi, 1985
Botryocladia madagascariensis	G.Feldmann, 1945	*Clytia hummelincki*	(Leloup, 1935)
Caloneis liber	(W. Smith) Cleve, 1894	*Clytia linearis*	(Thorneley, 1900)
Caulerpa racemosa	(Forsskål) J.Agardh, 1873	*Cordylophora caspia*	(Pallas, 1771)
Ceramium strobiliforme	G.W.Lawson & D.M.John, 1982	*Diadumene cincta*	Stephenson, 1925
Chondria pygmaea	Garbary & Vandermeulen, 1990	*Ectopleura dumortieri*	Van Beneden, 1844)
Codium fragile ssp. fragile		*Eudendrium merulum*	Watson, 1985
Cylindrotheca closterium	(Ehrenberg) Reiman & Lewin, 1964	*Garveia franciscana*	(Torrey, 1902)
Diploneis didyma	(Ehrenberg) Ehrenberg, 1845	*Helgicirrha schulzei*	Hartlaub, 1909
Diploneis interrupta	(Kützing) P.T. Cleve, 1894	*Thyroscyphus fruticosus*	(Esper, 1793)
Entomoneis paludosa	(W. Smith) Reimer, 1975	*Callinectes danae*	Smith, 1869
Gomphonema olivaceum	(Hornemann) Brébisson, 1838	*Callinectes sapidus*	Rathbun, 1896
Grateloupia turuturu	Yamada, 1941	*Dyspanopeus sayi*	(Smith, 1869)
Gyrosigma acuminatum	Kützing) Rabenhorst, 1853	*Eriocheir sinensis*	H. Milne Edwards, 1853

Species	Author	Species	Author
Gyrosigma attenuatum	(Küzing) Rabenhorst	*Marsupenaeus japonicus*	(Spence Bate, 1888)
Gyrosigma fascicola	(Ehrenberg) J.W. Griffith & Henfrey, 1856	*Rhithropanopeus harrisii*	(Gould, 1841)
Gyrosigma wansbeckii	(Donkin) Cleve, 1894	*Scyllarus caparti*	Holthuis, 1952
Halothrix lumbricalis	(Kützing) Reinke, 1888	*Anadara inequivalvis*	(Bruguière, 1789)
Heterosiphonia japonica f. nipponica	Yendo, 1920	*Anadara transversa*	(Say, 1822)
Laurencia chondrioides	Børgesen, 1918	*Bursatella leachi*	Blainville, 1817
Leathesia difformis	J.E.Areschoug, 1847	*Cerithium scabridum*	Philippi, 1848
Licmophora gracilis	(Ehrenberg) Grunow. 1867	*Chrysallida fischeri*	(Hornung & Mermod, 1925)
Lomentaria hakodatensis	Yendo, 1920	*Crassostrea gigas*	(Thunberg, 1793)
Lophocladia lallemandii	(Montagne) F.Schmitz, 1893	*Cuthona perca*	(Er. Marcus, 1958)
Navicula cryptocephala	Kützing, 1844	*Haminoea japonica*	Pilsbry, 1895
Navicula digito-radiata	(Gregory) Ralfs, 1861	*Mercenaria mercenaria*	(Linnaeus, 1758)
Navicula ramosissima	(C.Agardh) Cleve, 1895	*Musculista senhousia*	(Benson in Cantor, 1842)
Navicula salinarum	Grunow, 1880	*Mya arenaria*	Linnaeus, 1758
Neosiphonia harveyi	(J.W.Bailey) M.-S.Kim. H.-G.Choi, Guiry & G.W.Saunders, 2001	*Rapana venosa*	(Valenciennes, 1846)
Nitzschia apiculata	(Gregory) Grunow, 1878	*Saccostrea commercialis*	(Iredale & Roughley, 1933)
Nitzschia bilobata	W. Smith. 1853	*Saccostrea cucullata*	(Born. 1778)
Nitzschia constricta	(Gregory) Grunow in Cleve & Grunow, 1880	*Tapes philippinarum*	(Adams & Reeve, 1850)
Nitzschia dissipata	(Kützing) Grunow, 1862	*Tremoctopus gracilis*	(Eydoux e Souleyet, 1852)
Nitzschia frustulum	(Kützing) Grunow in Cleve & Grunow, 1880	*Xenostrobus securis*	(Lamarck, 1819)
Nitzschia microcephala	Grunow in Cleve & Möller, 1878	*Epinephelus coioides*	(Hamilton, 1822)
Nitzschia obtusa	W. Smith, 1853	*Siganus luridus*	(Rüppell, 1829)
Nitzschia tryblionella	Hantzsch in Rabenhorst, 1860	*Branchiomma luctuosum*	(Grube, 1870)
Pinnularia appendiculata	(C.A. Agardh) P.T. Cleve, 1895	*Desdemona ornata*	Banse, 1957
Pleurosigma aestuarii	(Brébisson ex Kützing) W. Smith, 1853	*Fabriciola ghardaqa*	Banse, 1959
Pleurosigma naviculaceum	Brébisson, 1854	*Leiochrides australis*	Augener, 1914

Species	Author	Species	Author
Pleurosigma normanii	Ralfs, 1861	*Lumbrinerides neogesae*	Miura, 1981
Polysiphonia morrowii	Harvey, 1857	*Megalomma claparedei*	(Gravier, 1906)
Sargassum muticum	(Yendo) Fensholt, 1955	*Notomastus aberans*	Day, 1957
Scytosiphon dotyi	M.J.Wynne, 1969	*Novafabricia infratorquata*	(Fitzhugh, 1973)
Stauroneis salina	W. Smith, 1853	*Platynereis cfr australis*	(Schmarda, 1861)

The biogeographical composition of alien biota is region-specific: for example, in the Mediterranean Sea most of the alien species (65–95%. depending on the western or eastern sub-basin) originate from tropical areas, mainly from the Red Sea, Indian Ocean or Indo-Pacific due to direct transport of species through the Suez Canal (Lessepsian migration) (JRC, 2010).

3.5 Other characteristics

3.5.1 Situation with regard to chemicals, sediment contamination, Hotspots, health issues and contamination of biota

Heavy metals and persistent organic compounds enter the Mediterranean from urban and industrial wastewater discharges, run-off from urban/industrial areas and accidental discharges from shipping activities, as well as through atmospheric deposition. In the marine environment, metals and Persistent Organic Pollutants (POPs) tend to precipitate with settling particles, accumulate in the sediments and enter into the food chain.

It is well known that large cities are critical sources of pollution, since most of the hazardous substances and “hot spots” are located in their neighbouring sediments. In particular metal industries accounts for major emissions of several heavy metals, such as air emissions of cadmium, lead or chromium and emissions to water of cadmium, nickel and zinc; chromium to water is instead mainly emitted by oil refining followed by the fertilizer and tanning industry. Concerning organic pollutants, the manufacture of metals is also responsible for PAHs and benzene releases. Oil refining accounts for the majority of phenols emissions, and is also relevant for benzene and PAH emissions to water (UNEP-MAP, 2009). Moreover high concentrations of hazardous substances are also found in sediments located in river mouths and estuaries of major Mediterranean rivers (like Po river) and in some areas of coastal lagoons (as in the case of Venice and Marano – Grado lagoons in Italy). For pollutants such as PAHs, atmospheric deposition may be more significant in the transfer of pollution to the open sea (UNEP-MAP, 2009).

The MED POL report on priority pollution hot spots and pollution sensitive areas developed in 1997 includes the list of pollution hot spots in all Mediterranean countries. A later revised list (EEA, 2006) of pollution hot spots and sensitive areas was developed taking into consideration the potential trans boundary effect of those hot spots, if any. Figure 3-208 shows the location along the Adriatic coasts of one or more points of diffused sources that potentially can affect in a significant manner human health, ecosystems, biodiversity, sustainability or economy.

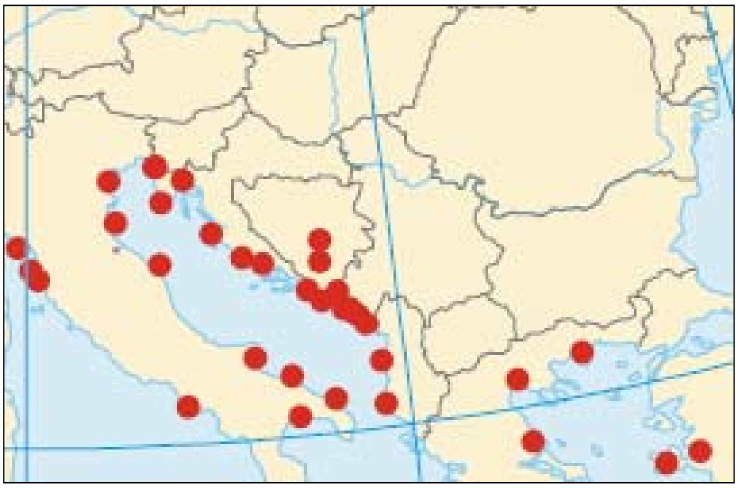

Figure 3-208 Pollution "hot spots" around the Adriatic coasts (Source: EEA, 2006).

Country specific situation are derived from European Environment Agency (EEA, 2006). Italy's coastline stretches 7,500 km and the whole territory is located in drainage basins flowing into the Mediterranean Sea. Major environmental problems are caused by urban and industrial wastewater, agricultural run-off and shipping (Figure 3-209).

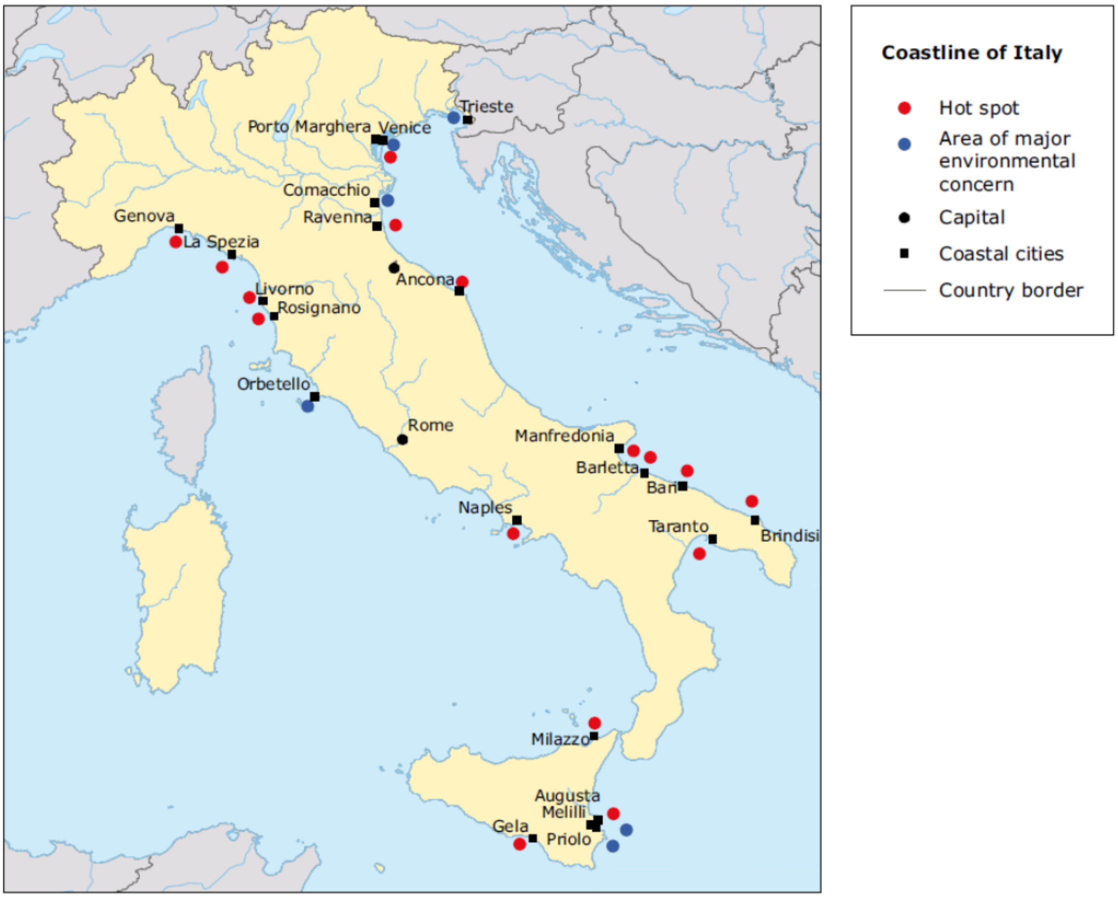

Figure 3-209 Coastline of Italy with areas of major environmental concern and pollution hot spots (Source: EEA, 2006).

Urbanisation and concretisation of the coastline is also occurring because of tourist infrastructure development. Most cities have wastewater treatment plants. however only 63 % of the population is connected to them. Furthermore, 13% of the existing plants have operational problems or need upgrading (OECD, 2002).

The river Po is a very important pollution vector in the area. transporting urban and industrial wastewater as well as agricultural run-off from its drainage basin to the Adriatic Sea.

Most important Adriatic Italian hot spot areas with relative pressures are:

- Gulf of Trieste: eutrophication problems because of nutrients transported by the river Po, as well as coastal discharges;
- Lagoons of Venice, Comacchio and Orbetello: relevant eutrophic to hypertrophic problems in the past (mid 1990s); regarding Venice lagoon in particular, high pollutants concentrations in the sediments in some areas as those facing Porto Marghera;
- Coastal areas of Emilia-Romagna: eutrophication problems because of urban/industrial wastewater derived from Po discharges; high PCB concentrations in the sediments near the Po delta. Concerning other pollutants, values registered by ARPA during 2010 in marine sediments in eight sampling stations (Figure 3-53) with half yearly sampling along Emilia Romagna coastline, showed that for PAH, arsenic, chrome VI, dioxins, furans, PCB dioxin like, environmental quality standard have not been overcome; metals like nickel and total chrome showed instead high values, not derived from anthropic activities but from the particular geologic origin of the sediments;
- Coastal areas of Marche: both in water and sediments heavy metals have been found along all the coastline, even if with values lower than fixed quality standard and without generation of pollution hot spots;
- Harbours and industrial areas of Trieste, Venice, Brindisi, Ancona, and Ravenna: petroleum hydrocarbon contamination because of intense maritime traffic (41% of the Mediterranean oil transport takes place through whole Italian ports, a relevant percentage through the Adriatic) and refineries' oil losses.

For contamination in the biota, metal concentration detected in the flesh of mussels (*Mytilus galloprovincialis*) is considered as an indicator for marine pollution because of the tendency of bivalves to accumulate pollutants in their tissues at elevated levels in relation to pollutant biological availability in the marine environment. Along the Adriatic Italian coastline values detected during 1996-2002 for lead and mercury are shown in the following pictures. For mercury in particular situations with moderate concentrations of this metal have been found in the north and south Adriatic. Site specific situations may significantly vary from the proposed figure and in some cases be particularly relevant. Thus it’s rather difficult to depict an overall picture at the basin scale.

Slovenia possesses a short coastline on the Adriatic Sea (46.6 km). It hosts approximately 80,000 people who mainly reside in the towns of Koper, Izola and Piran (Figure 3-211). More than 80% of the Slovenian coastline is urbanised and mostly within 1.5 km from the sea front. This leaves only 8 km (18%) of coast in its natural state. Major environmental problems are related to discharge of partly treated urban and industrial wastewater and run-off from agricultural land (NDA Slovenia, 2003). The areas of concern are:

- Koper Bay: receives primary treated wastewater from the town of Koper, nutrients and heavy metals (Ni, Cr and Zn) through the rivers Rizana and Badasevica (585 tonnes of nitrogen and eight tonnes of phosphorus per year);
- Bay of Piran: receives primary treated wastewater from Piran and untreated wastewater from Izola, as well as nutrients and heavy metals through the rivers Dragonja and Drnica (61 tonnes of nitrogen and 1 tonne of phosphorus per year).

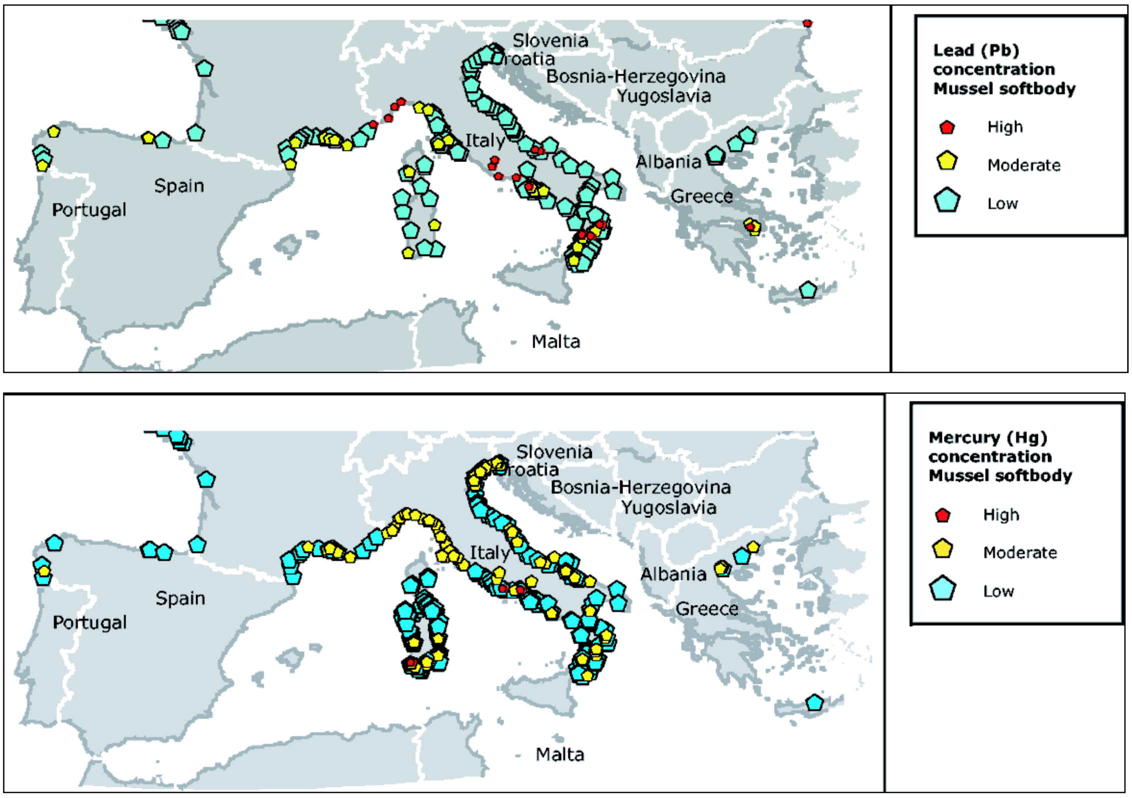

Figure 3-210 lead and mercury median concentration in mussel soft-body during 1996-2002 period (Source: EEA http://www.eea.europa.eu/data-and-maps/figures/heavy-metals-in-mussels-mytilus-edulis-median-concentration-1996-2002 last visit 22/11/2012).

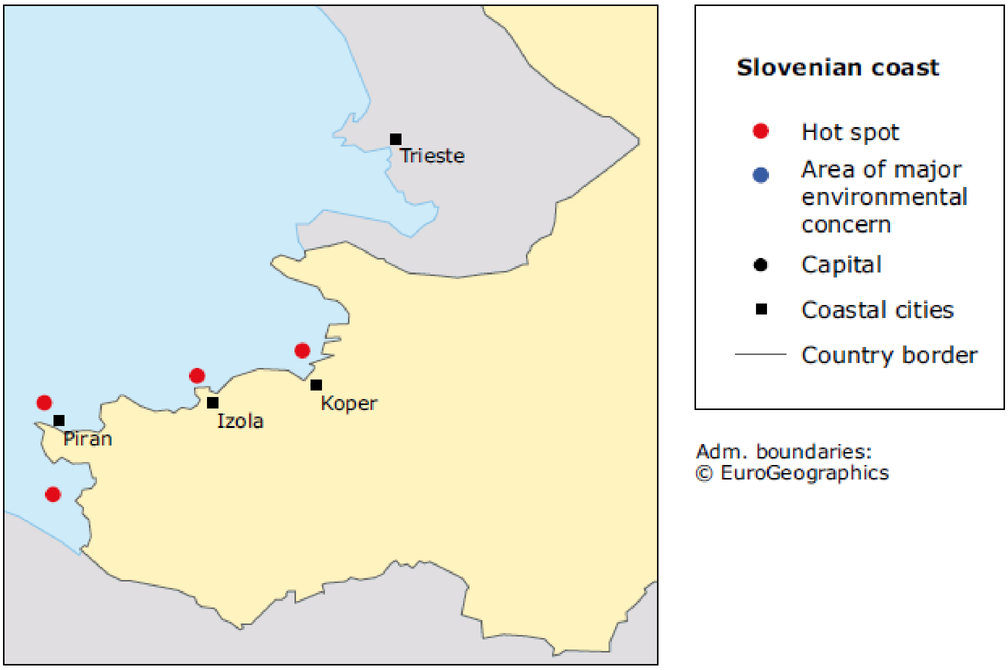

Figure 3-211 Slovenian coast with areas of major environmental concern and pollution hot spots (Source: EEA, 2006).

Croatia has a permanent coastal population of 1,000,000 which increases considerably during the summer because of tourism. The larger coastal towns are Split, Rijeka, Zadar, Pula, Sibenik and Dubrovnik. Major pollution problems include urban wastewater, eutrophication of coastal waters, and urbanisation and destruction of the marine coastal habitat (Figure 3-212). The areas of concern are:

- Kastela Bay (Split): eutrophication and accumulation of organic matter, metals and organohalogen compounds in the sediment due to the discharge of untreated urban and industrial wastewater. Biodiversity changes due to exotic species;
- Rijeka, Zadar, Pula, Sibenik and Dubrovnik: untreated urban and industrial wastewater;
- Primorsko-Goranska County (Omisalj/Rijeka oil terminal and refinery): Pipeline System located in the area (JANAF, Plc JAdranski NAFtovod Joint Stock Company). with an international oil transport system from the oil terminal to refineries in eastern and central Europe. The design capacity of the pipeline is 34 million tonnes of oil per year and the current installed capacity is 20 million tonnes per year. Although no major pollution has occurred so far, there is concern about future crude oil leakages.

Figure 3-212 Coastline of Bosnia and Herzegovina and Croatia with areas of major environmental concern and pollution hot spots (Source: EEA, 2006).

Concerning Bosnia and Herzegovina, its coastline on the Adriatic is 23 km long (Figure 3-212). hosting the town of Neum. The pollutants generated in the drainage basins of the major Bosnian rivers of Neretva (from the nearby towns of Konjic, Mostar, Caplinja, Ploce and Metcovic) and Trebisnjica (from the towns of Bileca and Neum) are carried to the Adriatic Sea affecting its environment (NDA Bosnia and Herzegovina, 2003). The major pollution problems are untreated urban wastewater and occasional stockpiles of obsolete chemicals. The areas of concern are:

- Mostar (population 130,000), Urban and industrial wastewater is discharged into the River Neretva without any treatment and urban solid wastes are dumped without proper management. Barrels of obsolete chemicals are left on both riverbanks. During the war (1992–1995), bombing destroyed electric power transformers leading to oil leakage and contamination of soil and water with PCBs;
- Neum (population 4,300) is the only urban centre in Bosnia and Herzegovina that discharges its primarily treated urban wastewater directly into the Adriatic Sea. The town population doubles during summer months because of tourism.

Concerning Montenegro the major coastal towns with environmental issues are: Bar, Herceg Novi, Kotor, Ulcinj, Budva and Tivat. The summer population of these towns increases because of tourism. Owing to the discharge of untreated urban wastewater, eutrophication problems and microbial pollution can be detected in the vicinity of coastal towns (west beaches of Bar, Herceg-Novi Bay, Kotor Bay, Port Milena Ulcinj and Tivat Bay). Similar problems exist at Velika Plaza and Ada at the river mouths.

Quarrying of stones occurs near the town of Bar and Platamuni peninsula. This causes dust generation and alteration of the coastal morphology; land erosion signs are detected in all the coastal areas. The major pollution problems are untreated urban wastewater, eutrophication of coastal waters and uncollected solid wastes. The areas of concern (Figure 3-213) are:

- Bar: urban and industrial wastewater (food);

- Herceg Novi: urban and industrial (shipyard, harbour and food);
- Kotor: urban and industrial (metal, chemicals, petroleum storage and harbour);
- Ulcinj: urban and industrial (salt and harbour);
- Budva: urban and harbour;
- Tivat: urban and industrial (shipyard and harbour).

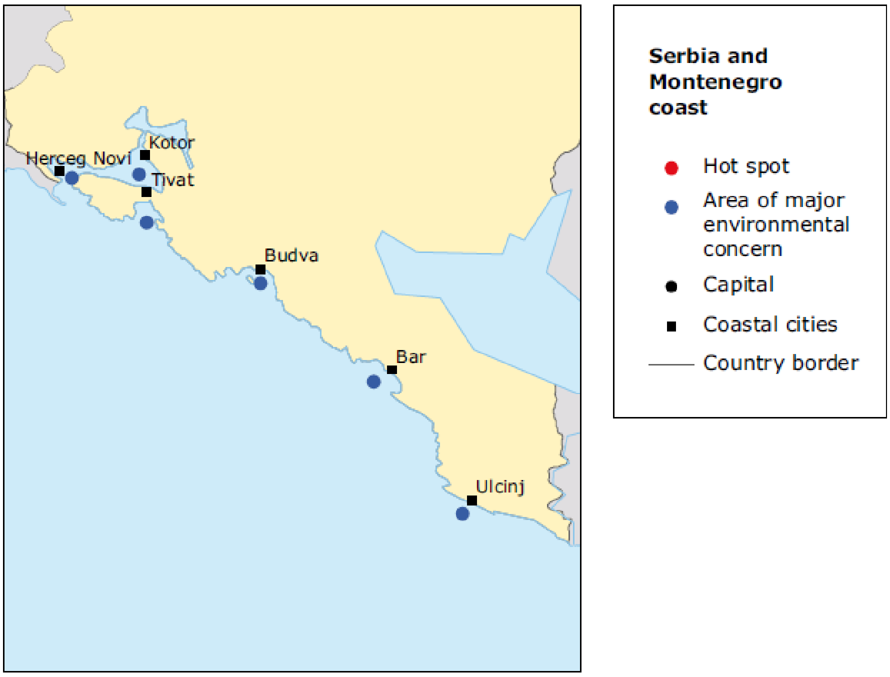

Figure 3-213 Montenegro coast with areas of major environmental concern and pollution hot spots (Source: EEA, 2006).

However, in the period between 2006- 2011 major activities have been started in all municipalities along Montenegrin coast for the improvement of the environmental situation and reduction of the land-based sources of pollution. The VODACOM consortium of coastal water supply and wastewater local companies started in 2004 the realisation of project “Improvement of water supply and wastewater system on the Coast”. So far two wastewater treatment plants are in construction for municipalities of Herceg Novi and Bar, while joint wastewater treatment plant for Kotor and Tivat is in the procedure to be built. About 130 km new sewerage pipelines are built in municipalities of Bar, Herceg Novi, Kotor and Tivat. The preparation for improvement of wastewater system and treatment plant project in Ulcinj is in final phase (source: http://www.vodacom.co.me; last access 18 June 2013). Municipality of Budva started in 2009 their own project for building of wastewater treatment plant and new sewerage system that will solve the wastewater problem for the entire territory of Budva.

Regarding the solid waste disposal problem on the Montenegrin coast, the improvements can also be seen In 2012, a new regional sanitary landfill “Možura” was opened to serve municipal waste companies from municipalities of Bar, Ulcinj and Budva. Documentation is in preparation for building of another regional sanitary landfill for municipalities of Tivat, Kotor and Herceg Novi.

Concerning Albania, approximately 58% of the Albanian population live in the coastal areas along the Adriatic and the Ionian Seas. After 1991, most large Albanian industries (e.g. mineral production and processing, pesticides, fertilisers, chemicals, plastics, paper, food and textiles) were obliged to close down.

This left stocks with obsolete hazardous substances as well as contaminated land. The main contamination problems are stockpiles of obsolete chemicals, untreated urban wastewater and solid wastes. Discharge of untreated urban wastewater, beach erosion and illegal construction on the coastline are witnessed at Vlora Bay, Porto Romano Bay, Durres Bay, Saranda Bay, Kune-Vaini lagoon, Drini River mouth (at the city of Lezhe), the Fieri district (on the Semani River), Karabasta lagoon and Divjaka Beach (Figure 3-214).

Most land based sources are located in:

- Durres district: stockpiles of lindane and chromium VI salts, untreated urban wastewater, incorrect management of solid wastes, harbour activity;
- Vlora district: mercury contamination inland of the former chlor-alkali plant detected in an area of 20 ha around the factory at a soil depth of 1.5 m; mercury in groundwater and coastal sediments of Vlora Bay; chlorinated hydrocarbons and other dangerous pollutants in soil.

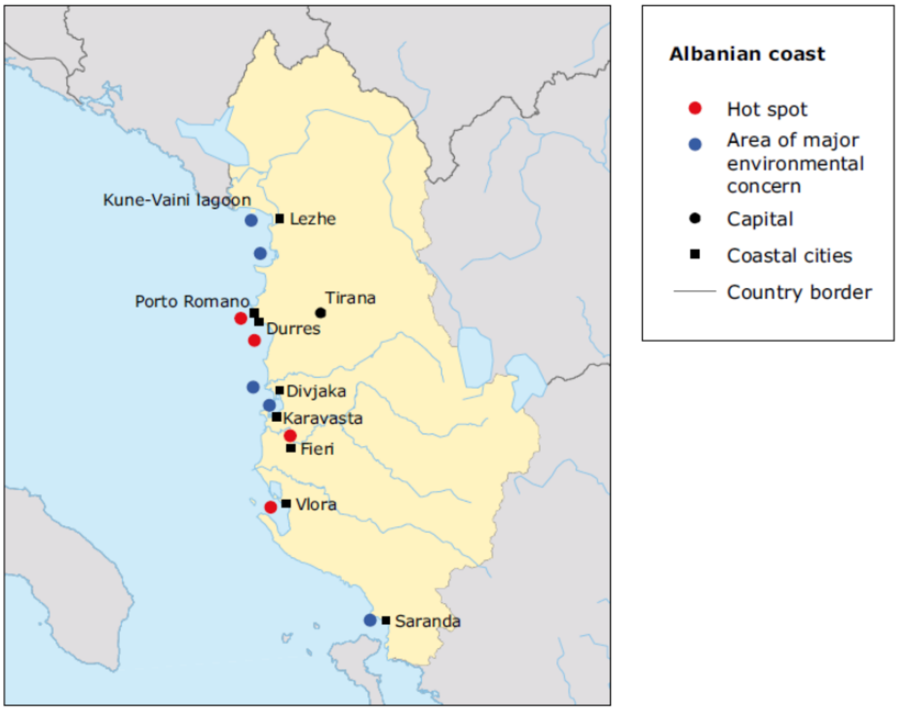

Figure 3-214 Albanian coast with areas of major environmental concern and pollution hot spots (Source: EEA, 2006).

3.6 Pressures and impacts

EU Directive 2008/56 prescribes that every Member State has to make an analysis of main pressure and impacts, including those derived from human activities, on water ecological state. In particular the analysis should consider all aspects cited in Table 3-25 (Annex III of the Directive) and include qualitative and quantitative aspects of different pressures and their tendencies. Cumulative effects, synergies and evaluations made following Community in force legislation should be considered.

Table 3-25 pressure and impact on the marine environment derived from EU Directive 2008/56.

Impact	Pressures
Physical loss	Smothering (e.g. with man-made structures, disposal of dredge spoil, etc.)
	Sealing (e.g. with permanent constructions)
Physical damage	Changes in siltation (outfalls, increased run-off, dredging/disposal of dredge spoil, etc.)
	Abrasion (e.g. impact on the seabed of commercial fishing, boating, anchoring)
	Selective extraction (e.g. exploration and exploitation of living and non-living resources on seabed and sea subsoil)
Other physical disturbance	Underwater noise from shipping, underwater acoustic equipment
	Marine litter
Interferences with hydrologic processes	Relevant changes in the thermal regime (e.g. discharge of electric power plants)
	Relevant changes in the saltiness regime (e.g. construction blocking water circulation, water extraction)
Contamination by hazardous substances	Introduction of synthetic compounds (e.g. priority substances under Directive 2000/60/EC such as pesticides, antifoulants, pharmaceuticals, resulting from diffuse sources losses, pollution by ships, atmospheric deposition and biologically active substances, etc.)
	introduction of non-synthetic substances and compounds (e.g. heavy metals, hydrocarbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration and exploitation, atmospheric deposition, riverine inputs)
	Radionuclide introduction
Systematic and/or intentional substances emission	Introduction of other substances, both solid, liquid or gaseous, in marine waters, coming from their systematic and/or intentional emission in the marine environment, allowed by other Community legislation and/or international agreements
Nutrient and organic matter enrichment	Inputs of fertilisers and other nitrogen and phosphorus-rich substances (e.g. from point and diffuse sources, including agriculture, aquaculture, atmospheric deposition)

Impact	Pressures
	Inputs of organic matter (e.g. sewers, mariculture, riverine inputs).
Biological disturbance	Introduction of microbial pathogens
	Introduction of non-indigenous species
	Selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing).

The following chapters give a general description of specific pressure and impacts identified in the assessment area following classification and guidelines provided by the EU Directive. Some of the pressure and impacts are related uses of the maritime space; their mapping is one of the scope of Shape Action 4.4 and details can be found in the related final report.

3.6.1 Physical loss

3.6.1.1 Smothering

Smothering is attributed mainly to two activities (ISPRA, 2012):

- Material discharge derived from ports dredging;
- Discharge of drilling sludge (with high water content).

In Italy the first category is regulated by DM 26 January 1996 and Legislative Decree 152/2006; these decrees allow the immersion of such materials only in marine sites with the same bottom characteristics; consequently this activity should not change the bottom nature.

Regarding the second type of materials, Information, provided by the Ministry of the Environment for the period 2006-2011, evidence that no request of discharge of these materials have been made. Consequently in Italy impacts from physical loss derived from smothering has not be detected (ISPRA, 2012).

3.6.1.2 Sealing

The following chapters analyse possible permanent anthropic structures that can create impact and pressure on the Adriatic ecosystem.

<u>Offshore gas and oil platforms</u>

The Italian Adriatic Sea is divided into different zones according to regulations and international agreements (Figure 3-215). In particular, Zone A extends in the north Adriatic Sea. north of 44° N parallel, and is bounded to the west from the low tide coast line and to the east by the boundary line Italy-Slovenia and Italy-Croatia. Zone B extends in the central Adriatic Sea between 44 ° and 42 ° N parallel and is bounded to the west from the low tide coast line and to the east by the boundary Italy-Croatia and Italy-Bosnia. Zones D and F extend in the Adriatic Sea south of 42 ° parallel and in the Ionian Sea until the Messina Straits. These zones are bounded to the west by the low tide shoreline and to the east from isobath line of the 200 m and from the Italian continental shelf as defined in the agreements with Bosnia. Montenegro, Greece and Albania.

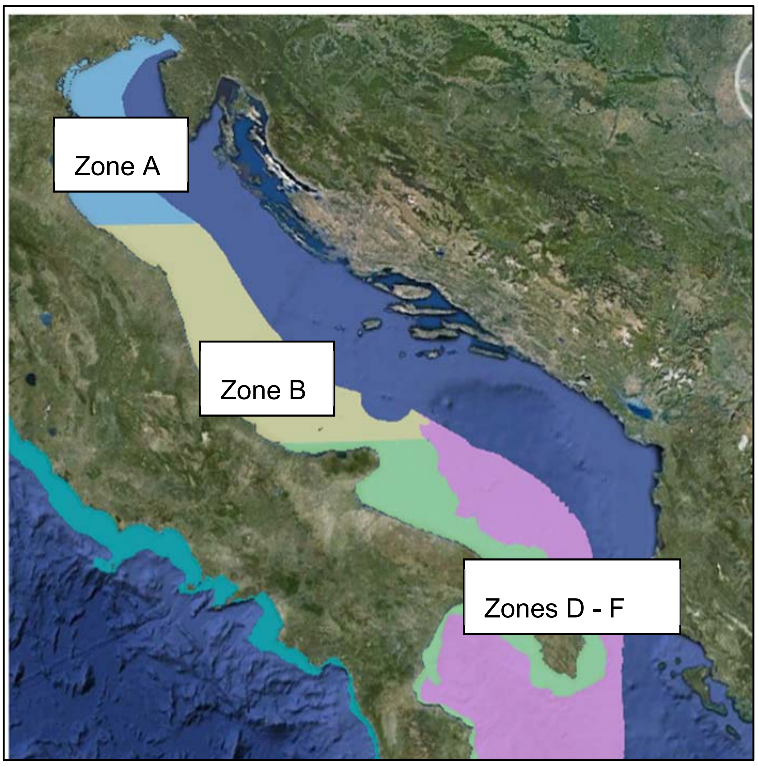

Figure 3-215 Marine zones in the Adriatic sea (Italian coasts) (source: Ministry of Economic Development, Directorate General for Energy and Mineral Resources, http://unmig.sviluppoeconomico.gov.it, last access 22 November 2012).

Within the zones above defined, the Ministry of Economic Development has granted several mining concessions for oil and gas extraction, in particular in Zone A and B. Up to the end of 2011 the number of production and exploration licenses is summarized in the following table.

Table 3-26 mining marine shares (Source: Ministero dello Sviluppo Economico - Dipartimento per l'Energia, 2012).

Marine zones	Exploration licenses		Production licenses		Total area (km^2)
	Number	Area (km^2)	Number	Area (km^2)	
Zone A	7	1,257.64	38	4,143.35	5,400.99
Zone B	3	827.23	19	3,365.13	4,192.36
Zone D	0	357.97	3	153.40	511.37
Zone F	2	1,111.17	3	618.68	1,729.85

93% of Italian production licenses concentrate in these four areas (46% in zone A and 38% in zone B), while 31% of Italian exploration licenses have been given in the Adriatic (11% in zone A and 10% in zone F). Figure 3-216 shows the areas with mining concession (both exploration and production). Regarding the distribution, Figure 3-217, derived from Ministry of Economic Development Directorate General for Energy and Mineral Resources website[34], shows, with a more detailed resolution, the situation, updated at 11/30/2011 of gas productive platforms, oil productive platforms and support non-productive platforms.

Figure 3-216 Mining concession areas in the Adriatic sea (Source: Ministry of Economic Development Directorate General for Energy and Mineral Resources http://unmig.sviluppoeconomico.gov.it/unmig/monitoraggio/mare/off-shore.asp, last access 18 June 2013).

34 http://unmig.sviluppoeconomico.gov.it/dgrme/dgrme.asp; last access 22 November 2012

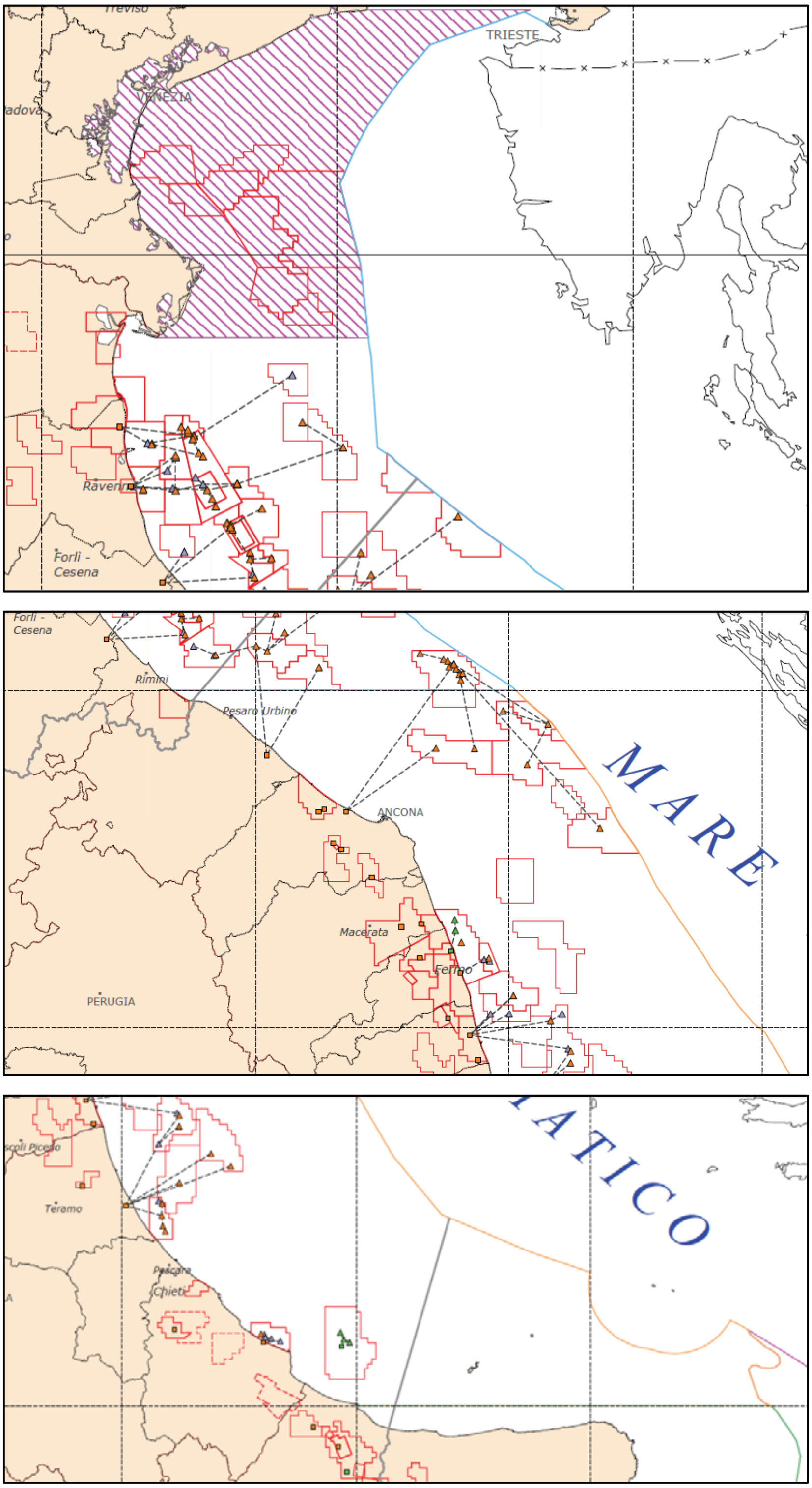

Figure 3-217 Gas and oil support platform distribution in Adriatic Sea (Italian territory) (Source: Ministry of Economic Development Directorate General for Energy and Mineral Resources[35]).

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35 http://unmig.sviluppoeconomico.gov.it/unmig/cartografia/tavole/impianti/impianti.pdf; last access 22 November 2012.

Orange triangle represents gas platforms, green triangle oil platforms and violet triangle support platforms. Polygons defined with red colour represent areas of exploration and production. Striped area in the northern Adriatic means that the area will be accessible to exploitation once there is clear evidence of non-remarkable danger of subsidence along the coasts.

Several offshore gas platforms can be identified, mostly located offshore Emilia-Romagna region. Out of the 99 platforms which are placed in the sea area between the coast and the border, considered as continental shelf, separating Italy and Croatia, over 80% are located within the 12 miles limit from the coast, which is the marine area under the jurisdiction of the Emilia-Romagna Region. Other platforms are in Marche region, located off shore Ancona city and in Abruzzo region.

Many of the active platforms are automated and remotely controlled. These plants were designed and built to last only for the period of exploitation of the methane gas field. They have an average lifespan of 20-40 years, after which the structures must be dismantled, the trench closed and the pipelines eliminated. These structures are still important elements for both the environment and navigation, are connected in an artificial way to the sea floor and therefore must be considered surface structures.

Of particular relevance is the offshore LNG terminal located in the Northern Adriatic in the proximity of Porto Levante (province of Rovigo, Veneto) (Figure 3-218), which is the first offshore structure in the world realized for the reception, storage and regasification of natural liquid gas.

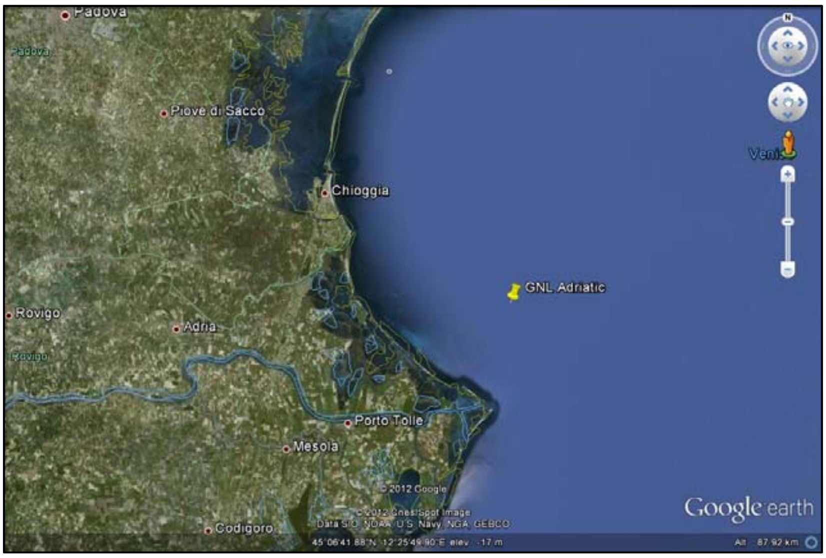

Figure 3-218 LNG Adriatic (Source: Google Earth with coordinates derived from http://www.subrovigo.it/notiziario/rubriche/normativa/64_08.pdf, last access 22 November 2012).

The structure has a regasification capacity of 8 billion cube meters which is approximately 10% of national natural gas requirement. It has a strategic relevance because it opened a new gas route independent from land pipelines. Other companies have proposed plans for developing new offshore LNG terminals. For instance an offshore terminal is proposed in the Gulf of Trieste (Terminal Alpi Adriatico, by Endesa Europa) in the Italian territorial sea, near Slovenia.

Regarding oil platforms, they are lower in number with respect to gas platforms and are concentrated in two areas, in front of Molise and Abruzzo and Marche region.

The presence of such terminals leads to competition with other maritime activities within the Adriatic Sea basin. For example, fishing is prohibited around the terminal and around the pipeline that connects the terminal with the shore (Franceschini, Raicevich & Bonometto – ISPRA, meeting in Chioggia on May 25, 2010). Offshore platforms also involve a certain risk of strong pressure on the environment; if accidents happen, the effects on the marine environment can be significant.

Some platforms have had major accidents, which have not turned into ecological disasters only because there was no oil or other fossil fuel involved. In particular, on the 29th of September 1965, the Paguro platform exploded and subsequently sank in the crater formed in the seabed by the gas that exploded and that continued to flow at a pressure of about 600 atmospheres. Consequently, even if the analysis of this component on total physical loss is still in progress, first considerations for Italy suggest that oil and gas platform incidence is not negligible (ISPRA, 2012). Concerning Croatia, there are several plans and projects to establish large natural gas platforms in the Northern Adriatic Sea basin. The only concessionaire for the exploration and production of hydrocarbons in the Croatian Adriatic waters is INA's Exploration and Production BD. In 2006 a record number of platforms have been released into production (7 platforms), which resulted in a big jump in production quantities in 2007. Consequently since 2006, due to the discovery and exploitation of new fields, gas production in the Adriatic Sea had a strong growth trend. Currently in the Croatian Adriatic there are 19 platforms (included one processing platform). The following figure shows production area (red zones). Blue areas instead indicate exploration areas. Up to now in Croatia main pressures from this component are consequently concentrated in the north Adriatic.

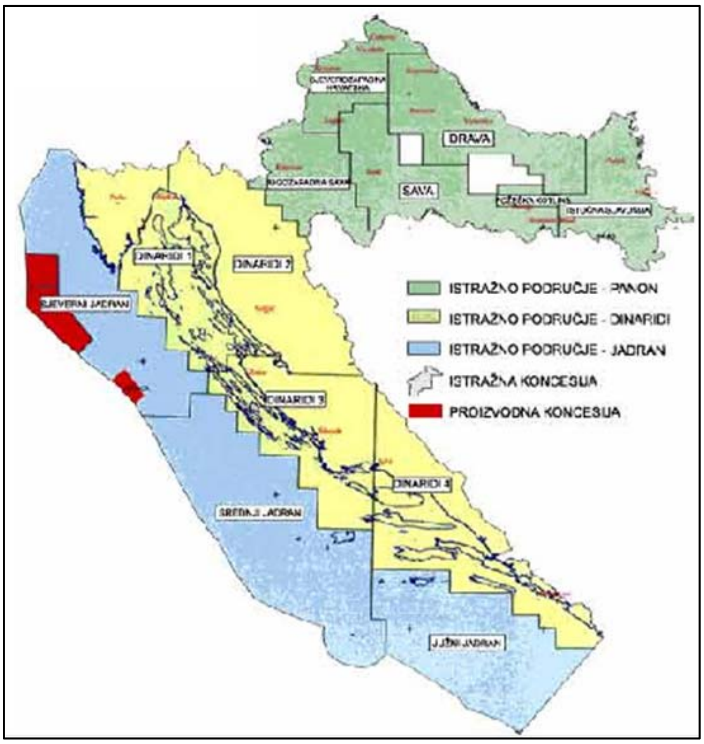

Figure 3-219 Croatian oil and gas production areas (Source: INA http://www.ina.hr/default.aspx?id=476, last access 18 June 2013).

In Albania, several foreign investments for oil and gas research have taken place. Nevertheless, no exploitation projects are in place at present. The same for Montenegro. offshore oil and gas exploration were conducted but no projects are in place at present.

In regard to Slovenia offshore natural gas platforms, the planning for a new gas terminal by Italy is expected to compete with marine environment and coastal tourism in Slovenia as the Terminal would be established only 300 m from the territorial sea of Slovenia.

Underwater pipelines

Regarding gas and oil pipelines distribution in the Adriatic, it should be noted that are mostly concentrated in Italian waters and connect oil and gas platforms with the coastal power plants and deposits. The existing connection is represented in the figure below (Figure 3-220), which identifies also areas of exploration and production (yellow zones).

Most important pipelines are located offshore central Italy and connect offshore gas production platforms with coastal power plants; in Croatian waters relevant is the pipeline connecting gas platforms offshore Istria peninsula with mainland. Consequently, even if the analysis of this component on total physical loss is still in progress. first considerations suggest that the pressure of this component regards firstly Italy and then Croatia.

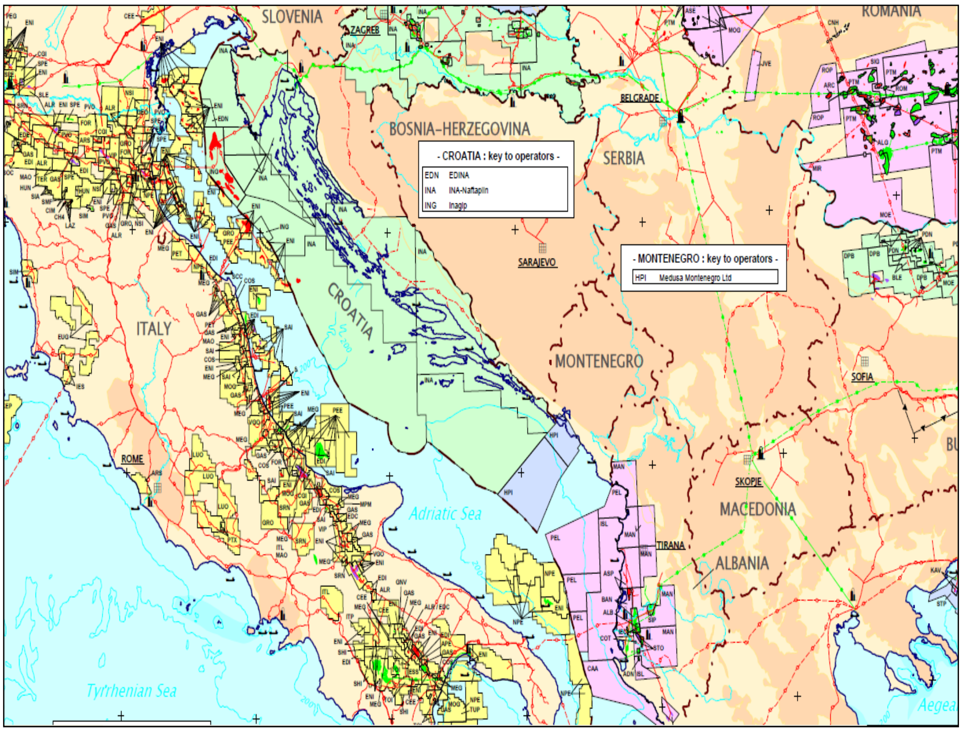

Figure 3-220 Underwater pipelines in the Adriatic sea (Source: Ministry of Economic Development Directorate General for Energy and Mineral Resources; http://unmig.sviluppoeconomico.gov.it/unmig/cartografia/cartografia.asp; last access 22 November 2012).

There are moreover some projects for the construction of other pipelines like the one connecting Albania and Puglia coast or the project for the connection between Italy and Greece via IGI project (Interconnection Greece-Italy, IGI) for the import of natural gas. This last project forms part of a larger project, named ITGI (Interconnection Turkey-Greece-Italy) project, which is a project of European interest. The IGI project (a pipeline of around 800 km) comprises an onshore (590 km) and an offshore (207 km) section called Poseidon pipeline (European Commission study, 2011).

<u>Off shore wind farms</u>

Currently Italy has no active offshore wind farms (Policy Research corporation, 2011). consequently there isn't pressure of this component on physical loss. However, according to 4C offshore[36] a considerable number of offshore wind farms are expected to be built in the next years, mostly in the south of Italy. Main project or planned Italian offshore wind farms in the Adriatic are the followings (Figure 3-221):

- Chieuti (consent application submitted with 150 MW planned);
- Termoli (concept/early planning with 441 MW planned);
- Gargano (consent application submitted with 342 MW planned);
- Manfredonia (consent application submitted with 300 MW planned);
- Margheria di Savoia (concept/early planning with 720 MW planned);
- Bari (concept/early planning with 441 MW planned);
- Cerano (concept/early planning with 441 MW planned);
- Tricase (concept/early planning with 92 MW planned);
- Trieste (concept/early planning with 30 MW planned).

Figure 3-221 Potential Italian offshore wind farms in Adriatic (Source: Policy Research corporation, 2011).

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36 http://www.4coffshore.com/ last visit 22/11/2012

In regard to the offshore wind farms in Albania, it must be noted that one offshore wind farm is currently in the early planning phase and would be located in the Albanian territorial sea. The exact location of this offshore wind farm. with 539 MW planned, is presented in Figure 3-222.

Figure 3-222 Off shore wind farms in early planning phase – Albania (Source: Policy Research Corporation, 2011).

Regarding Croatia, two wind farms projects, still dormant, have been planned offshore Bilice and Dubrovnik, with a power installed of respectively 448 and 392 MW; another one still in concept/early planning should be realized in the middle Adriatic. Off shore wind energy are not expected to be used as energy resources in the short medium term by Bosnia and Herzegovina (Policy Research corporation, 2011).

Up to now offshore power generation from wind farm in the Adriatic is still not active and consequently there is no impact, but it is likely that in the future potential deriving from this renewable energy source could became a component in Adriatic countries electricity production, even if likely not the most important one.

Concerning impacts deriving from offshore wind farms, information derived from literature (Cavicchioli et al, 2012) suggest that main social, economic, cultural impacts derive from:

- Landscape impact;
- Impacts on local environment like alteration of seabed;
- Interference with local marine activities like fishing or aquaculture and maritime transport.

An interesting still in study application for reducing the impact of offshore wind farms is the realization of multipurpose offshore stations (Airoldi et al., 2012). The concept is the integration of these plants with activities like electricity production from waves/currents, desalinization and aquaculture generating different kinds of synergies:

- Space sharing with competition reduction, improvement of electric power quality, administrative simplifications, facilitation in marine space planning;

- Infrastructure sharing with common executive design of the structures, sharing of electric connecting grids, sharing harbours and relative structures, tools sharing for installation in the sea;
- Integration of different technological processes.

The following figure shows a possible application of a multipurpose offshore wind farm associated with aquaculture activities (mussel and seaweed cultivation).

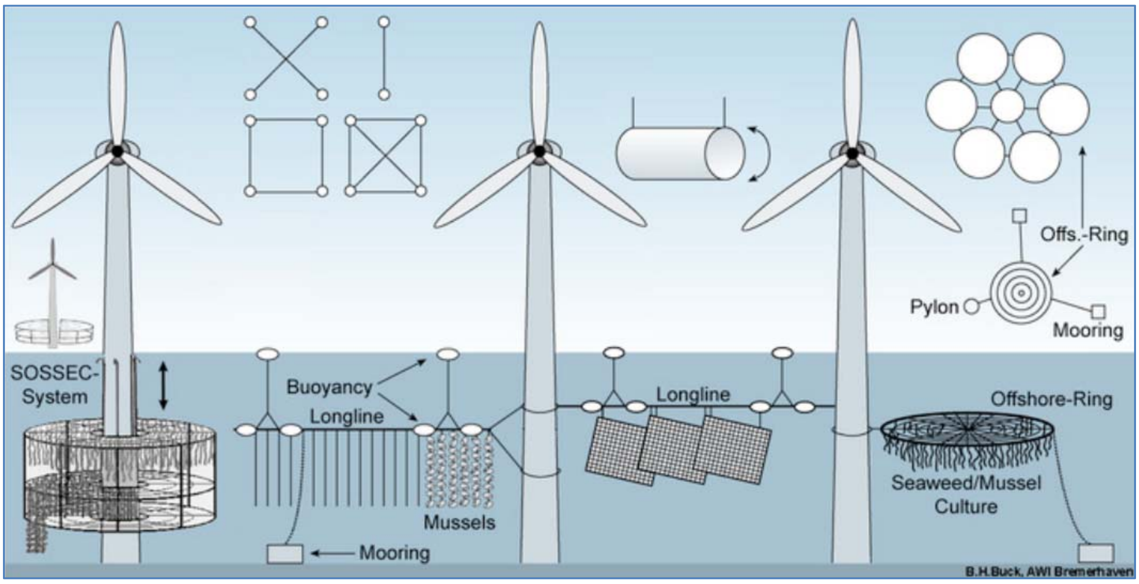


Figure 3-223 scheme of offshore multipurpose wind farm associated with aquaculture structures (molluscs and seaweed). proposed by AWI Bremerhaven (Germany) (Source: Airoldi et al, 2012).

The relevance of these kind of projects has also been recognized by the European Commission, which in 2012 launched the research project "MERMAID: innovative multi-purpose offshore platforms: planning, design and operation", with the main goal of developing concepts for the next generation of offshore platforms.

In the Adriatic a possible association between offshore wind farms and electricity production using sea current, considering also distance from the coast and water depth, could be realized in two specific areas located in south Adriatic near Gargano promontory and Otranto channel (Figure 3-224).

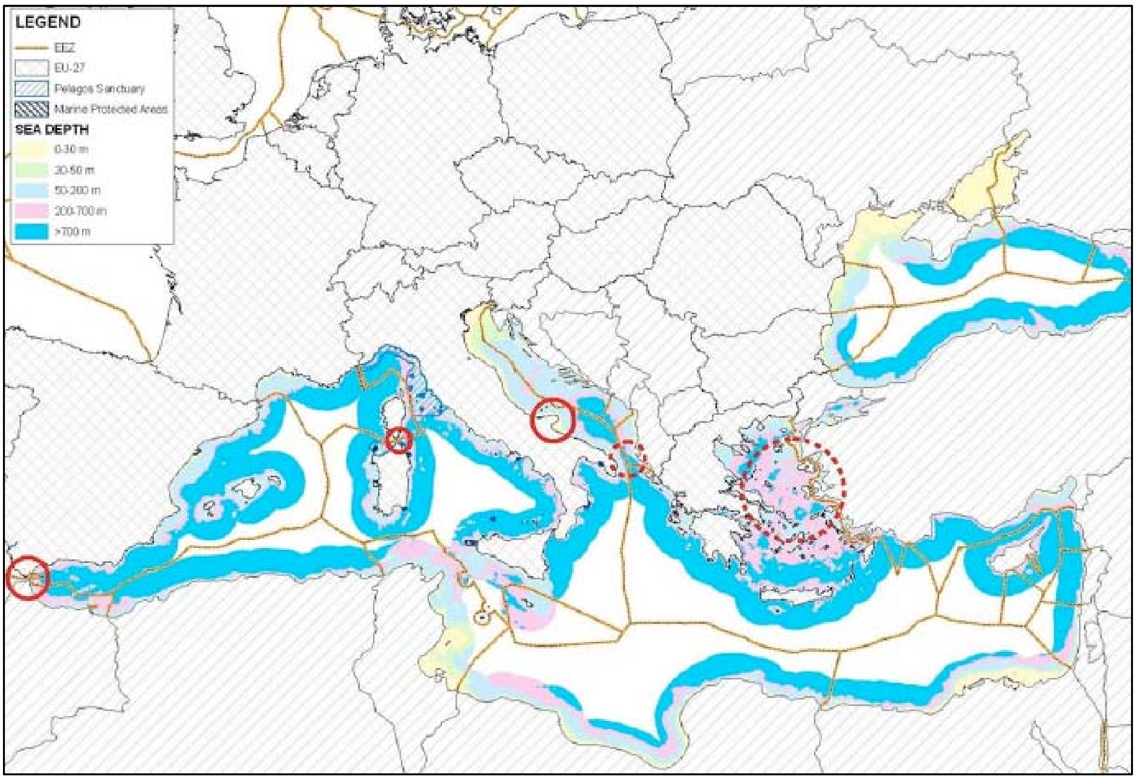


Figure 3-224 promising Mediterranean areas for combined wind and current use. continuous line: suggested areas for possible demonstrator. dotted line: interesting areas for examination (Source: Airoldi et al, 2012).

Harbours

Growing economic activity both inland as well as along the coasts have led to increased port and near-shore marine activities. These activities, which can involve shipbuilding, maintenance and repair work, as well as the operation of a large number of transport, cruise and recreational ships, are expected to increase in the future, especially in the Adriatic because of its strategic position connecting central Europe with Middle East and Africa.

Harbour and shipyards activities give, with oil and gas platforms, the most important contribute to physical loss in the Adriatic. Depending on their type, port activities range from the handling of goods, shipbuilding, maintenance and repair services, to recreational marinas and can also be associated with a large number of environmental concerns. Among the worst are damage to marine ecosystems and interferences with biological processes in marine species.

Regarding the Adriatic sea, in Italy potential hot spot areas can be identified nearby harbours listed in Table 3-27 and Figure 3-225, representing main Adriatic Italian ports. Quantities of goods handled, number of container inwards/outwards (expressed in TEU) and passengers arrived/departed in 2011 can give an indication of the correlated potential impact.

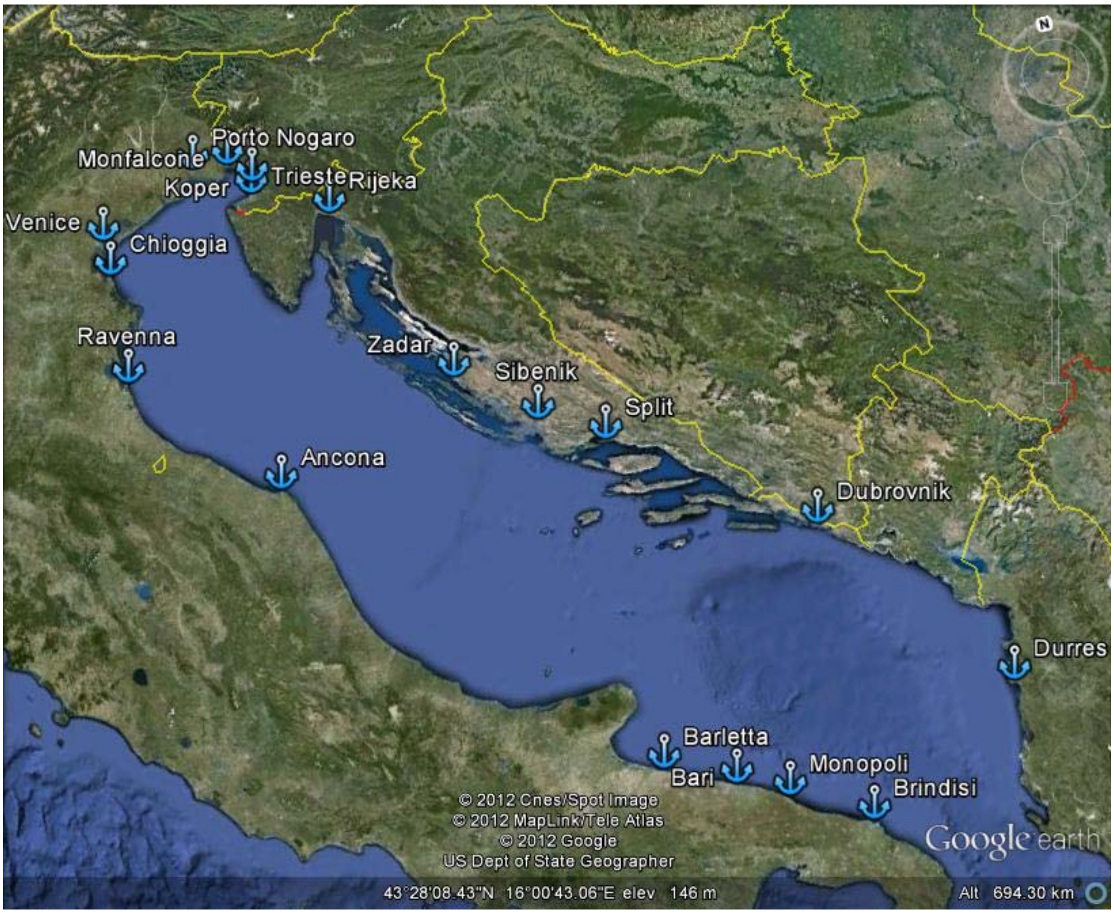


Figure 3-225 map of Adriatic ports (Source: Google Earth).

Table 3-27 main Italian Adriatic harbours and relative handled goods and passengers arrived/departed in 2011 (Source: Assoporti; http://www.assoporti.it/; last access 22 November 2012).

Harbour	Total good handled (solid. liquid. various) (x 1000 ton)	Total TEU's	Passengers
Brindisi	9,892	485	527,001
Bari	5,063	11,121	1,951,665
Barletta	942	-	-
Monopoli	326	-	193
Ancona	8,413	120,674	1,553,787
Ravenna	23,343	215,336	163,829
Chioggia	2,141	-	-
Venezia	26,321	458,363	2,239,751
Portonogaro	1,206	-	-
Monfalcone	3,467	591	213
Trieste	48,237	393,186	56,973

Venice, with high cruises traffic and important quantities of goods handled especially, in the past, oil products, combined with the relevance and fragility of lagoon ecosystem, can be surely considered a hot spot, but also Trieste, main Adriatic Italian freight harbour can suffer relevant impacts. Going southern Ravenna, with its petrochemical industries, Ancona both with cruises and freight transport are vulnerable areas. Relevant are finally Bari and Brindisi harbours.

Concerning specifically north Adriatic ports it needs also to be underlined that, following EU indications on the development of the “Motorway of the seas”, there are two projects for the realization of a new terminal Ro-Ro in the Venice lagoon and a terminal offshore Venice for container and tanker ships. This last project in particular could create an important network also with other north Adriatic ports like Trieste, Ravenna, Koper and Rijeka and could realize a gateway of goods fluxes between northern Africa-Middle East and central Europe generating high traffic fluxes of ships with relative pressures.

For ports belonging to the Slovenia and Croatian main ports the 2010 situation (Koper port data refers to 2011) is summarized in Table 3-28. In the case of Croatia, the table reports data referred to the whole Harbour Master Office (including the major port and minor ports as for example those located in the islands) and the data related to the corresponding principal port.

Table 3-28 Eastern Adriatic harbours and relative handled goods, TEU and passengers arrived/departed (Croatian data refers to 2010, Slovenia data refers to 2011) (Source: http://www.luka-kp.si/ita/, last access 22 November 2012; for the Slovenia data and Croatian Bureau of Statistics, 2011 for the Croatian data).

	Country	Total good handled (solid, liquid, various) (x 1000 ton)	Total TEUs	Passengers (x 1000)
Port of Koper (2011)	Slovenia	16,198	590,000	133
Harbour Master Office Dubrovnik	Croatia	212		5,288
Port of Dubrovnik	Croatia	11		2,940
Harbour Master Office Ploce	Croatia	4,510		171
Port of Ploce	Croatia	4,485	20,155	169
Harbour Master Office Pula	Croatia	3,976		2,009
Port of Pula	Croatia	669		535
Harbour Master Office Rijeka	Croatia	10,727		3,876
Port of Rijeka	Croatia	2,095	121.090	186
Harbour Master Office Senj	Croatia	93	-	2,099
Harbour Master Office Split	Croatia	3,195		8,384

	Country	Total good handled (solid, liquid, various) (x 1000 ton)	Total TEUs	Passengers (x 1000)
Porto of Split	Croatia	2,746	3,397	3,836
Harbour Master Office Sibenik	Croatia	645		783
Port of Sibenik	Croatia	645		552
Harbour Master Office Zadar	Croatia	947		4,951
Port of Zadar	Croatia	790		2,168

Most important commercial ports are those of Koper and Rijeka both in terms of good handled and TEUs, while the ports of Split, Zadar and Dubrovnik assumes particular relevance in terms of passengers (including cruise and ferries traffic); passenger traffic are also significant in Pula and Senj.

Concerning shipyards, they are the hub around which the maritime industrial sectors structure themselves; they face a growing number of issues due to importance of environmental and climate change matters, with a focus on pollution control and prevention measures. Some important Adriatic shipyards are: Cantiere Navale Visentini (based in Donada near Venice, Italy), Fincantieri Cantieri Navali Italiani S.p.A. (based in Trieste and Venice, Italy), 3 Maj (based in Rijeka, Croatia), Kraljevica Shipyard (based in Kraljevica, Croatia) Brodosplit Shipyard Company, located in the Supaval bay (Croatia), Uljanik (located in Pula, Croatia) (See Figure 3-226).

The most direct environmental impact from shipbuilding is naturally incurred by the shipyards'own activities, which apart from the construction of ships typically also include ship maintenance and repair services. Activities in shipbuilding that are of highest direct environmental concern include metal working activities (thermal metal cutting, welding and grinding), surface treatment operations (abrasive blasting, coating and painting), ship maintenance and repair activities (bilge and tank cleaning) (OECD, 2010). Each of these processes is a major undertaking in its own right and includes a large number of intermediate steps. For shipbuilding these would include the:

- Handling of raw materials;
- Fabrication and surface treatment of basic steel parts;
- Joining and assembly of fabricated parts into blocks;
- Erection of ship structures through the fitting and welding of blocks;
- Outfitting of ships with electronic equipment;
- Preparation and installation of various fabricated parts that are not of a structural nature.

Figure 3-226 Map of some Adriatic shipyards (Source: Google Earth).

Maintenance and repair activities instead typically include:

- Surface cleaning and treatment operations;
- Oil transfer operations;
- Servicing of machinery and other equipment.

Moreover, due to the size of ships only a few shipyards have the capability of constructing, maintaining and repairing vessels under cover. Like other outdoor construction zones this leads to elevated risks of exposing the surrounding environment to potential pollutants. For shipyards this risk is further exacerbated by the fact that shipyard activities happen over, in, under or around water, which creates additional pathways for exposing waterways to toxic and hazardous materials; either directly or through runoffs, also known as stormwater.

Environmental impacts deriving from shipbuilding, maintenance, transport activities and cruises consequently create specific hot spots areas near harbours generating different kind of impact on local ecosystem and human health.

Coastal defence

In addition to harbour construction, sealing is also correlated to operas like dikes for the protection of ports and coasts against storms and winds. These works are also associated with coastal erosion protection. In particular such operas can include (APAT, 2007):

- Remote lengthwise operas like emerged or flooded barriers;
- Transversal emerged or flooded composite, transition, flooded operas and headlands;
- Adherent operas like cliffs, bulkheads, walls;
- Beach reconstitution operas like nourishment.

In Italy most of Adriatic coastline has been reinforced with such operas, as shown in the following figure referred to year 2005.

Figure 3-227 Italian and Slovenian Adriatic coastal defence works year 2005 (Source: European Atlas of the Sea; http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/, last access 17 June 2013).

3.6.2 Physical damage

3.6.2.1 Changes of sedimentation rates

Changes of sedimentation rates mainly include the effect of ship transport, river contribution, and offshore platforms. Data provided regarding Italy (ISPRA, 2012) identifies two areas (assessment areas) that can be considered mostly representative of Adriatic conditions, based on physical chemical and hydrologic characteristics, pressure presence or absence and presence of particular habitats (Figure 3-228).

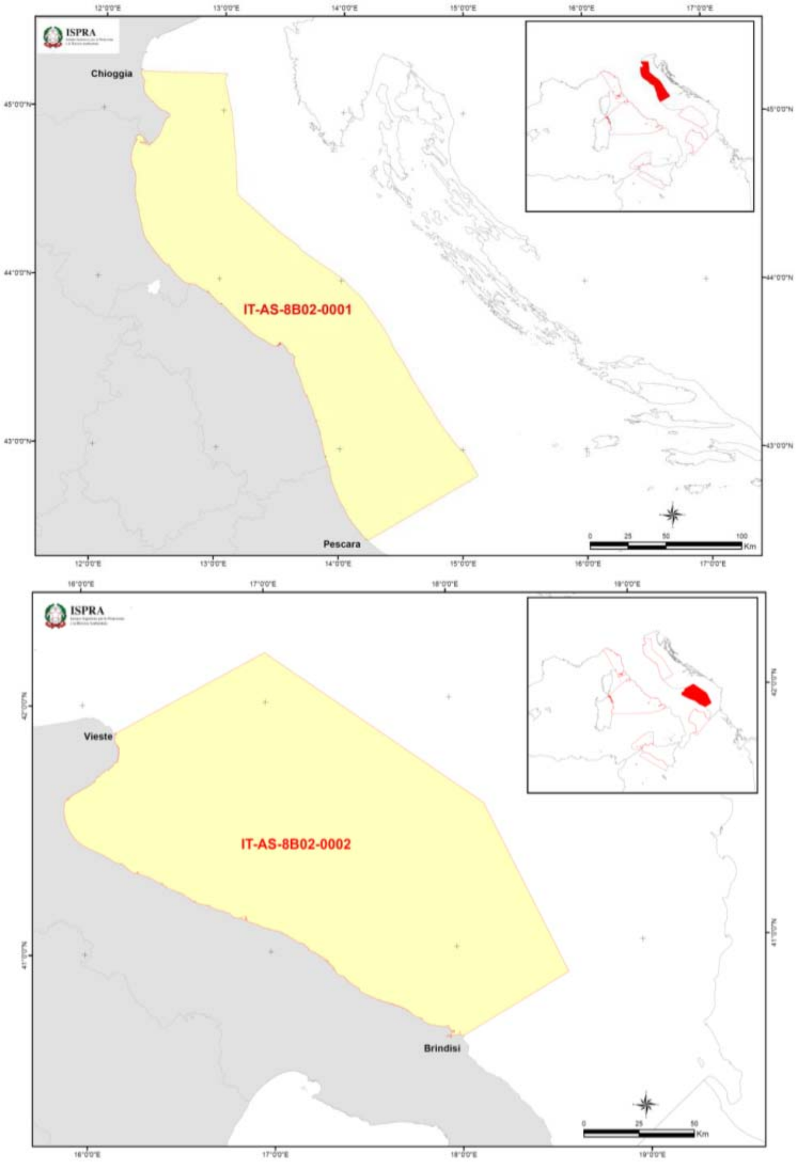


Figure 3-228 assessment areas for physical damage (Source: ISPRA, 2012).

At the moment the percentage of the assessment areas undergoing physical damage caused by changes in the sedimentation rates is not known and no pressure evaluation can be done because data still have to be gathered or are partial.

3.6.2.2 Scraping

Scraping involves the following activities:

- Trawling, which affects mostly mobile seabed beyond 3 nm from the coast with depths ranging from 50 to 1000 meters; it is considered the most relevant activity generating a physical damage in the open sea;
- Ship berth, within 3 nm from the coast or at depths less than 50 m.

Data provided by ISPRA (2012) regarding Italy detect two relevant assessment areas, based on physical chemical and hydrologic characteristics, pressure presence or absence and presence of particular habitats (Figure 3-228). At the moment the percentage of the assessment areas undergoing physical damage caused by scraping is not known and no pressure evaluation can be done because data still have to be gathered or are partial.

3.6.2.3 Selective extraction

Selective extraction mainly includes two activities:

- Marine sands dredging;
- Harbour sediment dredging.

At the moment the percentage of the areas undergoing physical damage caused by selective extraction is not known and no pressure evaluation can be done because data still have to be gathered or are partial. Nevertheless some areas committed to these activities can be defined. In the north Adriatic areas used for dredging and discharges of coastal muds are mainly located in front of Emilia Romagna coastline and near Trieste gulf.

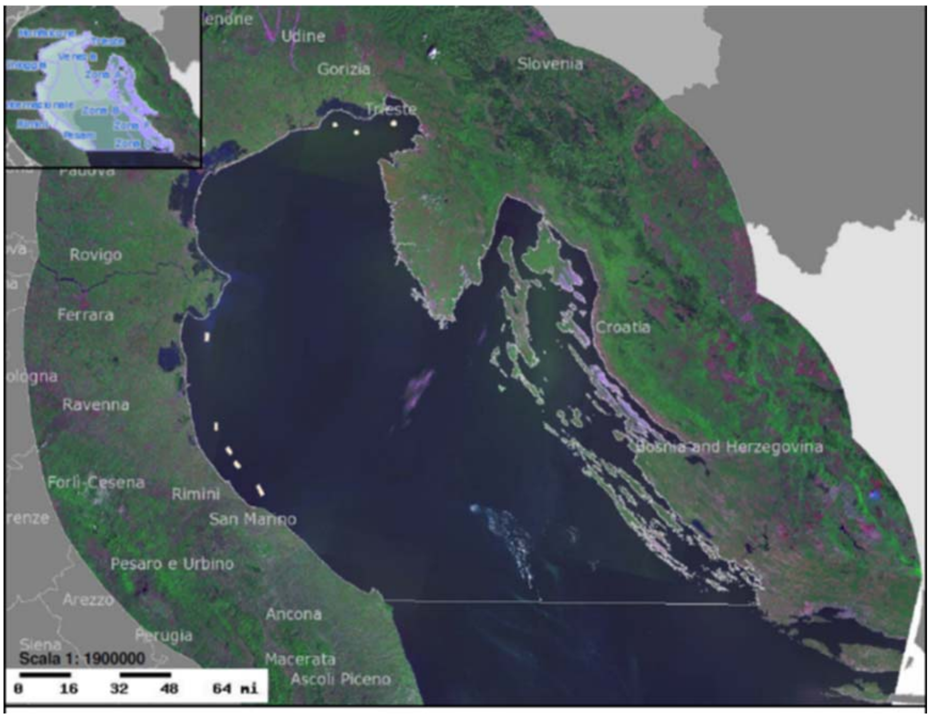


Figure 3-229 Northern Adriatic areas used for dredging and discharge of coastal muds (Source: ARPA Friuli Venezia Giulia http://mapserver.arpa.fvg.it/adriblu/map.phtml, last access 22 November 2012).

The use of sand extraction for beach nourishment is expected to increase in a significant way. Potential competition can be expected between the extraction of sand from marine deposits for the nourishment of eroding beach zones, the exploitation of oil and gas and other economic activities of the area (among others fishing, mariculture and submarine pipelines). Beside competition with maritime activities, the sand extraction also has environmental impact. The impact depends on the area of extraction, since richness of the soil in terms of flora and fauna is different in each area. It is believed that their impact is particularly significant only on a local scale, as testified by Emilia Romagna, one of the first regions in Italy to identify beach nourishment as the best method to defend beaches from erosion (Figure 3-230) (European Commission Maritime Affairs, 2011). The figure shows also the thickness of sandy deposits. A map of sand borrows areas for littoral reinforcement of Veneto Region is also provided (Figure 3-231).

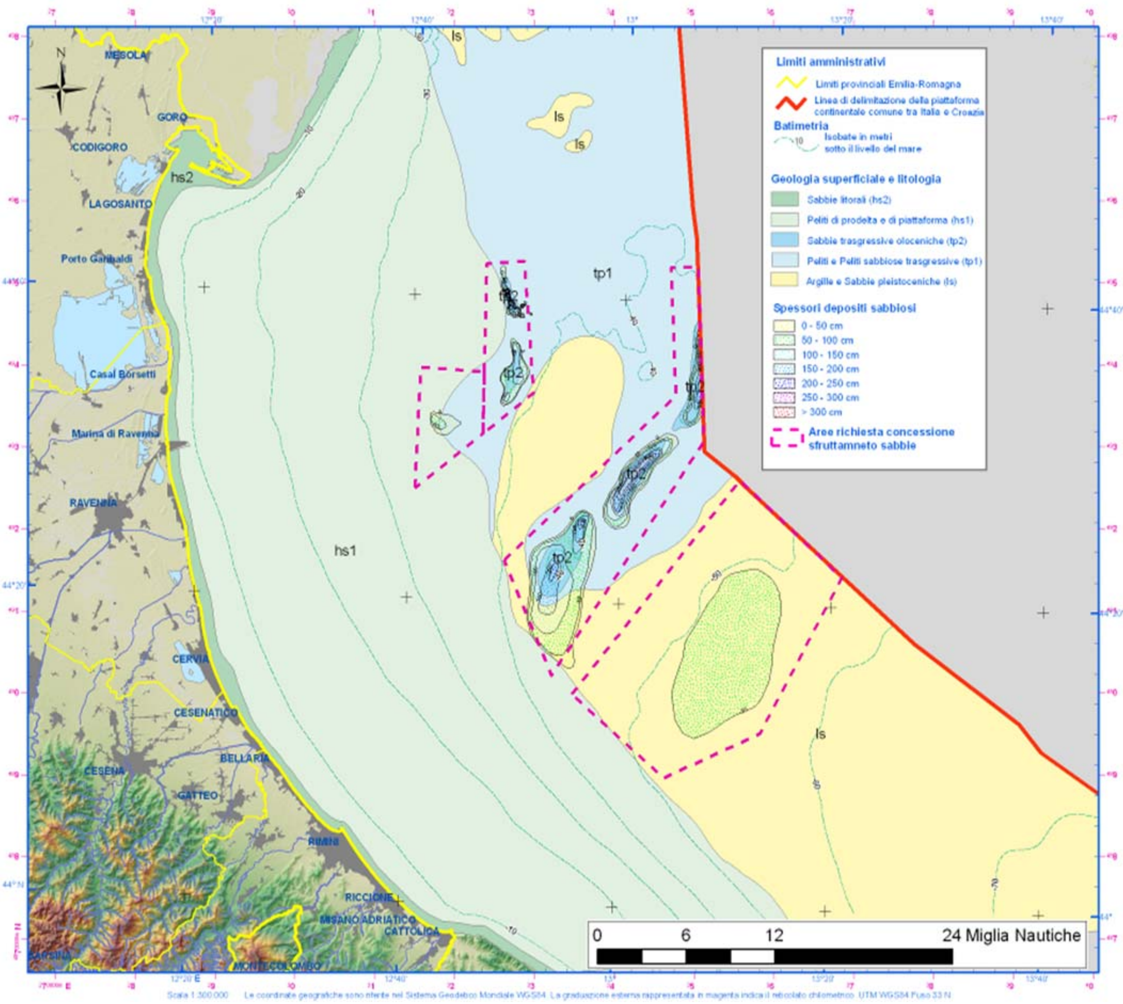


Figure 3-230 Maritime activities in Emilia Romagna Region (Source: Regione Emilia Romagna[37]).

37 http://ambiente.regione.emilia-romagna.it/geologia/notizie/primo-piano/in_sand-sistema-informativo-per-la-gestione-dei-depositi-di-sabbia-sommersi-utili-al-ripascimento-costiero , last access 12 December 2012.

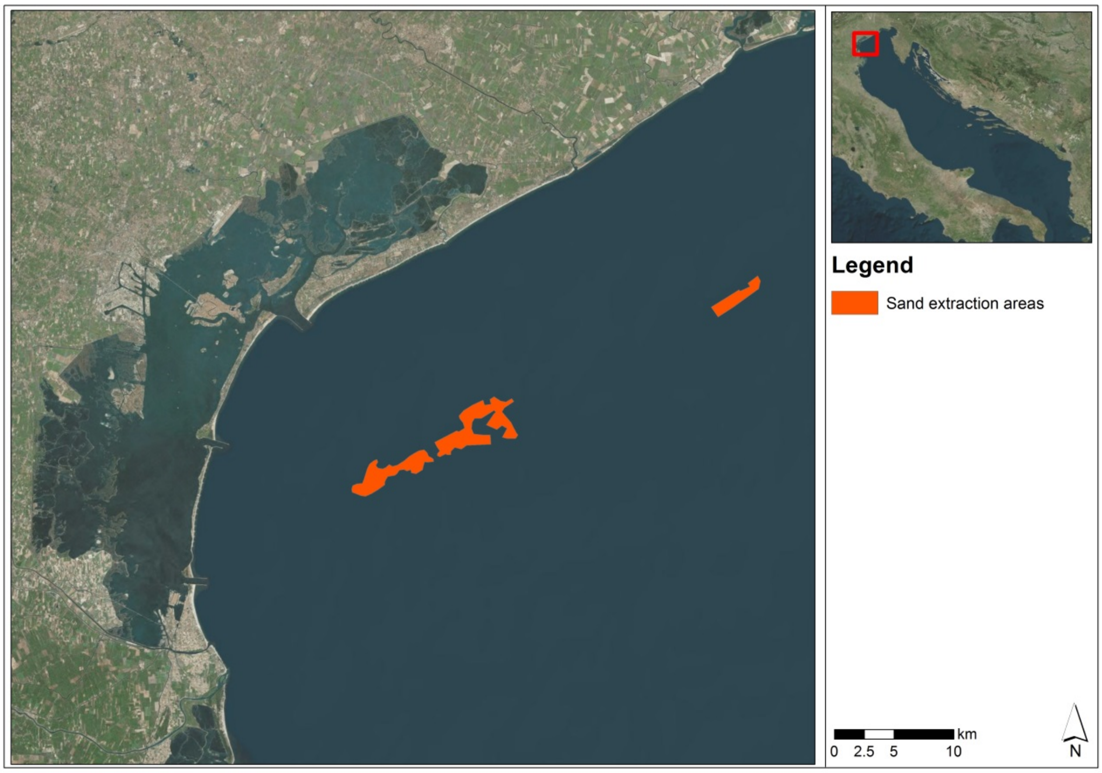


Figure 3-231 Sand extraction areas in front of Veneto Region.

3.6.3 Other physical disturbance

3.6.3.1 Marine litter

Marine litter produces a wide variety of negative environmental, economic, safety, health and cultural impacts. Most marine litter has a very slow rate of decomposition, leading to a gradual, but significant accumulation in the coastal and marine environment.

Pollution caused by discharge of solid waste and litter into the sea (especially non-biodegradable plastic packaging and tar balls) is a significant cause of degradation of both the land and marine coastal fringe.

The relevance of marine litter problem has also been stressed by European Commission, which recently launched three studies to gather strategic information and support the implementation of Marine Strategy Framework Directive (MSFD) requirements on marine litter and further develop the policy framework for this issue. One of these projects, entitled “Pilot projects – plastic recycling cycle and marine environmental impact – Case studies on the plastic cycle and its loopholes in the four European regional sea areas” was developed in order to pinpoint the major possible sources of marine litter in four study-sites, representative of the four European areas. Sources of marine litter are traditionally classified into land-based or ocean-based, depending on where it enters the water; marine litters are moreover strongly influenced by ocean currents, tidal cycles, regional-scale topography, including sea-bed topography and wind.

Land-based sources of marine litter originate from coastal or inland areas including beaches, piers, harbours, marinas, docks and riverbanks. Municipal landfills (waste dumps) located on the coast, water bodies such as rivers, lakes and ponds that are used as illegal dump sites, riverine transport of waste from landfills and other inland sources, discharges of untreated municipal sewage and storm water, industrial facilities, medical waste, and coastal tourism involving recreational visitors, are the primary sources of land-based marine litter. Natural storm-related events can all create large amounts of materials that are washed from coastal areas and end in the marine environment. High winds, large waves and storm surges produced by these natural events cause land-based items to be introduced into the marine environment (NOAA, 2008).

Human behaviours and actions – accidental or intentional – are the sources of ocean-based marine litter. The majority of sea or ocean-based sources of marine litter come from (UNEP, 2009):

- Merchant shipping;
- Ferries and cruise liners;
- Fishing vessels;
- Military fleets and research vessels;
- Pleasure craft;
- Offshore oil and gas platforms and drilling rigs;
- Aquaculture installations.

Regarding the Mediterranean sea, result emerged from UNEP 2011 report for years 2002-2006 showed that marine litter on beaches in the Mediterranean originates from shoreline and recreational activities and is composed mainly of plastics (bottles, bags, caps/lids etc.), aluminium (cans, pull tabs) and glass (bottles) (52% - based on item counts). Marine litter from smoking related activities accounts for 40% (collected items) which is considerably higher than the global average. In terms of marine litter floating in the sea, plastics account for about 83.0%, while all other major categories (textiles, paper, metal and wood) account for about 17% (Figure 3-232).

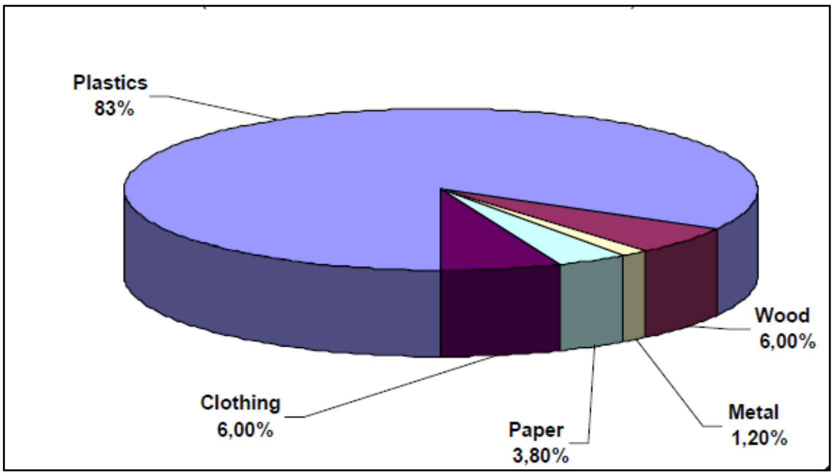


Figure 3-232 Major types of marine litter found in the Mediterranean (in terms of number of items observed) (Source: UNEP, 2011).

Concerning the Adriatic the UNEP/MAP/MED POL Report (2005) identifies for each Adriatic country the main sources of marine wastes (Figure 3-233). For Italy and Albania no data are available. The situation emerged shows that for Croatia different marine solid waste sources have generally the same relevance, for Bosnia Herzegovina sources are equally distributed between “households”, “villages” and “tourist facilities” categories, while for Slovenia the most important contribute (50%) is given by “household” category.

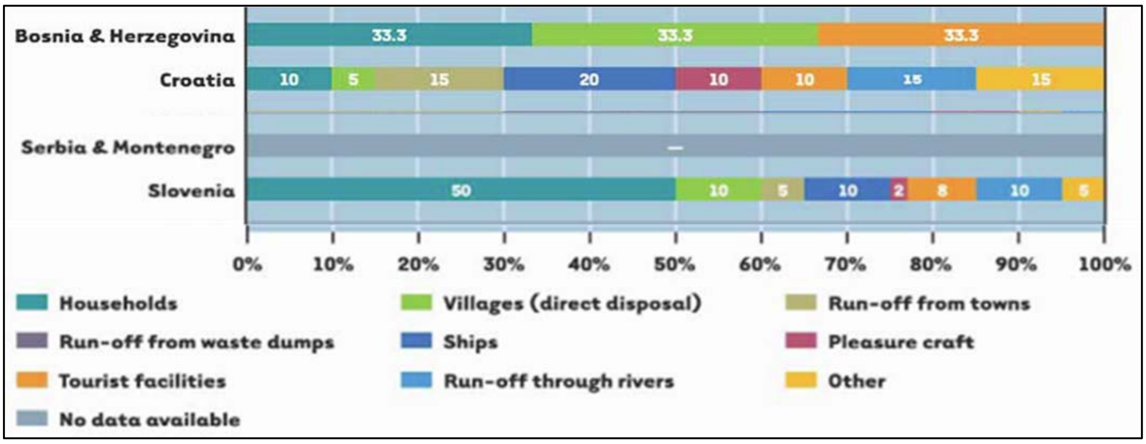


Figure 3-233 Sources of marine solid waste in some Adriatic country (Source: UNEP/MAP/GEF).

The sources of marine waste are nevertheless country specific and are dependent from the country of origin of the waste. Moreover the degree of awareness and response varies according to the source of litter. The proximity of the land and the control of litter produced from the land. together with concerns regarding visual pollution. mean that this waste receives the greatest attention, as it is harmful for beaches, ports and coastal zones.

Regarding litter management in relation to merchant ships, pleasure craft and marinas there are country specific regulations for their management, with necessary facilities and units often placed under the responsibility of port authorities and managers of marinas. By contrast. management of marine litter particularly that on the seabed is almost ignored by the majority of the countries. Up to now in Italy main pressures derive from marine transport, coastal development and oil extraction. There aren’t nevertheless sufficient data for giving a complete assessment of the marine litter situation. As suggested by ISPRA (2012), quantities, distribution and composition along the coastline, in the surface, in the water column and bottom are not well known and specific monitoring campaigns considering also currents should be made. Also impact on biological communities adopting appropriate indicators and identifying target species need to be done.

3.6.3.2 Underwater noise

Underwater noise presents a risk to marine biodiversity, although specific data and examples are not available to assist in identifying policy options to address this threat. Further information is still needed on noise distribution and trends and its effects on different organisms.

Energy input can occur at many scales of both space and time. Anthropogenic sounds may be of short duration (e.g. impulsive) or be long lasting (e.g. continuous). The first type derives mainly from oil and gas extraction activities, pole installation for platform and wind farm construction while the second is mainly generated by marine transport. Impulsive sounds causes different behavioural reactions like stop feeding and breeding in the area involved or physiological effects (temporary or permanent harm to aural system); continuous sound instead degrades auditory habitat obstructing breeding, feeding and predator localization. Impulsive sounds may however be repeated at intervals (duty cycle) and such repetition may become "smeared" with distance and echoing and become indistinguishable from continuous noise.

Higher frequency sounds transmit less well in the marine environment (fine spatial scale) whereas lower frequency sounds can travel far (broad spatial scale). There is however great variability in transmission of sound in the marine environment.

Organisms that are exposed to sounds can be adversely affected over a short time-scale (acute effect) or a long time-scale (permanent or chronic effects). Adverse effects can be subtle (e.g. temporary harm to hearing, behavioural effects) or permanent (e.g. worst case, death).

High amplitude, low and mid-frequency impulsive anthropogenic sounds (e.g. pile driving, seismic surveys and some sonar systems) are those that have caused the most public concern, particularly in relation to perceived effects on marine mammals (mostly odontoceti and misticeti) and fish (coastal, pelagic demersal and abyssal fishes). There is a variety of degradation gradients caused by such noise, the scale of these depending on the marine organism under consideration and the loudness, frequency and persistence of the sound. In principle, sound input is likely to have greater adverse effects at higher sound amplitudes (loudness) and with a greater number of inputs (persistence). Lower frequency sounds instead affect a wider area, but this is complicated by the ability of organisms to detect a limited range of sound frequencies; sounds outside their range of detection will be less likely to have an adverse effect (JRC, 2010).

In relation to the underwater noise, Good Environmental Status certainly occurs when there is no adverse effect of energy inputs on any component of the marine environment. Nevertheless the current knowledge still doesn't allow defining precisely the Good Environmental Status; this inability has partly to do with insufficient evidence, but also to no fully accepted definition of when, for example, a behavioural change in an organism is not good. The regulation of highly visible activities such as tourism and fishing has proven very difficult; regulating across user groups and industries and national boundaries to control noisemaking activities will prove even more challenging.

Up to now Italy has not yet developed a strategy for underwater noise measurement, ISPRA (2012), only mentions punctual measurements (in Adriatic only nearby Po delta and Miramare area near Trieste) and a whole map of the Adriatic underwater noise distribution with sensitive areas and causes generating such noise does not exist.

Nevertheless because underwater noise can be considered a transboundary pollutant, it implies that underwater noise can create negative externalities over across political and legal boundaries and affect marine mammal populations. Because of its nature, ocean noise should be consequently best regulated with an international transboundary strategy, rather than purely national approach, particularly in the Adriatic with its high maritime traffic and gas/oil platforms presence.

3.6.4 Interferences with hydrological processes

3.6.4.1 Changes in the thermal regime

Regarding Italy, results derived from ISPRA (2012), based on a period of three years (2008-2010) during which Italian Regions made pressure and impact analysis in accordance with article 5 of the Water Framework Directive (Directive 2000/60/CE), don't' evidence coastal and marine water systems subjected to changes in the thermal regime (less than 1% of the whole basin is subjected to interferences with hydrological processes). Consequently physical, chemical and biological impacts of the disturbances with hydrologic processes and alterations of physiographic conditions on seabed (and associated communities), functional groups (including birds and mammals) and water column are not considered as significant.

3.6.4.2 Changes in the salinity regime

Regarding Italy, results derived from ISPRA (2012), based on a period of three years (2008-2010) during which Italian Regions made pressure and impact analysis in accordance with article 5 of the Water Framework Directive (Directive 2000/60/CE), don't' evidence coastal and marine water systems subjected to saline intrusions or alterations (less than 1% of the whole basin is subjected to interferences with hydrological processes). Consequently physical, chemical and biological impacts of the disturbances with hydrologic processes and alterations of physiographic conditions on seabed (and associated communities), functional groups (including birds and mammals) and water column are not considered as significant.

3.6.5 Contamination by hazardous substances

3.6.5.1 Introduction of synthetic and non-synthetic substances and compounds

Synthetic and non-synthetic substances and compounds include many contaminants with specific properties and toxicity which can be divided into:

- Metals like chromium, mercury, cadmium, nickel, arsenic, lead and zinc;
- Hydrocarbons (heavy with C>12 and light with C<=12);
- Polycyclic aromatic hydrocarbons (IPA), particularly anthracene and benzo(a)pyrene;
- Organic halogenated compounds, like PCBs and DDT;
- Pesticides and biocides;
- Organic stannic compounds;
- BTEX compounds (benzene, toluene, ethylbenzene and xylene);
- Phenols;
- PCDD and PCDF (dioxins and furans);
- Phthalates.

They can be divided into three main groups, based on their origin:

- Land based sources from industrial waste water discharges into the sea or into the hydro graphic network and river contribution;
- Sea based sources from maritime transport activities and water production of offshore platforms;
- Air based sources after fallout deposition.

In the following paragraphs results of monitoring campaign for some of these pollutants for Adriatic countries are presented.

For Italy, results, derived from ISPRA (2012), are still in progress and consider three specific coastal areas (A1, A2 and A3, see Figure 3-234) representative of the assessment area. A specific chapter with hot spot areas identified in the Adriatic is also provided.

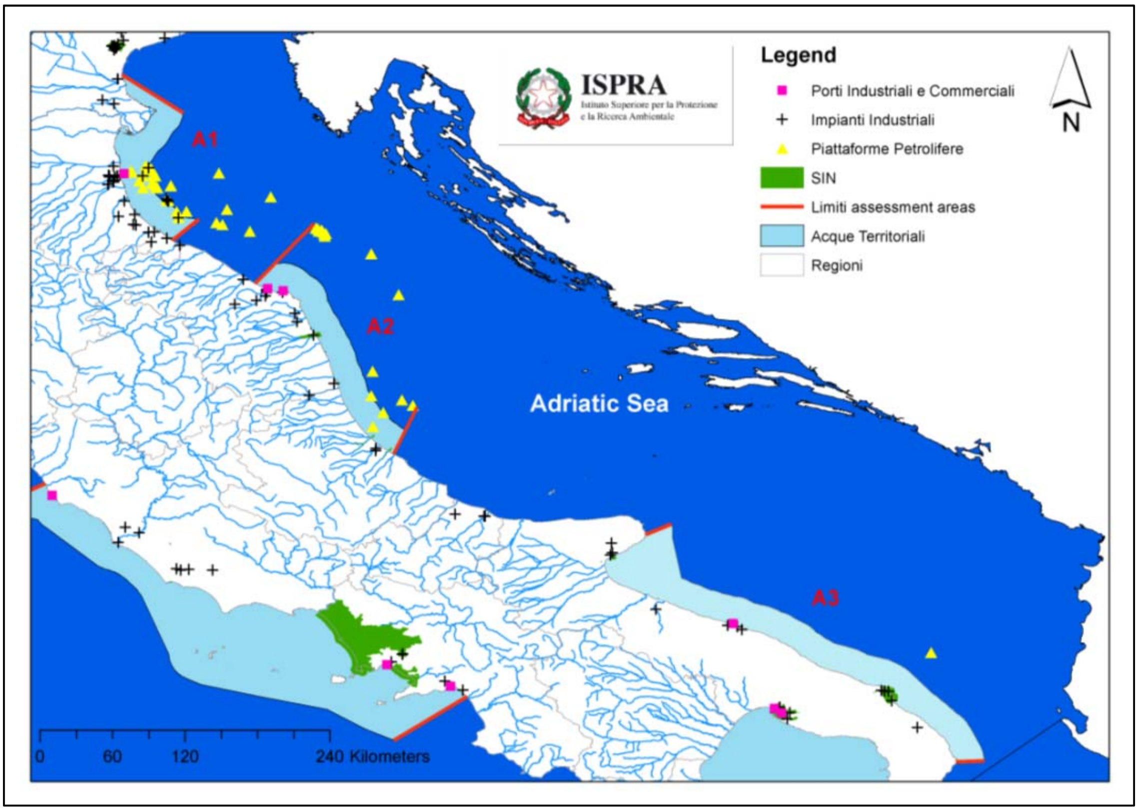


Figure 3-234 identification of evaluation areas for Italy (Source: ISPRA, 2012).

<u>Land based sources</u>

Concerning Italy, main pollution sources are found inside areas considered Sites of National Interest (SIN). These industrial zones are characterized by important releases of different types of pollutants (heavy metals, PCB, hydrocarbons), depending on main activities placed in the areas. In the Adriatic such sites are distributed quite evenly along the coastline of Veneto, Friuli Venezia Giulia, Marche, Abruzzo and Puglia (Figure 3-235).

Figure 3-235 Italian Adriatic SIN distribution.

<u>Sea-based sources</u>

As evidenced before, Italy has several offshore platforms that can contribute to marine waters pollution with dangerous discharges; nevertheless up to now data on offshore platforms discharges are still not available and no consideration can be done at the moment.

Regarding maritime traffic, generally speaking, the nature of accidents has changed over recent years, with less major disasters but still many collisions and groundings producing small-scale pollution. The eastern part of the Mediterranean with its many islands is the leading accident spot of this type. Most pollution incidents occur in ports during mooring, loading and unloading operations, albeit involving tiny quantities (UNEP-MAP).

The Adriatic Sea is an important maritime transport route used by merchant ships in international and national trade, by yachts, fishing vessels, war ships and other non-merchant ships (Figure 3-236). This nautical traffic can cause the release of pollutants in the sea.

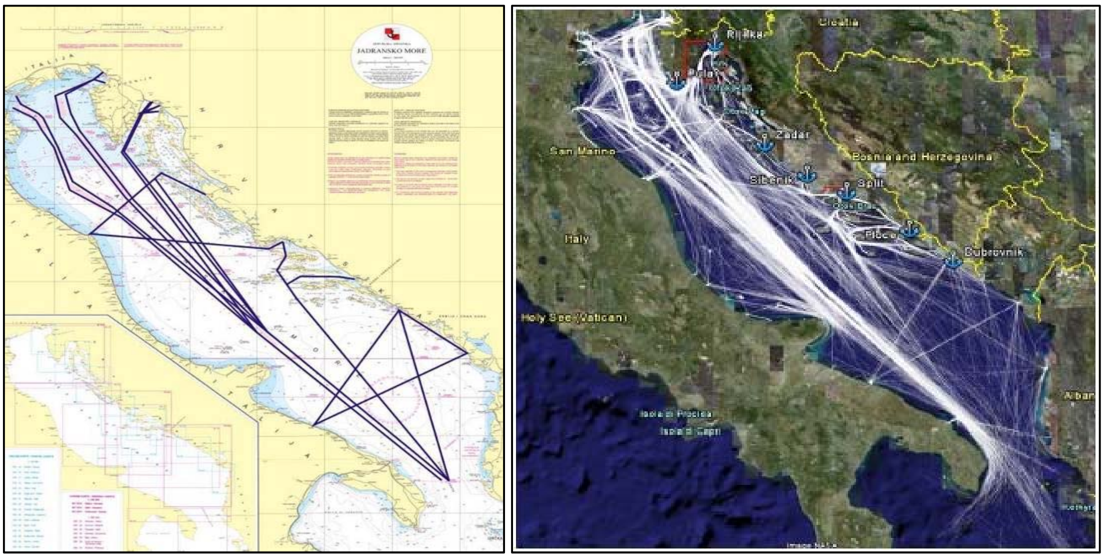


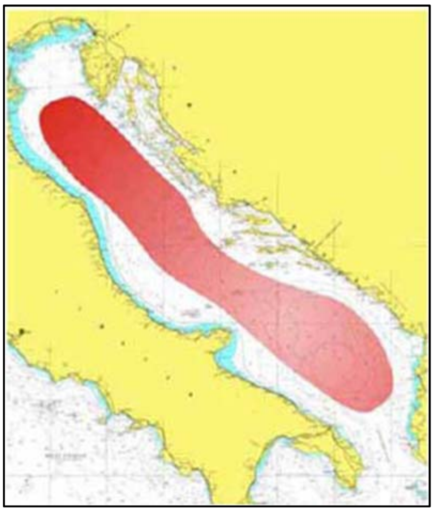
Figure 3-236 Traffic routes and maritime traffic intensity in the Adriatic Sea in 2008 (Source: Policy Research Corporation, 2011).

A significant number of important industrial centres are located along the western Adriatic coast and several mid-European countries heavily depend on the Northern Adriatic ports (among others the port of Trieste, Venice, Koper and Rijeka) for the import of energy. In addition, several of the eastern Adriatic ports are deep-water ports – especially in Croatia – which could host super-tankers.

Concerning the other Adriatic basin countries, Albania does not seem to have a significant share in international maritime transport (with the exception of Durres port), since there are only some small harbours along the coastline and the main maritime routes are not located near the Albanian coast. Albania's maritime activities are rather limited and are predominantly focused on fisheries. Bosnia & Herzegovina as well, has no maritime ports in operation at the moment (see paragraph 3.6.2).

Montenegro instead has several ports in operation (port of Bar, port of Budva (marina),port “Porto Montenegro” (marina) in Tivat, port of Kotor, port of Zelenika and port of Risan), the latter three being located in the Bay of Boka, which implies intense use of space in the relatively small area of the Boka bay. This ports are however small and are characterized only by local ship traffic.

The intensive maritime transport in the Adriatic Sea basin implies a significant risk of accidents and consequently a potentially strong impact on the marine environment. Given the enclosed nature of the Adriatic Sea basin, the impact of a single accident – even though accidents are rare – can be highly disastrous. Following figures illustrate areas of increased risk of sinking, collisions and groundings.



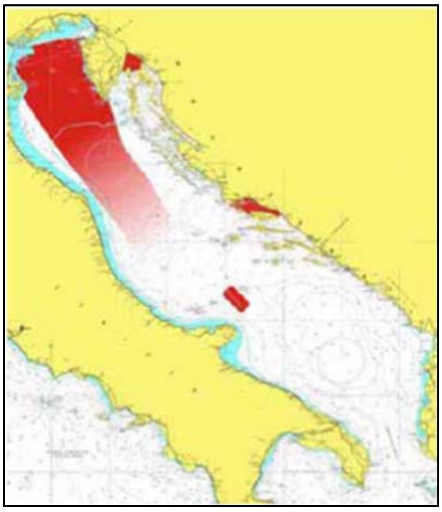


Figure 3-237 Areas of increased risk of sinking (left) and collisions (right) (Source: Policy Research Corporation, 2011).

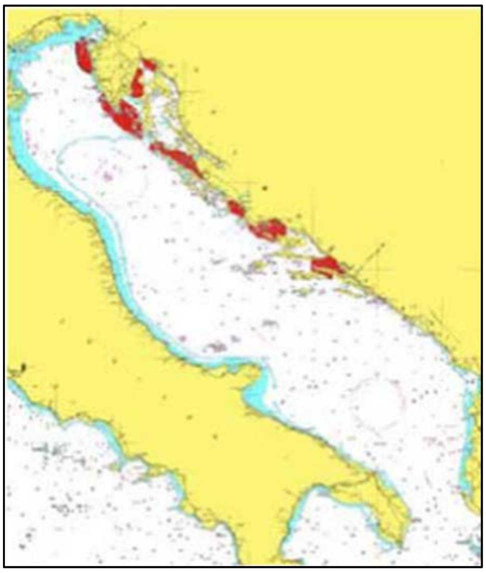


Figure 3-238 Areas of increased risk of groundings (Source: Policy Research Corporation, 2011).

A particular mention needs to be made for hydrocarbons like crude oil, gasoline, diesel, kerosene, natural gas and GPL. For their presence in the sea in fact, with the exception of pollution events, there is surely evidence of a correlation between hydrocarbons leaks and maritime transport. It has been estimated that, at a Mediterranean level, the most important contribute (80%) to hydrocarbon pollution derives from routine shipping operations like tanker washing or ballasting, while accidental spills account for 10% (Regione Marche and Zara County, 2008). In the Adriatic there are relevant maritime oil products traffics, as testified by Figure 3-239 and Table 3-29 (Italian situation).

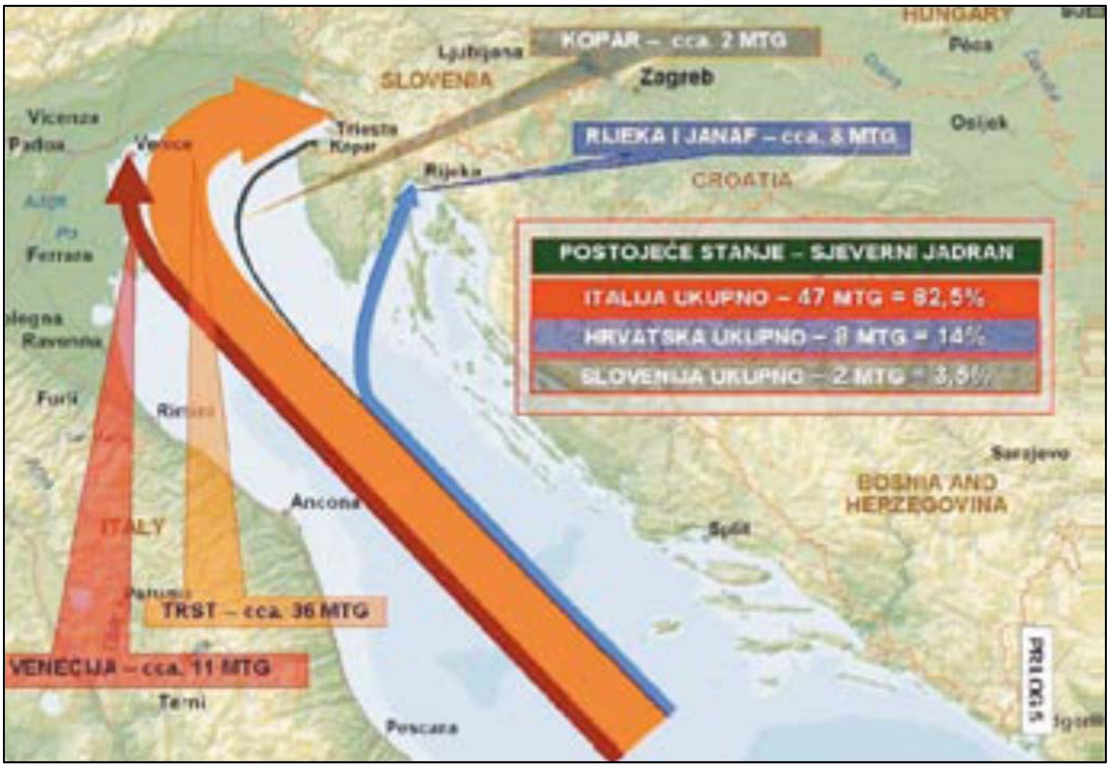


Figure 3-239 Status of crude oil traffic in the Adriatic - total for Italy: (Venice, Ancona, Trieste) 82%; total for Croatia (Rijeka) 14%; total for Slovenia (Koper) 3.5% (Source: Regione Marche and Zara County, 2008).

Table 3-29 Crude arrivals by ports of the Adriatic in Italy (thousands of tons) (Source: Unione Petrolifera, 2009).

Year	1990	1995	2000	2004	2005	2006	2007	2008
Falconara (Ancona)	2,850	3,340	3,300	3,390	3,365	3,335	3,525	3,520
Ravenna	270	235	60	40	40	140	140	135
Trieste	25,865	27,190	34,520	35,880	36,990	36,820	33,590	35,650
Venice - Porto Marghera	4,210	4,940	5,600	5,800	5,760	6,575	6,370	5,580

The arrivals of crude oil in the Adriatic Sea are concentrated in the Port of Trieste because of the presence of an important terminal connected with SIOT pipeline which reaches Austria and Germany. In the Adriatic Sea there are, including also not Italian ports, about 10 oil ports, 7 terminals, 3 pipelines, 13 oil refineries, and almost 100 offshore platforms (many platforms are still active). Particularly relevant are the possible expansion of the port of Rijeka, and more precisely, the construction of a second terminal in Omisalj, according to the project of the "JANAF Pipeline" (Regione Marche and Zara County, 2008).

An indication of the density of oil spills in the Adriatic Sea, based on satellite pictures that recorded oil spills normalised for the number of pictures taken for specific parts of the sea is shown in Figure 3-240.

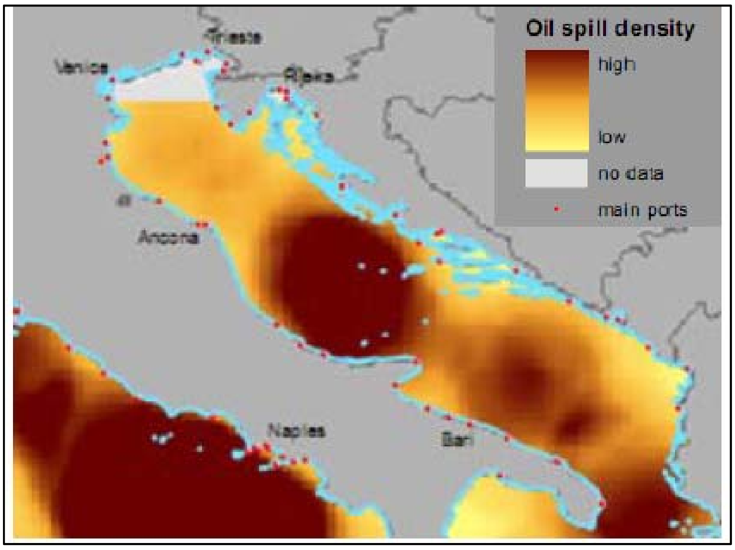


Figure 3-240 Oil spill density in the Adriatic Sea (Source: Policy Research Corporation, 2011).

<u>Air based sources</u>

For Italy concentration levels are derived from the European Monitoring and Evaluation Programme (EMEP) web site and refer to year 2009. Total yearly setting values registered for the specific coastal areas before identified (A1, A2 and A3) for some pollutants are the followings (ISPRA, 2012):

- Lead: minimum <0.1 kg/m^2/y, maximum >3 kg/m^2/y;
- Cadmium: minimum <1 kg/m^2/y, maximum >100 kg/m^2/y;
- Mercury: minimum <1 kg/m^2/y, maximum >303 kg/m^2/y;
- Benzo(a)pyrene: minimum <1 kg/m^2/y, maximum >100 kg/m^2/y.

3.6.5.2 Radionuclide introduction

Most relevant radionuclides responsible of the main dose of marine radioactivity are imputable to two main elements: Cesium ^{137}Cs (anthropogenic source); Polonium ^{210}Po (natural source).

Regarding the main sources of radioactivity can be defined: (i) Land based sources from nuclear power plant and deposits of radioactive materials; (ii) Sea based sources like phosphogypsum residual products of fertilizer production discharged into water and offshore hydrocarbons extraction platforms; (iii) Air based sources after nuclear test in the atmosphere and nuclear accidents. In the following paragraphs results of monitoring campaign for Adriatic countries are presented. For Italy results are derived from ISPRA (2012), and consider the whole assessment area.

<u>Land based sources</u>

Regarding Italy. currently situation on nuclear power plants (not in operation) and deposits is shown in Figure 3-241.

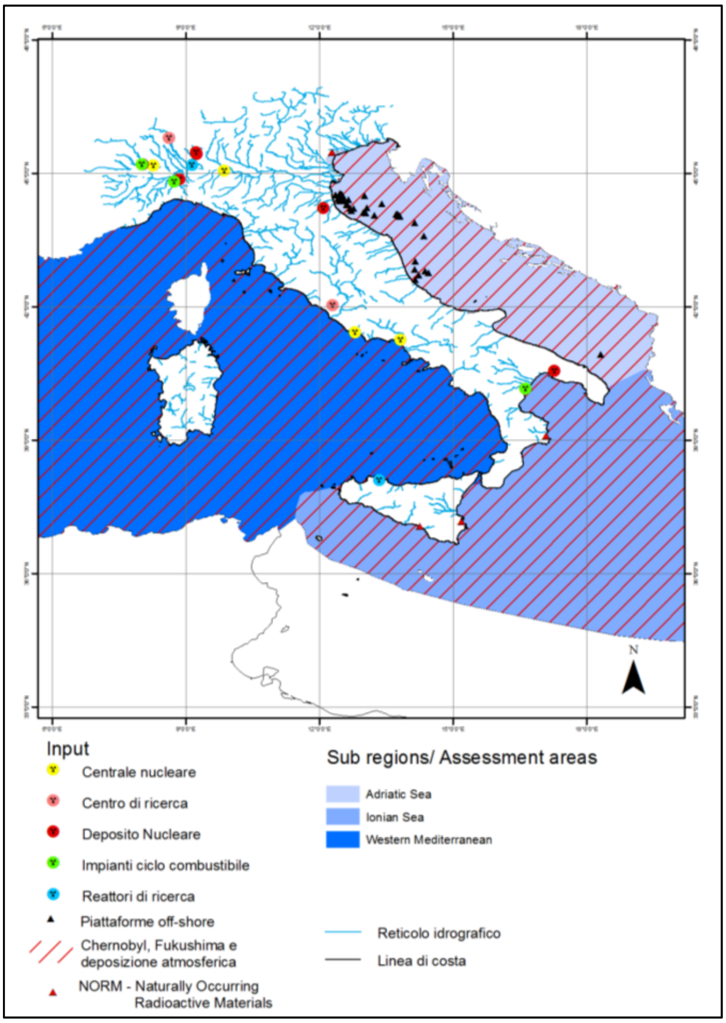


Figure 3-241 Italian nuclear sites and offshore platforms distribution (Source: ISPRA, 2012).

For the Adriatic main potential impact derives from point sources discharging into rivers (mainly the Po river and its tributaries), where a significant fraction of radionuclides is temporarily trapped. The most impacted area from these sources is then the Po river mouth. When ^{137}Cs is considered, even assuming that the whole annual total amount (0.5 Gbq/y) is discharged directly into the sea, this would be one order of magnitude lower than present atmospheric deposition over the region due to global fallout. The authorized discharges of ^{137}Cs and ^{90}Sr, are limited and almost constant with time. Input might slightly increase in the future in connection with decommissioning of nuclear power plants.

Sea-based sources

In Italy in the Adriatic there are two potential sources of radioactivity. The first, which mainly can emit radium, derives from offshore hydrocarbons extraction platforms but currently no data are available. The second derives from fertilizer industry with phosphogypsum production disposed at coast or in the sea during the last century. For these sources of ^{226}Ra, ^{214}Pb and ^{210}Po there aren't sufficient information but it is known that some landfills with these materials are localized near Porto Marghera industrial area.

Air based sources

In Italy the main source of anthropogenic radionuclides is the fallout from atmospheric weapon testing and the Chernobyl accident. The cumulative deposition of ^{137}Cs from atmospheric weapon testing is considered uniform in all the sub areas considered. The deposition from the Chernobyl accident was quite patchy, ranging in Italy between 0.7 (southern area) to 15 KBq m^{-2} (northern area), corresponding today to 0.4-8 KBq m^{-2}, respectively. Only traces were deposited as consequence of the Fukushima accident. Present input, corresponding to a total load in the subregion of approximately 4 GBq y^{-1}, does not show significant spatial or temporal variation.

Present day fallout deposition is much lower than in the past but it is yet considered to give the most relevant dose to man and to the environment. Based on currently information, inputs of anthropogenic radionuclides are generally low, even in proximity of point sources. Concentrations in the different compartments of the marine environment are correspondingly mostly background levels. However, at the moment information are not systematic and do not cover all environmental matrices necessary for a complete environmental risk assessment.

3.6.6 Nutrient enrichment and eutrophication

3.6.6.1 Inputs of fertilisers and other nitrogen and phosphorus-rich substances

Eutrophication was defined by Nixon (1995) as "an increase in the rate of supply of organic matter to an ecosystem". Besides this main direct effect, an holistic assessment of eutrophication should include causative factors (e.g. nutrient enrichment), supporting environmental factors (e.g. hydromorphological conditions), and indirect effects (e.g. oxygen deficiencies or changes in benthic community structure).

Eutrophic waters or waters where there is abundant food (nutrients) are a major environmental concern particularly for areas close to big cities, industrial agglomerations and river deltas. Joint UNEP/FAO/WHO reviews (1996) have identified nutrient discharge and eutrophication as a serious source of environmental degradation for marine ecosystems due to the common practice of untreated or partially treated urban sewage discharge and leaching from fertilized agricultural areas. Eutrophication is consequently primarily a problem of coastal waters, but with also transboundary aspects . An excess of nutrients in the water gives rise to a complex chain of reactions that disrupt aquatic ecosystems. Under eutrophication, long-living (and slow growing) plants that are important for biodiversity (and support diversified fauna) do less well and are outcompeted by fast growing opportunistic species. Among the most serious consequences of eutrophication for biodiversity are algal blooms or red tides. These phenomena can seriously affect marine environment and biodiversity and have also consequences on local activities like fishing and tourism.

Figure 3-242 shows hot spot eutrophication phenomenon distribution with relative impacts in the Mediterranean sea; in the Adriatic they are concentrated in the northern part of the basin, near Gargano promontory and in some areas of Croatian coastline.

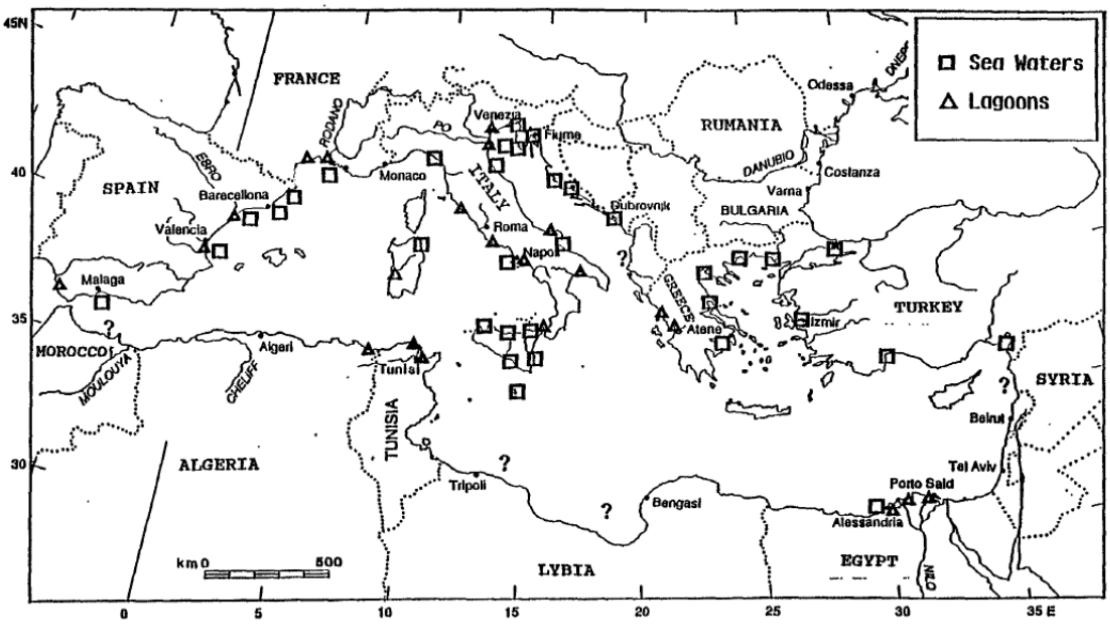


Figure 3-242 Mediterranean areas where eutrophication phenomena where reported (Source: UNEP, 1995).

Focusing on the Adriatic sea, the following figure shows the different trophic conditions of the basin.

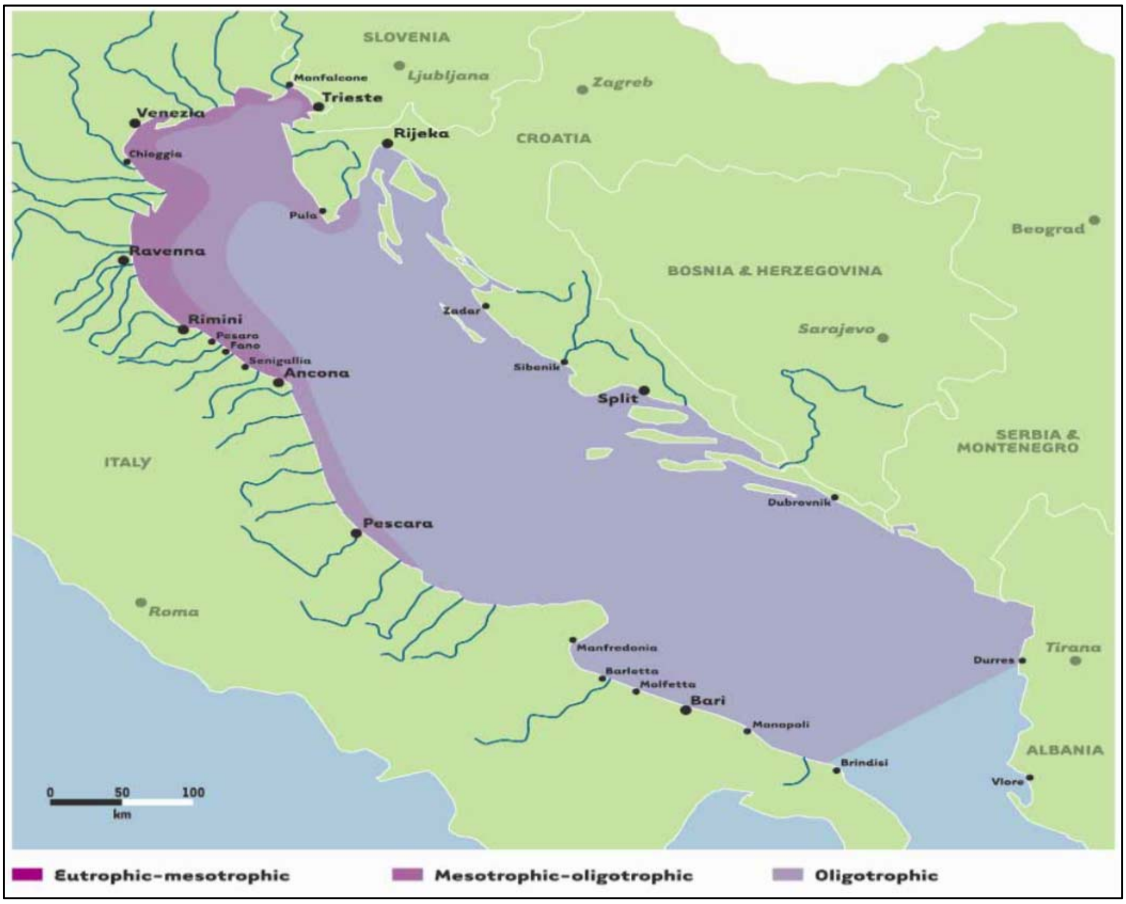


Figure 3-243 Aerial mapping of trophic conditions of the Adriatic Sea (UNEP/MAP/MED POL, 2005*).*

Waters eutrophication indexes are used to monitor pressures and impact; they are essential to monitor changes in the state of coastal and marine environments, to assess trends in socioeconomic pressures and conditions in the coastal areas, and to appreciate the effectiveness of integrated coastal management (Mageau & Barbière, 2003). In literature, numerous eutrophication indexes are described, varying from one region to the next and using different thresholds. Existing indices linked to eutrophication can be classified into 3 main groups: trophic indices, eutrophication indices and nutrient sensitivity (i.e. response to nutrient over enrichment) indexes.

Regarding Italian north Adriatic coastline, results emerged from ISPRA (2012) and ARPA Emilia Romagna (2010) showed, using trophic TRIX index (Ministerial Decree 260/2010), that some potentially critical areas exist. The index includes direct and indirect effects and resumes all parameters that can generate the eutrophication phenomenon creating an impact on local enviroment. It is calculated with the following equation:

$$TRIX = (Log(Cha \cdot |OD\%| \cdot N \cdot P) - (-1.5)) / 1.2$$

Where:

- Cha represents the value of Chlorophyll “a”, expressed in µg/l;
- OD is the percentage of dissolved oxygen, expressed as variation from saturation;
- N is soluble nitrogen ($N\text{-}NO_3$, $N\text{-}NO_2$, $N\text{-}NH_3$), expressed in µg/l;
- P is total phosphorous.

The value varies ideally from 0 to 10 where 0 represents oligotrophic waters and 10 is associated to iper eutrophic waters, even if actual values range from 2 to 8 (Figure 3-244).

Trophic index	Environmental status
2-4	High
4-5	Good
5-6	Mediocre
6-8	Bad

Figure 3-244 trophic index scale.

ISPRA (2012) results, based on SIDIMAR database[38] and referred to the first 3 km of the coastline, focused on north Adriatic coastline, the most relevant Italian coast subjected to eutrophication, during a period of nine years (2001-2009) (Figure 3-245). As emerged in the figure areas which can be more subjected to eutrophication are located nearby Po mouth (in particular Porto Garibaldi and Rosolina).

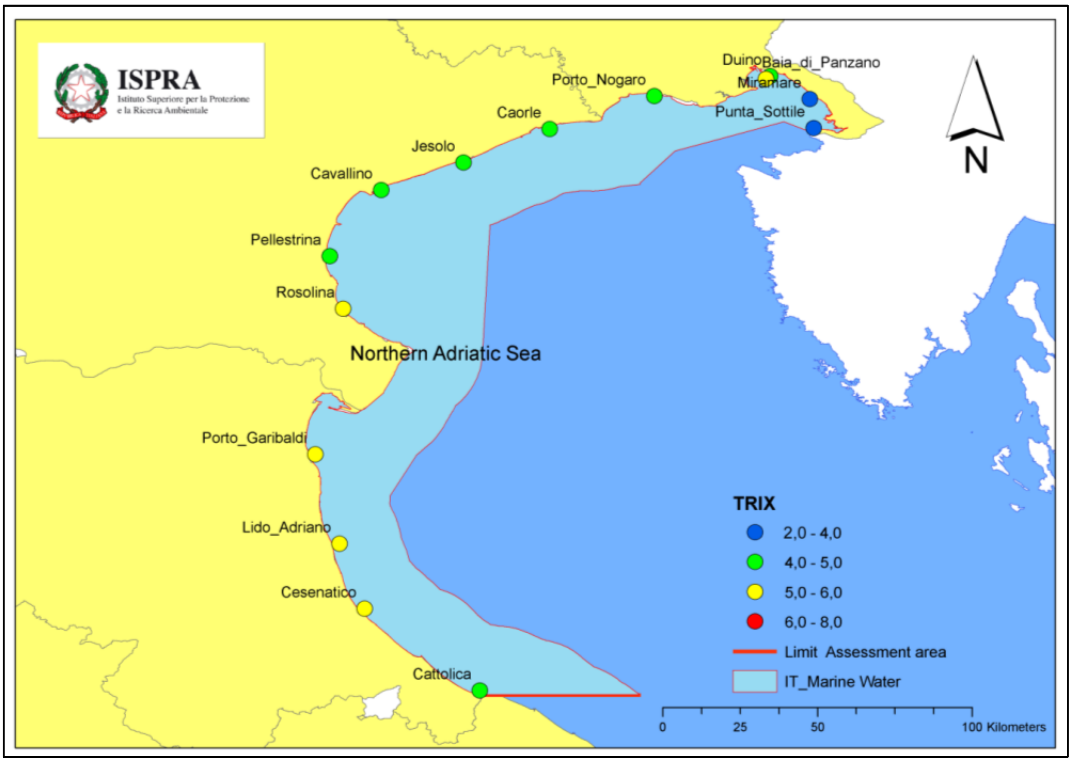


Figure 3-245 average yearly TRIX index years 2001-2009 (Source: ISPRA, 2012).

38 http://www.sidimar.tutelamare.it/ ; last access 22 November 2012.

Analysing TRIX variation yearly trend for the whole area (Figure 3-246), average values during the period are always over 4.5 with peaks reaching 5.2 in 2002, 2007 and 2009, evidencing the criticality for the risk of eutrophication. Even if an inter-annual variability exists, nevertheless a significant increasing trend is not observed.

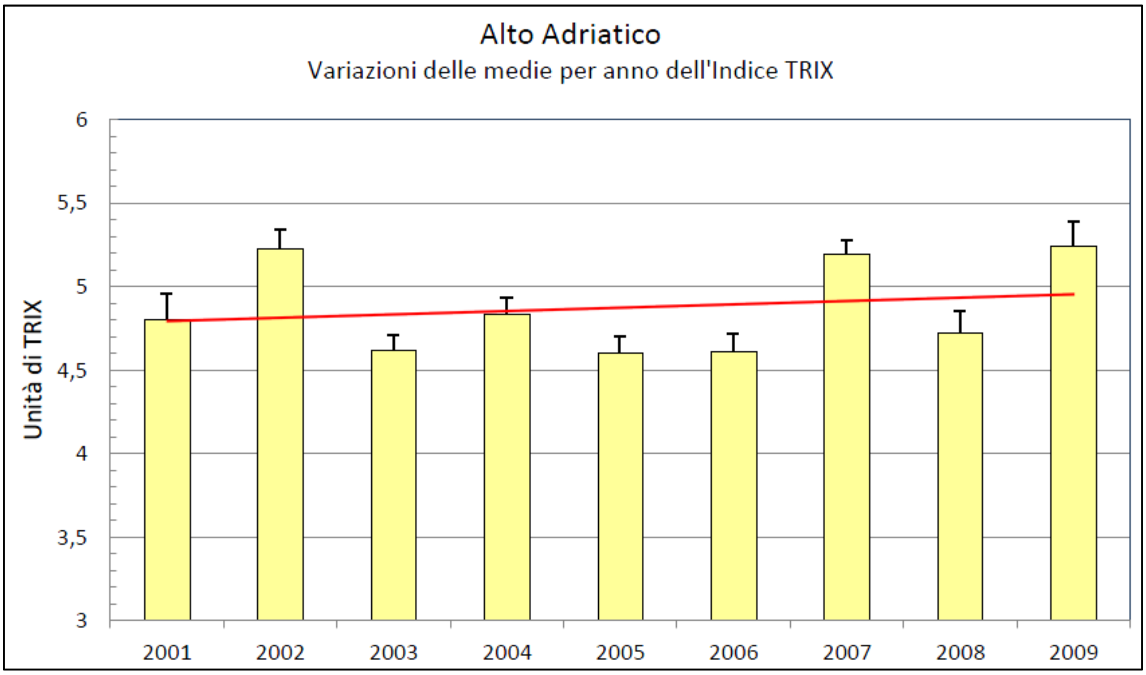


Figure 3-246 TRIX yearly average values for the Italian north Adriatic coastline, years 2001-2009 (Source: ISPRA, 2012).

Most critical areas are located nearby Po river mouth, the most important pollution vector in the area transporting urban and industrial wastewater as well as agricultural run-off from its drainage basin to the Adriatic Sea, with TRIX values in most cases over 5.5 (mediocre and in some cases bad environmental status), as testified by results derived from ARPA Emilia Romagna for year 2010 in the areas located southern Po river (see Figure 3-53 for monitoring stations and Figure 3-247). As emerged for nitrogen and phosphorous TRIX shows a constant decrease going southward and from the coastline to the open sea.

In this critical area chlorophyll “a” (for 2010) shows a trend, as marked for phosphorous and nitrogen previously discussed, reflecting decreasing concentration values in the northern-southern and landside to seaside direction (see Figure 3-53 for monitoring station distribution and Figure 3-248). Generally high chlorophyll “a” concentrations are associated with decreasing values in water transparency and with anomalous green/brown water coloration, depending on the species of microalgae blooming.

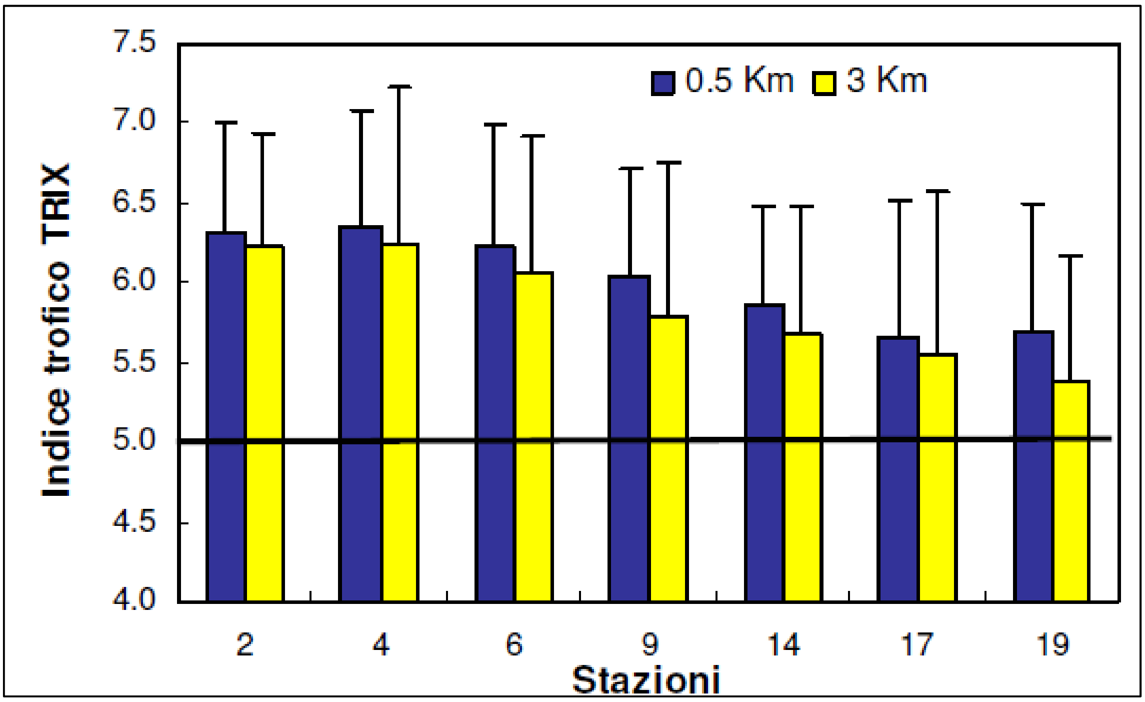


Figure 3-247 Emilia Romagna Region average TRIX yearly values in different sampling station at different distances from the coast (0.5 and 3 km) year 2010 (Source: ARPA Emilia Romagna, 2010").

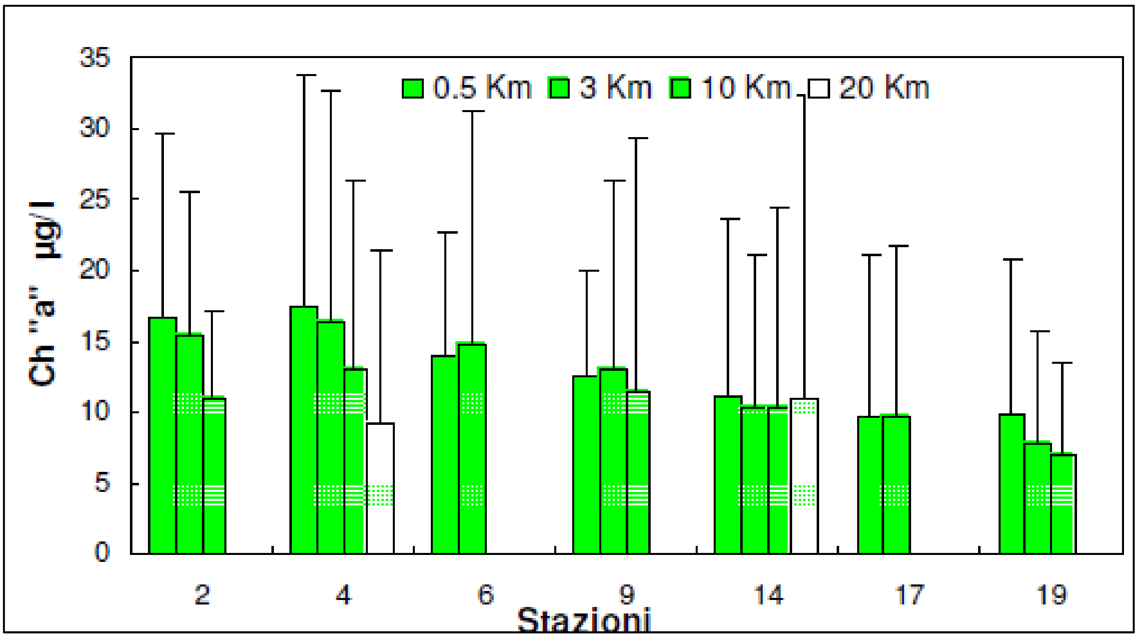


Figure 3-248 average yearly values and standard deviation in different sampling station at different distances from the coast (0.5, 3, 10, 20 km) in surface waters (Source: ARPA Emilia Romagna, 2010").

Going southern, TRIX values elaborated by ARPA Marche for year 2009 are presented in the following figure. Results illustrate average TRIX values in different monitoring stations located at 0.5 and 3 km from the coast. During this year water quality status showed values ranging from “mediocre” to “high”, depending on local river loads and loads derived from trophic water of northern Adriatic and are similar if compared with values during the period 2001-2008.

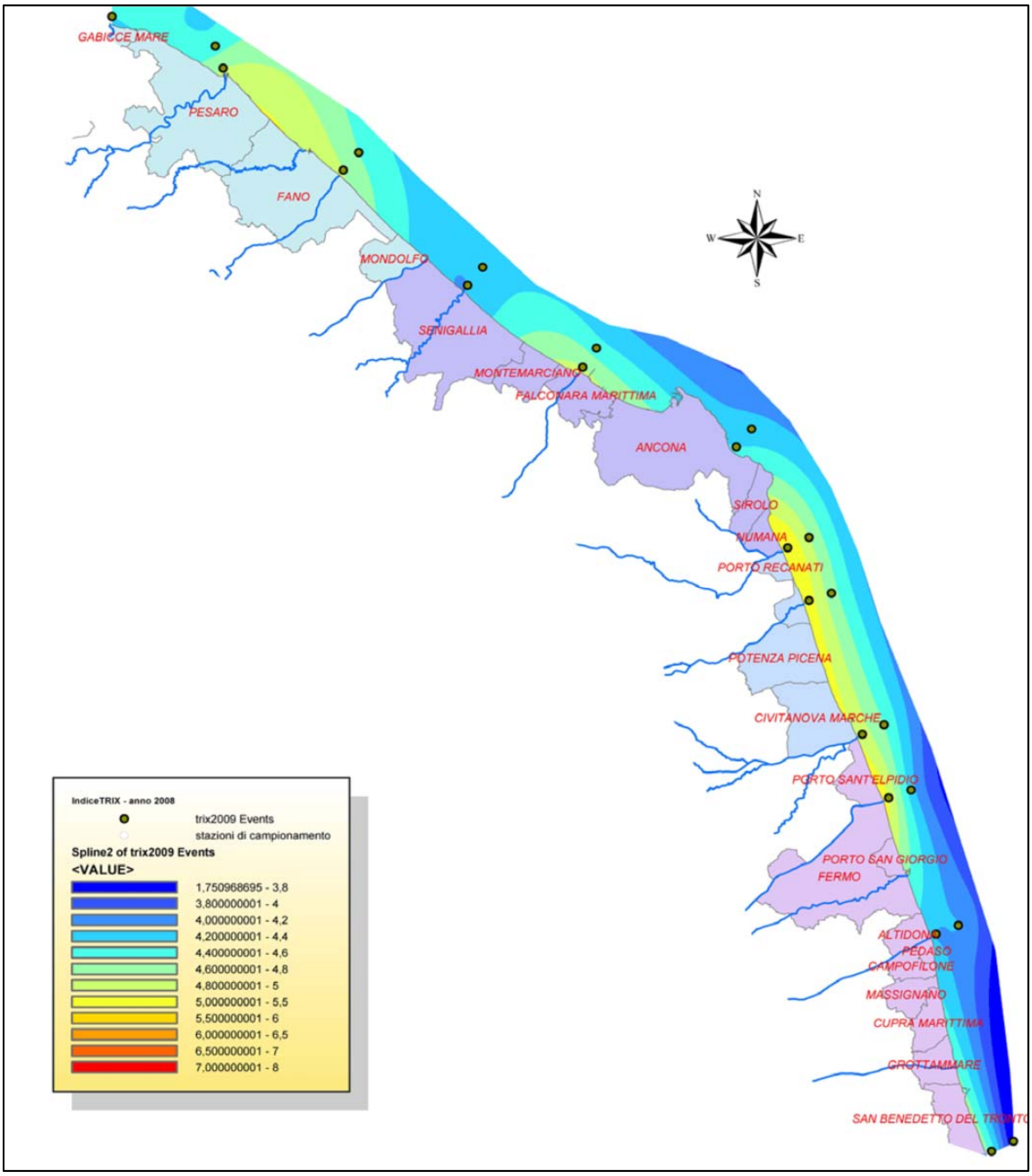


Figure 3-249 Marche Region average TRIX yearly values in different sampling station at different distances from the coast (0.5 and 3 km) year 2009 (Source: ARPAM, 2009).

In 2011 instead some eutrophication phenomena have been identified; they are strongly influenced by fresh waters loads derived from Po river transported by the Western Adriatic Coastal Current. In this year a light worsening of water quality status with respect to 2010 has been detected, in particular along Pesaro coastline. In association with higher TRIX values, eutrophication and algal blooms have been found during the whole year with the exception of summer months.

Concerning area located northern Po river, situation observed is better, with TRIX index decreasing until Trieste gulf where it reaches typical oligotrophic values (TRIX<4). In particular specific areas which affected in the past and are sensitive to the eutrophication phenomenon, divided per Region, are summarized in the following table. The table doesn't include Adriatic coastal lagoons systems that in past years might have also experienced eutrophication problems, such as in the case of the Venice lagoon in the 90's.

Table 3-30 List of Italian sites designated as eutrophic or as being at risk to become eutrophic and related pressures (Source: UNEP/MAP, 2007).

Region	Site	Pressure
Emilia Romagna	Lido Adriano	Nutrient inputs from Po river
	Cesenatico	
	Porto Garibaldi	
Marche	Foglia	Nutrient inputs from Po River and Foglia river
Veneto	Porto Lido Nord (Cavallino)	Nutrient (P and N) and organic inputs from aquaculture; human activities including tourism and densely populated coastline
Friuli Venezia Giulia	Duino-Baia di Panzano	Organic inputs from aquaculture activities; pollution coming from the harbour area of Monfalcone
	Porto Nogaro	Nutrient (P and N) inputs and organic from aquaculture and zootechnics; urban wastewater discharges; pollution from industries especially food and chemical industries

Concerning other Adriatic countries the following table indicates sites which can be subjected to eutrophication, divided per country, with relative pressures. It should be noted that TRIX index in most cases is not applied and other indexes are used for the trophic state identification.

Table 3-31 List of sites designated as eutrophic or as being at risk to become eutrophic and related pressures (Source: UNEP/MAP, 2007).

Country	Site	Pressure
Albania	Drini bay	Nutrient inputs, organic matter inputs from diffuse sources
	Rodoni bay	
	Karavasta bay	
	Ishmi estuary	
	Buna estuary	
	Drini estuary	
	Semani estuary	
	Karavasta lagoon	
	Kune-Vaini lagoon	
	Patoku lagoon	
Slovenia	Koper bay	Riverine nutrient loads, domestic wastes from Koper, industrial wastes
	Rizana estuary	Domestic and industrial wastes
	Seca	Fish/shellfish area

3.6.6.2 Inputs of organic matter

Regarding organic matter input into the Adriatic sea, main sources derive from river loads (in particular Po river), and other local activities like industrial liquid waste discharges into marine waters or intensive coastal tourism, especially when wastewater treatment plants lack the capacity to treat all wastewater, such as during peak tourist period.

Organic matter quantification can be estimated using specific models. In particular EUTRISK index characterizes the spatial distribution of potential hypoxia integrating oxygen availability near the bottom and the flux of organic matter reaching the seabed (Druon et al, 2004). It uses phytoplankton production as the main vector of oxygen consumption near the bottom. In order to determine where the organic matter produced at the surface sinks to the seabed, vertical and horizontal particulate organic matter (POM) transport is calculated using the advection produced by the model.

Figure 3-250 presents the results of POM export in the northern Adriatic Sea.

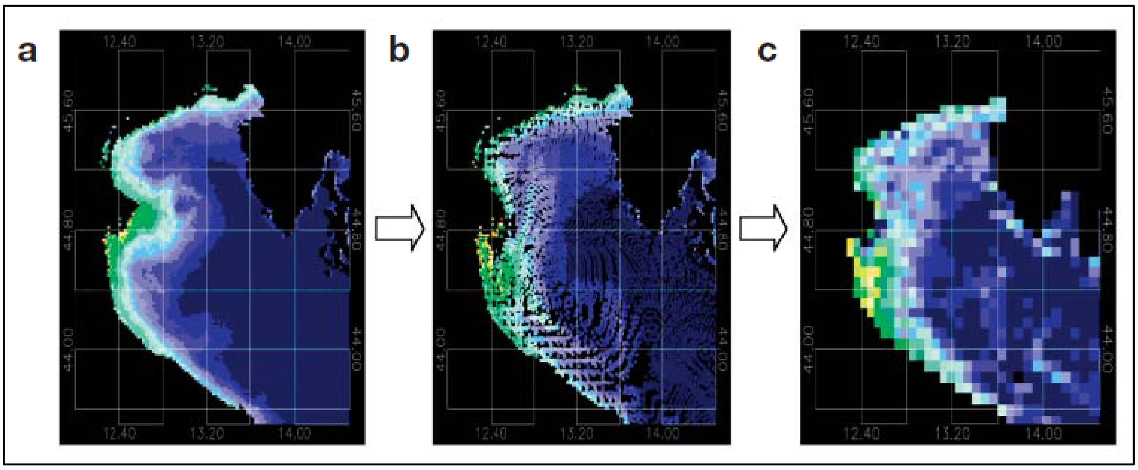


Figure 3-250 Transport procedure particularly required for the northern Adriatic Sea where organic matter production (POM area) and sinking area are different. (a) Monthly mean primary production estimated for August 2000 (in relative units); (b) final distribution of POM after horizontal and vertical advection procedure using the model velocity field; and (c) summary on model grid to derive the load of organic matter at sea bottom. Black area is not covered by model (Source: Jean-Noël Druon et al, 2004).

The monthly mean satellite measurement of chlorophyll a in August 2000 (SeaWiFS-OC5, Figure 3-250 a) shows maximum biomass in front of and south of the Po delta. After transport is completed, i.e. when the POM has reached the seabed (Figure 3-250 b), the bottom POM load is concentrated exclusively south of the Po river mouth and further south along the Emilia-Romagna coast. Figure 3-250 c) shows the integrated final distribution of bottom organic matter on the model grid.

A comparison of the POM load for August 2000 in the North and the whole Adriatic (C_POM Figure 3-251) shows the limited extension of the highly productive areas (the Emilia-Romagna coast in the Adriatic Sea). C_POM index represents monthly relative organic load of matter that reaches the seabed (or 100 m for deep waters) estimated primarily from satellite-derived chlorophyll "a" which has undergone horizontal and vertical transport and degradation in the water column.

Figure 3-252 presents the EUTRISK index in August 2000. Comparison of the C_POM (Figure 3-251) and EUTRISK (Figure 3-252) indexes identifies 3 main types of eutrophic waters:

- Eutrophic and sensitive;
- Mesotrophic and sensitive;
- Eutrophic and resistant.

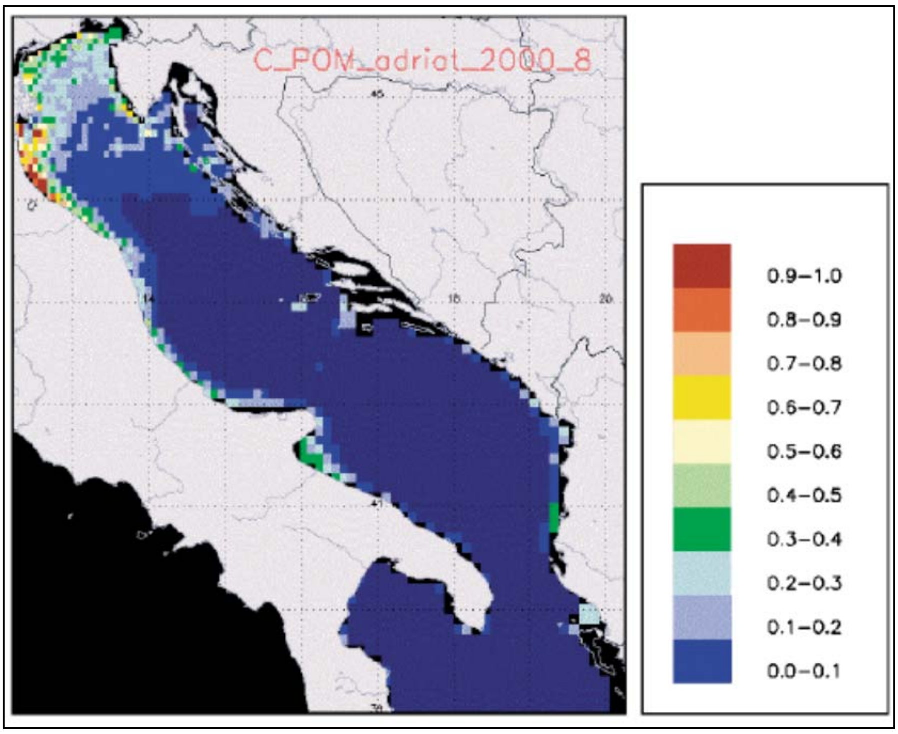


Figure 3-251 Comparison of particulate organic matter index. C_POM. in the Adriatic Sea in August 2000. Black area is not covered by model (Source: Jean-Noël Druon et al., 2004).

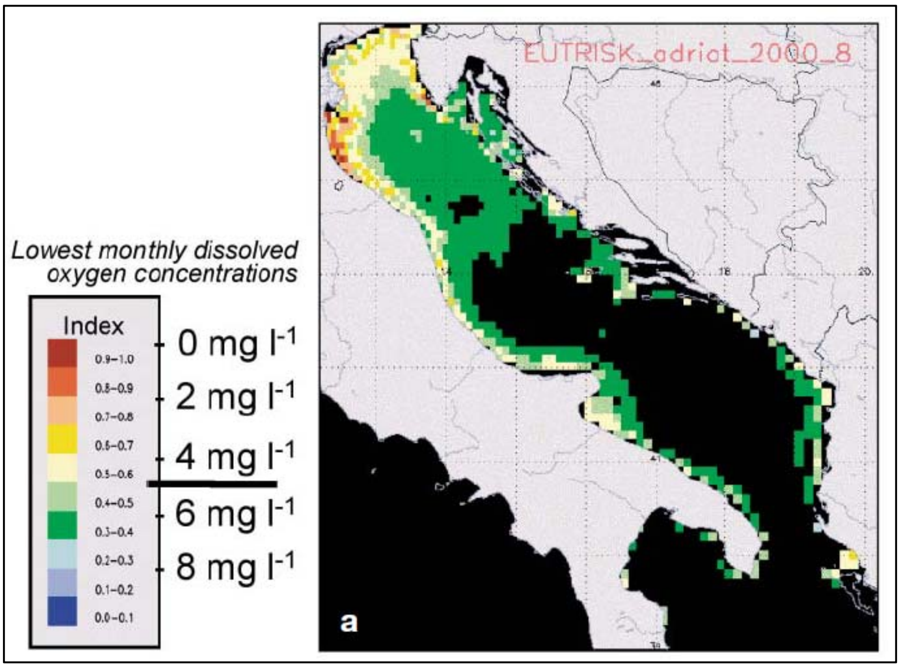


Figure 3-252 Eutrophication risk index. EUTRISK. based on 3-D hydrodynamic modelling results and remote-sensing of ocean colour in the Adriatic Sea. Black area is not covered by model. or is water deeper than 100 m. EUTRISK index represents most probable oxygen deficiency distribution near sea bottom for month considered. (Source: Jean-Noël Druon et al, 2004).

In the first category, oxygen depletion occurs regularly (red for EUTRISK, Figure 3-252); this category is represented by the Emilia-Romagna coastal waters south of the Po river mouth which is the area that can mostly suffer the impact of organic matter load and eutrophication. In the second category, severe hypoxia or anoxia occur due to particularly adverse physical conditions, even when primary production is relatively low (yellow to light blue for C_POM. Figure 3-251; yellow to red for EUTRISK, Figure 3-252). The third category concerns areas where near-bottom waters are protected from severe hypoxia by permanent, strong, vertical mixing; however, food-web alteration and the development of opportunistic species are generally observed.

On the EUTRISK scale, blue and green correspond to non-problem areas, although green colour does indicate higher potential vulnerability. Yellow and red correspond to 2 levels of eutrophication where food-web alterations and/or hypoxia characterize an intermediate step, and severe hypoxia or anoxia the ultimate level.

3.6.7 Biological disturbance

3.6.7.1 Introduction of microbial pathogens

Presence of pathogen microorganisms is one of the most important causes of biological disturbance in marine water. It can generate different kinds of problems like:

- Poisoning and death of local organisms;
- Human health risks;
- Interference with local human activities like aquaculture.

The following chapters distinct between water used for bathing and aquaculture activities.

<u>Coastal bathing waters</u>

Main pollution sources of microbial pathogens generating pressures on coastal bathing waters are, in order of relevance (ISPRA, 2012):

- Sewage and waste waters derived from urban centres;
- Runoff from agriculture activities;
- Industrial waste waters;
- Tourism activities.

The following text illustrates 2011 and, where available, previous years' results on coastal bathing water provided by the European Environment Agency for Italy, Croatia, Slovenia and Montenegro, which accounts for more than 90% of the total length of the Adriatic coastline.

All the countries have reported under the Directive 2006/7/EC since year 2010, except Croatia which has reported since 2009.

It needs to be underlined that before the necessary data set for assessment of bathing water quality under the Directive 2006/7/EC was compiled (data for three or four consecutive years) the rules for transition period assessment are applied. This means that the classification of bathing waters is defined on the basis of concentrations of intestinal enterococci and *Esche-*

richia coli that are reported under the Directive 2006/7/EC. The limit values for the classification are taken from the Directive 76/160/EEC. For the conversion of reported parameters under the Directive 2006/7/EC, Article 13.3 of the Directive 2006/7/EC foresees that the parameter *Escherichia coli*, reported under the Directive 2006/7/EC, is assumed to be equivalent to the parameter faecal coliforms of the Directive 76/160/EEC. The parameter intestinal enterococci reported under the Directive 2006/7/EC is assumed to be equivalent to the parameter faecal streptococci. The following table resumes mandatory and guide values (expressed in colony forming units cfu/100ml) with the relative correspondence between parameters provided by Directive 2006/7/EC and Directive 76/160/EEC.

Table 3-32 parameters. mandatory and guide values for marine bathing waters.

Parameters provided by Directive 2006/7/EC	Parameters provided by Directive 76/160/EEC	Guide values	Mandatory values
Intestinal enterococci (cfu/100 ml)	Faecal streptococci/100ml	100	-
Escherichia coli (cfu/100 ml)	Faecal coliforms/100ml	100	2000

Results are classified in the following categories:

- Class CI: Compliant with the mandatory value of the Directive 76/160/EEC for Escherichia coli and not compliant with the guide values of the Directive 76/160/EEC for Escherichia coli or intestinal enterococci;
- Class CG: Compliant with the mandatory value of the Directive 76/160/EEC for Escherichia coli and the more stringent guide values for the Escherichia coli and intestinal enterococci;
- Class NC: Not compliant with the mandatory value of the Directive 76/160/EEC for Escherichia coli;
- Class B: Banned or closed;
- Class NF: Insufficiently sampled;
- Class NS: Not sampled.

The frequency of sampling is set out in Annex IV of the Directive 2006/7/EC. Including a sample to be taken shortly before the start of the bathing season, the minimum number of samples taken per bathing season is four. However, only three samples are sufficient when the bathing season does not exceed eight weeks or the region is subject to special geographical constraints. Sampling dates are to be distributed throughout the bathing season.

Italy implemented contents of Directive 76/160/EEC and Directive 2006/7/EC respectively with two different laws:

- Ministerial Decree 470/82, and
- Legislative decree 116/08.

Historic statistics on the coastal bathing water quality in Italy (not at Adriatic scale) are available for the period 1990-2011 and are presented in Figure 3-253.

The graph shows, for coastal bathing waters separately:

- The percentage of bathing waters that comply with the guide values (class CG, blue line);
- The percentage of bathing waters that comply with the mandatory values (class CI, green line);
- The percentage of bathing waters that do not comply with the mandatory values (class NC, red line);
- The percentage of bathing waters that are banned or closed (class B, grey line).

Results on the whole period testify that generally more than 90% of bathing waters are compliant with mandatory values and more than 80% to guide values; instead less than 10% is not compliant with mandatory values and closed to bathing.

The trend shows a constant decrease for waters not compliant with mandatory values and an increase of waters compliant with mandatory and guide values, except for year 2010, which registered a worsening of coastal bathing water quality.

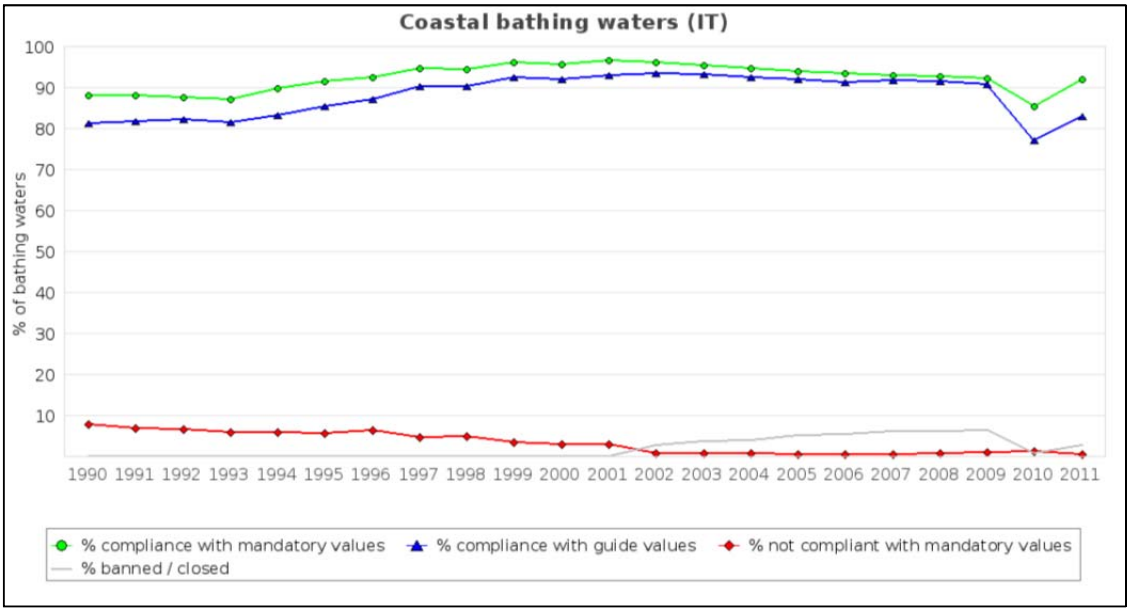


Figure 3-253 results of bathing water quality for Italy from 1990 to 2011 (Source: EEA, 2011).

For year 2011 in particular. the bathing season started between 1 April and 28 May 2011 and ended between 5 and 30 September, with a total of 4,902 coastal bathing waters reported.

During this year 91.9 % of the coastal bathing waters met the mandatory water quality. This is an increase of 6.6 % compared to the previous year. The rate of compliance with the guide values increased from 77.2 % to 83.0 %. A total of 21 bathing waters (0.4 %) were non-compliant with the mandatory value for Escherichia coli compared to 57 in 2010, which is a decrease of 0.8 %. A total of 133 bathing waters (2.7 %) were classified as closed compared to 33 (0.7 %) in 2010. A total of 242 bathing waters (4.9 %) were insufficiently sampled or not sampled compared to 632 (12.9 %) in 2010. The following figure resumes 2011 Italian bathing season.

Figure 3-254 bathing waters reported during the 2011 bathing season in Italy (Source: EEA, 2011).

Analysing the situation for the same year at regional Adriatic level (Table 3-33), it emerges that in most cases mandatory values are respected; some hot spots can be found only in Marche and Abruzzo Regions.

Table 3-33 regional bathing water compliance, year 2011 (Source: Health Ministry, 2012).

Region	% monitoring frequency not compliant	% compliant to mandatory values	% not compliant to mandatory values	% closed
Veneto	0	100	0	0
Friuli Venezia Giulia	0	100	0	0
Emilia Roma-gna	0	100	0	0
Marche	0	91.7	0.4	7.9
Abruzzo	0	83.1	1.7	15.3
Molise	0	100	0	0
Puglia	1.2	98.7	0.1	0

Concerning benthic microalgae *Ostreopsis ovata* whose blooms can generate toxic effects on human health and benthic organisms, in 2010 species concentration resulted very changeable, depending on weather and marine conditions. In the Adriatic, 70 sampling sites have been identified, 22 showed the presence of the species but with values lower than mandatory values (<10,000 cell/l, as stated by Ministerial Decree 30/03/2010 transposing Legislative Decree 116/2008 and Directive 2006/7/CE), 11 hot spot sites (50% of positive sites), all concentrated in Marche and Puglia Regions, showed instead overcoming mandatory concentration but no human poisoning have been registered. For Croatia data available for the period 2009-2011 are presented in the following figure. Results show that every year almost all coastal bathing waters are compliant with mandatory values and more than 95% are compliant with guide values. Banned/closed or not compliant with mandatory values waters have not been detected.

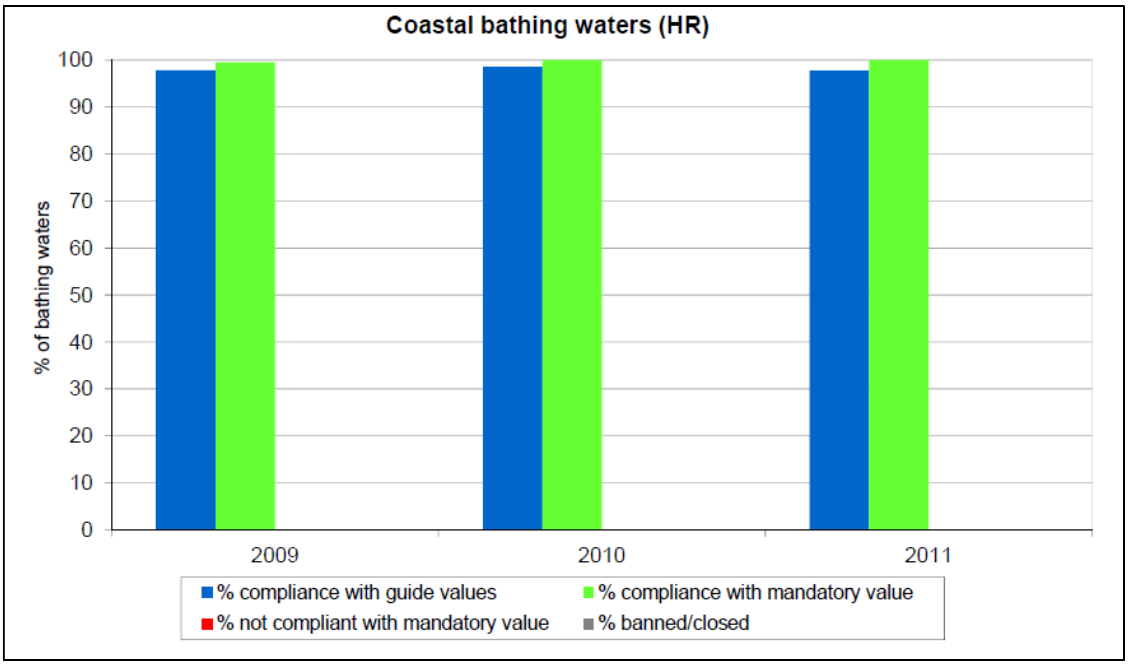


Figure 3-255 results of bathing water quality for Croatia from 2009 to 2011 (Source: EEA, 2011).

For year 2011 in particular, the bathing season for coastal bathing waters lasted 136 days, from 21 May to 3 October 2011, with 906 coastal bathing waters monitored; 100.0 % of the coastal bathing waters met the mandatory water quality in 2011, the same as in the previous year. The rate of compliance with the guide values decreased from 98.6 % to 97.8 %. No bathing waters (0.0 %) had to be closed during the bathing season, as happened in 2010. The following figure resumes 2011 Croatian bathing season.

Figure 3-256 bathing waters reported during the 2011 bathing season in Croatia (Source: EEA, 2011).

For Slovenia data available for the period 2004-2011 are presented in the following figure. Results evidence that 2009-2011 reached in all cases the complete compliance with mandatory values. Previous years show instead a constant improvement of water quality, with the exception of 2007, which registered a consistent worsening (with a 30% of coastal waters not compliant with mandatory values).

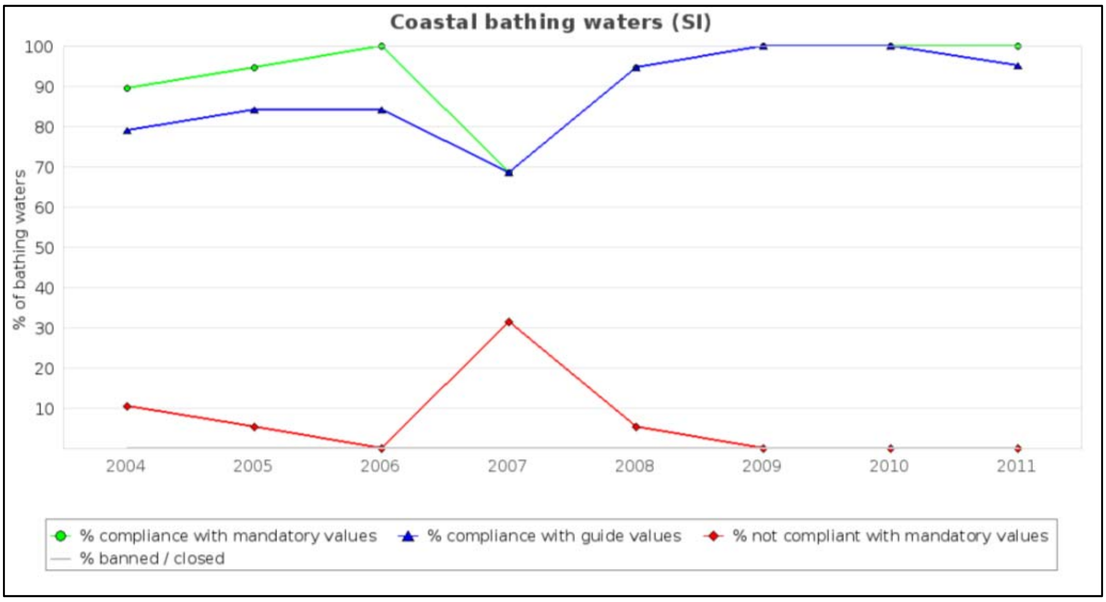


Figure 3-257 results of bathing water quality for Slovenia from 2004 to 2011 (Source: EEA, 2011).

For year 2011 in particular, the bathing season for coastal bathing waters lasted 107 days, from 1 June to 15 September, with 21 coastal bathing waters monitored; 100.0 % of the coastal bathing waters met the mandatory water quality, the same as 2010. The rate of compliance with the guide values decreased from 100.0 % to 95.2%. No bathing waters (0.0 %) had to be closed during the bathing season, the same as in 2010. The following figure resumes 2011 Slovenian bathing season.

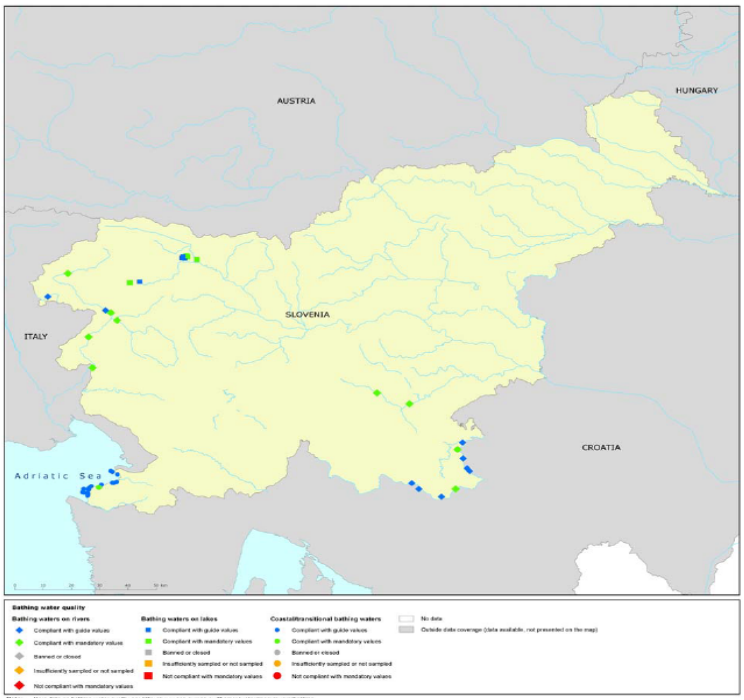


Figure 3-258 Bathing waters reported during the 2011 bathing season in Slovenia (Source: EEA, 2011).

For Montenegro data available for the year 2010-2011 are presented in the following figure. The mean for both years evidence an almost complete respect of mandatory values.

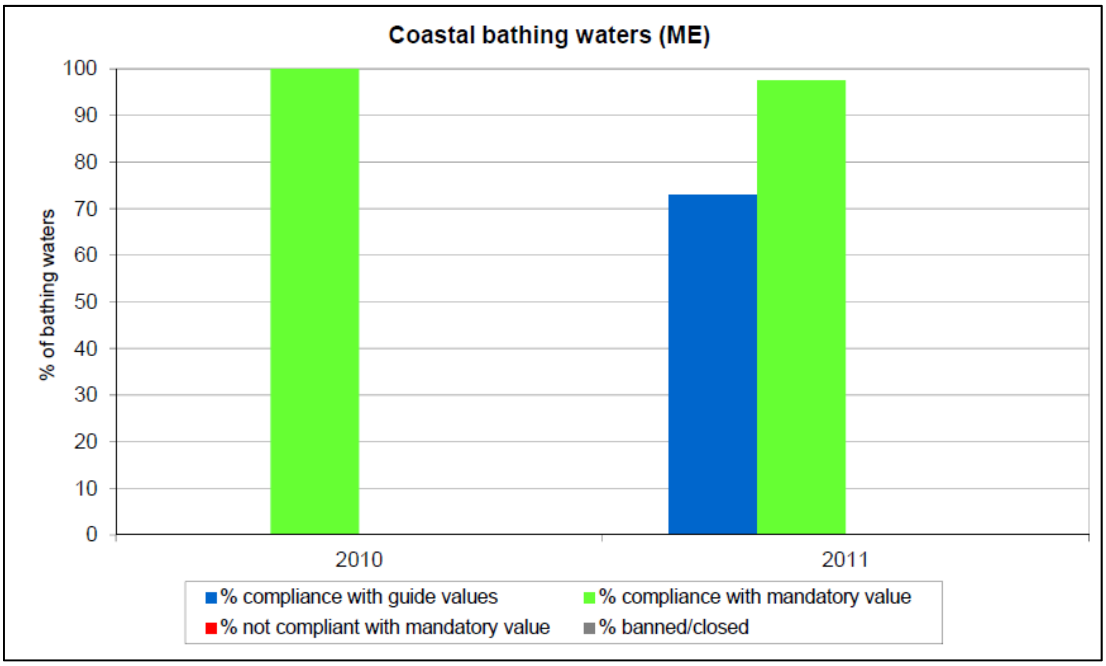


Figure 3-259 Results of bathing water quality for Montenegro for 2010 and 2011 (Source: EEA, 2011).

For year 2011 in particular the bathing season for coastal bathing waters lasted 134 days. from 23 May to 3 October, with 81 coastal bathing waters monitored; 97.5 % of the coastal bathing waters met the mandatory water quality in 2011. This is a decrease of 2.5 % compared to the previous year. No bathing waters (0.0 %) had to be closed during the bathing season, the same as in 2010. Two bathing waters (2.5 %) were insufficiently sampled compared to none (0.0 %) in 2010. The following figure resumes 2011 Montenegrin bathing season.

Figure 3-260 bathing waters reported during the 2011 bathing season in Montenegro (Source: EEA, 2011).

<u>Waters used for mariculture activities</u>

Main pollution sources of microbial pathogens generating pressures on mariculture activities (mollusc clams and mussels in particular) for human consumption are, in order of relevance (ISPRA, 2012):

- Waste water treatment plants (very high risk for public health);
- Industrial wastes fluxes (significant risk);
- Sewage discharges (significant risk);
- Not identifiable sources like waste discharges from boats, runoff, rural areas with domestic animals (potential or low risk).

In particular molluscs like clams and mussels tend to concentrate micro-organisms and toxic substances dissolved in water and are consequently taken as reference.

As prescribed by European law, some biological parameters need to be monitored. The following table resumes reference values to be respected for specific micro-organisms prescribed by Regulation 2073/2005/CE and Directive 2006/113/CE. Even if many other pathogen micro-organism like for example hepatic viruses are not controlled, they can become a sanitary problem and it's not excluded that they will be monitored in the future.

Table 3-34 parameters and values to be respected for molluscs.

Reference law	Parameter	Limit value
Regulation 2073/2005/CE	*Escherichia coli* *Salmonella*	<= 230 MPN/100 g of pulp and inter-valve liquid Absent in 25 g
Directive 2006/113/CE	Faecal coliforms	<= 300/100 ml in the inter-valve liquid and mollusc pulp

For *Escherichia coli* parameter higher values can be accepted (not bigger than 46,000 MPN (most probable number)/100 g of pulp and inter-valve liquid) but a specific treatment like purification after harvesting is required (Regulation 854/2004/CE).

Regarding Italian Adriatic mariculture water quality, the following consideration, derived from ISPRA (2012), can be done, referring to mandatory parameters to be monitored:

- For faecal coliforms monitoring, 2005-2007 results, even if not totally complete (data are available only for four Italian regions Veneto, Friuli Venezia Giulia, Emilia Romagna and Abruzzo), suggest that only less than 1% of regional total areas are unsuitable for molluscs farming and no qualitative worsening has been registered;
- For *Escherichia coli* and *Salmonella* it's not possible at the moment making considerations for the impact on public health in the assessment area due to information lacking.

At the moment for Italian mariculture waters. specific criteria for the evaluation of the waters status with respect to the pressure and impacts are still not defined; nevertheless the frequency of overcoming of mandatory values could give an indication of the general status. Also other indicators like the number of downgraded areas with respect to total housing zones can be useful. Effects on marine environment (habitats and functional groups) are not still evaluable.

Concerning *Ostreopsis ovata* dataset for year 2010, based on water column and the bottom, they are still partial and at the moment relationships between exposition and poisoning with risks for human health cannot be done, even if in the period considered any intoxication event has been observed. For risks in the biota, analysis in the hot spot areas didn't show suffering conditions or death of starfish, sea urchin and mussels.

3.6.7.2 Introduction of non-indigenous species

Species that have been moved, intentionally or unintentionally, as a result of human activity, into areas where they do not occur naturally are called ‘introduced species’ or ‘alien species.’ Many of them perish in their new environment but some thrive and start to take over native biodiversity and affect human livelihoods (these are known as invasive species). When a species establishes in a new environment, it is unlikely to be subjected to the natural controls that kept its population numbers in balance within its natural range. Without such control by predators, parasites or disease, such species tend to increase rapidly, to the point where they can take over their new environment. Marine invasive species have had an enormous impact on biodiversity, ecosystems, fisheries and mariculture (breeding and farming marine organisms for human consumption), human health, industrial development. Alien species can be introduced unintentionally or intentionally (IUCN).

Unintentional introductions are those where species enter new areas as ‘hitch-hikers’ or ‘stowaways’ through trade, travel and transport. They include the major long distance, shipping-related causes of introduction (IUCN):

- Ballast water transfer, mainly associated with large ships;
- Hull fouling, associated with ships as well as yachts and smaller crafts.

Unintentional introductions, including over shorter distances can also be associated with many other activities like:

- Fouling of buoys;
- Transport on fishing or diving gear;
- Transport on pleasure craft or other small boats;
- Alien pathogens in shellfish and other aquaculture introductions.

Intentional introductions are instead those where the transfer of the organisms was planned. Some alien species are introduced for release into the wild such as:

- Fish species released to increase local catches;
- Plants introduced for mudflat or dune management.

Many alien species are introduced into some form of containment, or for a use that does not mean them to be released in the wild. But very often such species ‘escape’ or are discarded into the environment. This category includes:

- Mariculture (farming of oysters, clams, etc.);
- Aquarium use;
- Live seafood trade;
- Live fish bait trade;
- Seaweeds used in packaging.

Generally speaking, 80% of the introduced species have no visible effect on the indigenous communities. On the other hand, a minority of introduced species do have an impact on the indigenous communities. According to Boudouresque and Ribera (1994), the biotopes most affected by marine species in the Mediterranean are the lagoons and ports. In general, coastal lagoons and harbours present the highest numbers of alien species, and this can be justified by favourable conditions for the establishment of new species. The natural and anthropogenic disturbance that characterises such environments produces a depauperate, low-competition biota that can easily be occupied by opportunistic species, including new invaders brought by shipping and/or aquaculture (Occhipinti-Ambrogi and Savini, 2003).

According to specific studies on alien species along Italian coasts (Occhipinti-Ambrogi et al. 2010) based on data collected during years 1945-2009 (Figure 3-261), 165 new species have been recorded, mostly of them introduced in the 1980s and 1990s whereas in the last few years the number of new records has decreased. The available data show that vessels (54%) and aquaculture (19%) are the main causes for alien species occurrence in Italian seas.

Concerning the Adriatic Italian sea, well documented cases of invasions in the area are:

- Seaweed *Caulerpa racemosa* var. *cylindracea* (south-Adriatic);
- Seaweed *Sargassum muticum* (northern Adriatic);
- Seaweed *Undaria pinnatifida* (northern Adriatic);
- Molluscs *Anadara transversa* (central and northern Adriatic);
- Molluscs *Musculista senhousia* (northern Adriatic);
- Molluscs *Ruditapes philippinarum* (northern Adriatic);
- Molluscs *Rapana venosa* (northern Adriatic);
- Molluscs *Crassostrea gigas* (northern Adriatic);
- Crustacean *Dyspanopeus sayi* (northern Adriatic);
- Bryozoan *Tricellaria inopinata* (northern Adriatic);
- Ctenophore *Mnemiopsis leidyi* (northern Adriatic).

One of the most important hot spot area is the Venice lagoon, with its crowded recreational and commercial harbours, as well as a flourishing mariculture activity (fish and shelfish farms), with 39 new species (mostly molluscs, macrophyta and crustaceans) on a total of 51 for the north Adriatic.

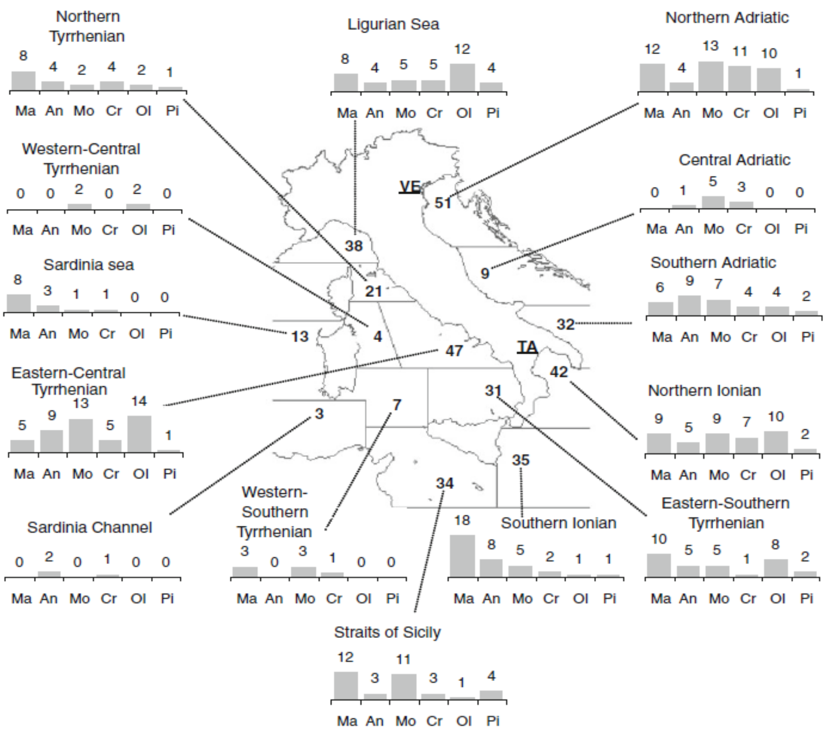


Figure 3-261 Number (in bold) of alien species recorded in each Italian sea, lagoons included. Continuous lines indicate borders between seas. Number of alien species belonging to different taxa are indicated over the bars: Ma Macrophyta, An Annelida, Mo Mollusca, Cr Crustacea, Ol other invertebrates, Pi Pisces. The two main hotspots of introduction are also indicated (VE Venice, TA Taranto) (Source: Anna Occhipinti-Ambrogi et al., 2010).

Regarding the impact of some of these species on the environment, for the invertebrates the most clear-cut examples are two bivalves introduced for farming purposes, having developed large natural populations:

- the Pacific oyster, *Crassostrea gigas*;
- the Manila clam, *Ruditapes philippinarum*.

They have respectively prevailed over native oysters (*Ostrea edulis*) and clams (the grooved carpet shells *Tapes decussatus*) in the lagoons of the northern Adriatic sea. They are also known as powerful vectors for unintentional introductions of other non-target species, concealed in the packaging material and among imported seed clumps, or dwelling as epibionts on the shells (Occhipinti et al., 2010).

Other species are known as habitat modifiers, such as:

- The seaweed *Caulerpa racemosa* var. *cylindracea,* causing a decrease of diversity and large differences in the structure and species composition related to non-invaded assemblages (Piazzi and Balata, 2009); this species, combined with *Caulerpa taxifolia* diffusion in Sicily, Sardinia, Ligurian Sea and Tyrrhenian, caused the most significant habitat modification ever in Italian coastal waters, invading large portions of the already degraded *Posidonia oceanica* meadows in many Mediterranean sectors;

- The seaweed *Sargassum muticum*; a canopy-forming species that reduces the Photosynthetically Active Radiation (PAR) with repercussions on the underlying layers, leading to a decrease in species number and surface cover (Curiel et al, 1998). In particular this species, associated with *Undaria pinnatifida,* has quickly colonized the hard substrata in the Venice lagoon, competing with indigenous species, and the lack of potential predators in the colonized area (such as sea urchin *Paracentrotus lividus*) probably has enhanced their spread. Moreover, according to several authors, manual eradication may be ineffectual, due to their efficient reproduction mechanisms.

Another species whose impact has not still been evidenced derives from the indopacific gastropod, the veined welk *Rapana venosa.* Being a selective and voracious predator of bivalves, *R. venosa* was thought responsible for altering local community structure, influencing competition amongst filter feeder/suspension feeder bivalves and causing a long-term ecological impact in many areas of the Mediterranean. Nevertheless no records of actual consequences have been reported from the northern Adriatic Sea. where it was introduced in the 1970s.

Concerning the others Italian Adriatic areas, south Adriatic is characterized by 32 new species recorded, mainly anellida and Mollusca, while in central Adriatic only 9 new species, more than 50% Mollusca, have been recorded. Factors that may explain the presence of a lower number of aliens in the central Adriatic are:

- Dominance of soft-bottom substrates, with consequent low habitat diversification;
- Oceanographic conditions that prevent both the colonization by thermophilic species from the South and the range expansion of cold-affinity species settled in the northern Adriatic;
- Minor concentration of research activities, compared to other Italian seas.

3.6.7.3 Selective extraction of species, including incidental non-target catches

Fishing activities affect the environment directly through their effects on target species as well as indirectly through their effects on the marine ecosystem. Among the indirect environmental impacts of fishing on the ecosystem the following ones can be identified:

- Alteration and destruction of benthic habitat, such as seagrass beds and hard-bottom coralline areas;
- Effects on non-target populations due to bycatch, discarding, ghost-fishing, etc.;
- Effects on other non-commercial and often endangered species incidentally captured in the fishing process (such as sea turtles, dolphins and others);
- Effects on the food web of the marine ecosystem by the harvesting of top predators, Lack of top predators alters the food chain and causes unanticipated imbalances in the food web.

Apart from being an important maritime transport route, the Adriatic Sea basin is among others a good area for fishing (including mariculture). Fishing has traditionally been an important sector for most Adriatic countries. Italy has by far the largest fishing fleet in the Adriatic. The following chapters illustrate the amounts and impact of fishing and mariculture activities in the Adriatic basin.

Fishing activities

As testified by literature data, the Adriatic is considered a productive sea. particularly in the north and central basin (Figure 3-262), with consequent relevant impact on the marine ecosystem.

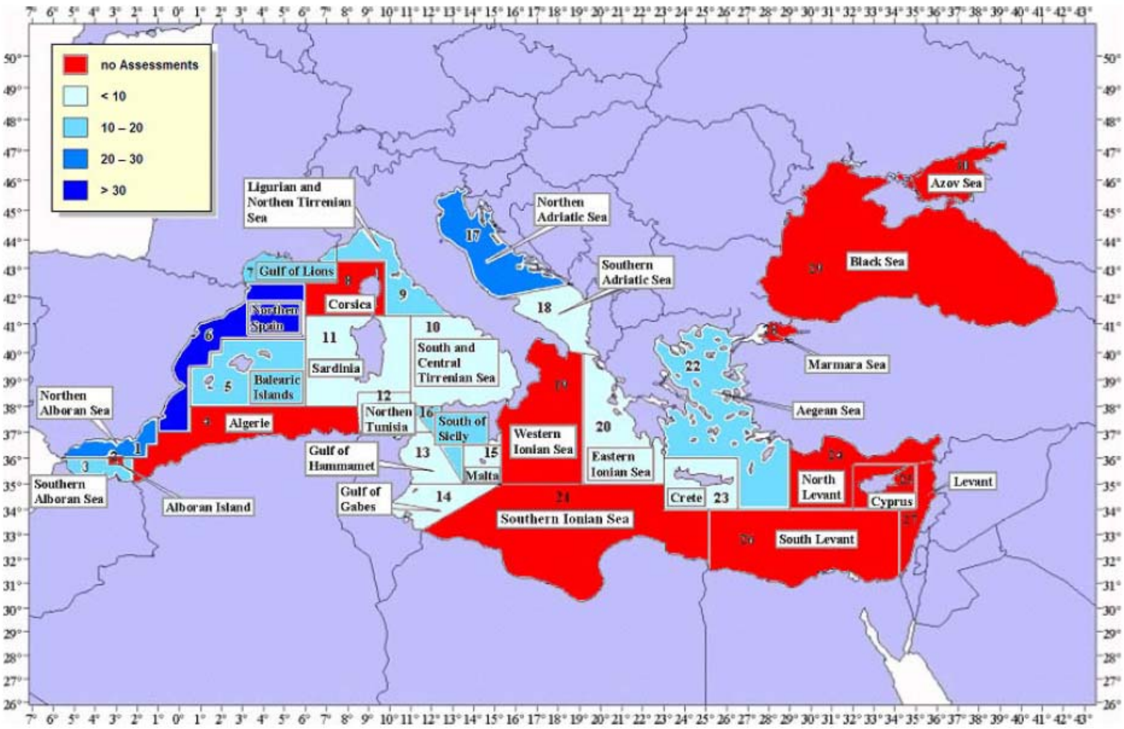


Figure 3-262 Mediterranean stock assessment (2001-2008) (Source: JRC, 2010).

This richness led to an over-exploitation of marine resources, as testified by statistics, which showed that fish stocks have suffered from overfishing and/or pollution, especially in the Italian part of the Northern Adriatic Sea (Policy Research Corporation, 2011). Figure 3-263 for year 2008 shows that the Adriatic is one of Mediterranean areas mostly overfished. The chart shows the proportion of assessed fish stocks that are overfished (red) and those within safe biological limits (green) in the ICES and GFCM fishing regions of Europe. The numbers in the circles indicate the number of stocks assessed within the given region. The size of the circles relates to the size of the catch in that region.

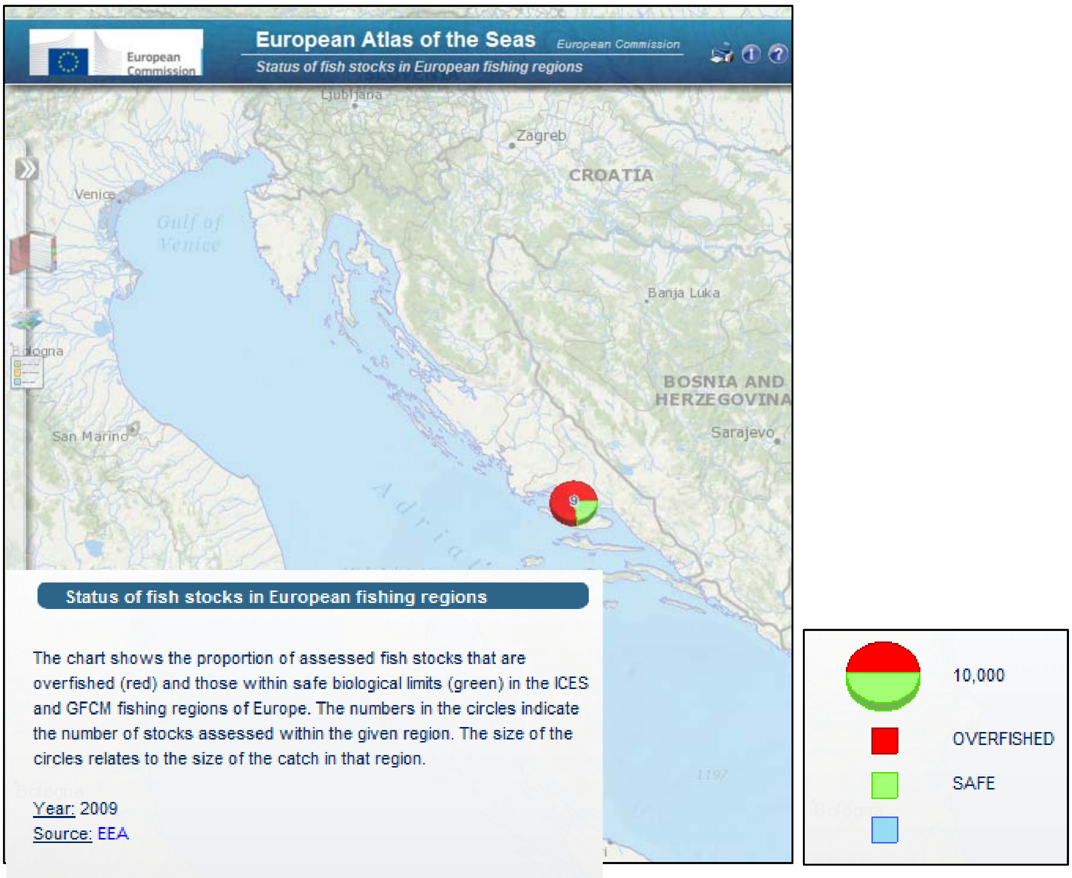


Figure 3-263 status of fish stocks in Mediterranean fishing Regions (Source European Atlas of the Sea; http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/, last access 18 June 2013).

Regarding Italy, despite the crisis involving the sector, Adriatic Regions all together contribute more than 50% of the total national catches (Table 3-35).

Table 3-35 Italian catches and fishing days for years 2010-2011 for the Adriatic Regions (Source: Mipaaf-IREPA).

Region	2011		2010	
	Fishing days	Catches (ton)	Fishing days	Catches (ton)
North Puglia	167,122	27,329	173,301	29,648
Molise	12,472	2,199	10,081	2,099
Abruzzo	70,368	11,449	64,797	10,914
Marche	132,248	25,360	134,390	29,621
Emilia Romagna	64,824	17,635	63,691	22,181
Veneto	75,129	19,625	77,692	23,428
Friuli Venezia Giulia	41,174	3,676	43,639	3,724
TOTAL Italian Adriatic Regions	**563,337**	**107,273**	**567,591**	**121,615**
TOTAL Italy	**1,748,461**	**210,323**	**1,667,835**	**223,007**

Regarding major pressures on target species, divided into macro categories (fishes, crustacean and mollusc), the situation for year 2010 is reported in Table 3-36; it should be noted however that percentage fluctuations between years exist but every Region has a dominant category.

Table 3-36 regional percentage catches distribution year 2010 (Source: Mipaaf-IREPA).

Region	Fishes (% on total regional)	Crustaceans (% on total regional)	Molluscs (% on total regional)
Puglia	67.6	10.0	22.4
Molise	35.7	25.2	39.1
Abruzzo	47.5	6.5	45.9
Marche	39.3	8.9	51.8
Emilia Romagna	76.8	9.7	13.5
Veneto	75.8	3.9	20.3
Friuli Venezia Giulia	41.7	7.2	51.1

Pressure on species present regionally differences. In particular it can be noted that (reworking of IREPA statistics[39]):

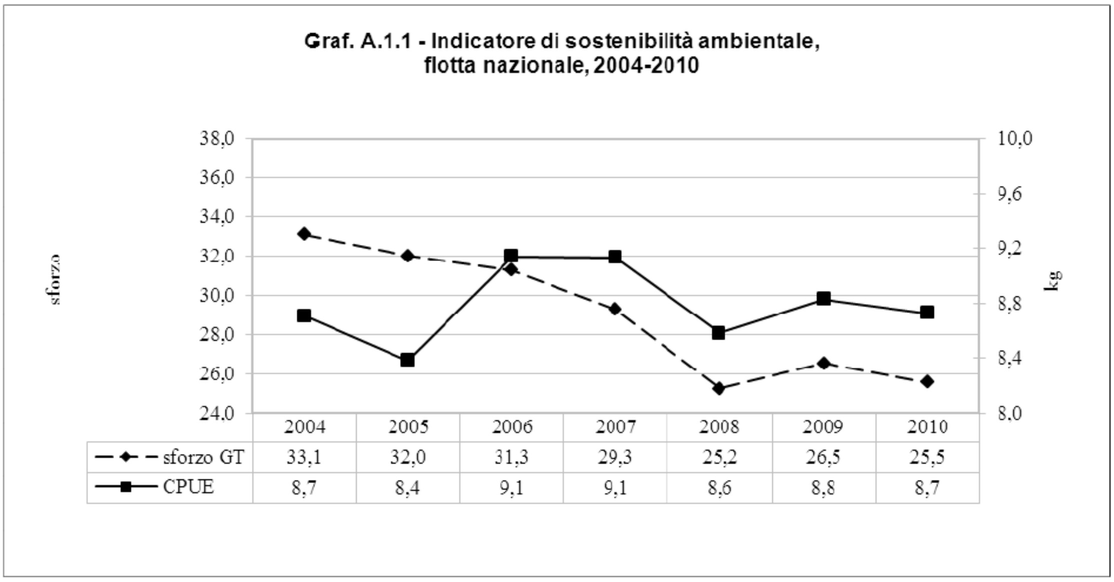
- in the north and central basin most important fish species are anchovy and pilchard (in particular Veneto and Emilia Romagna), while in the south (especially Molise and Puglia) dominates hake;
- concerning crustaceans in the north and middle Adriatic mantis shrimps is the most important captured species while in the south shrimps are relevant;
- regarding molluscs in the north dominate clam and cuttlefish, while in the middle and south clams are more relevant.

The study redacted by ISPRA (2012) within the MFSD implementation process in Italy, confirms that in the Italian south Adriatic hake population is over exploited while in the north and middle Adriatic main concerns regard mostly pilchard (sardine), followed by sole and anchovy; at the moment no information is available for molluscs and crustaceans.

In particular concerning the stock of Common Sole (*Solea vulgaris*) in the Northern Adriatic Sea, available data confirm that it is overexploited (high fishing mortality and low abundance). Advice is a reduction of 10% of the fishing pressure applied by rapido trawlers (in terms of number of vessels and/or fishing time) and a two months closure for rapido trawling inside 6 nm offshore along the Italian coast after the biological fishing stop (August). The safeguard of spawning areas (both in spatial and temporal terms) to prevent a possible future exploitation might be crucial for the sustainability of the Adriatic sole stock. Regarding sardine (over exploited) and anchovy (fully exploited) the suggestion is to reduce the fishing effort by the way of closing season (at least 45 days/year) and to protect the spawning of sardine, without increasing fleet capacity (GFCM, FAO, 2009).

39 http://www.irepa.org/ last visit 22/11/2012

At the Italian national level some general indications on sustainability are given by the following figures which show environmental sustainability indicators for overall fishing activities and trawling during the period 2004-2010. Efforts represent the use of productive factors adopted during marine fish captures while Catch Per Unit of Effort (CPUE) is the ratio between total catches and total effort.



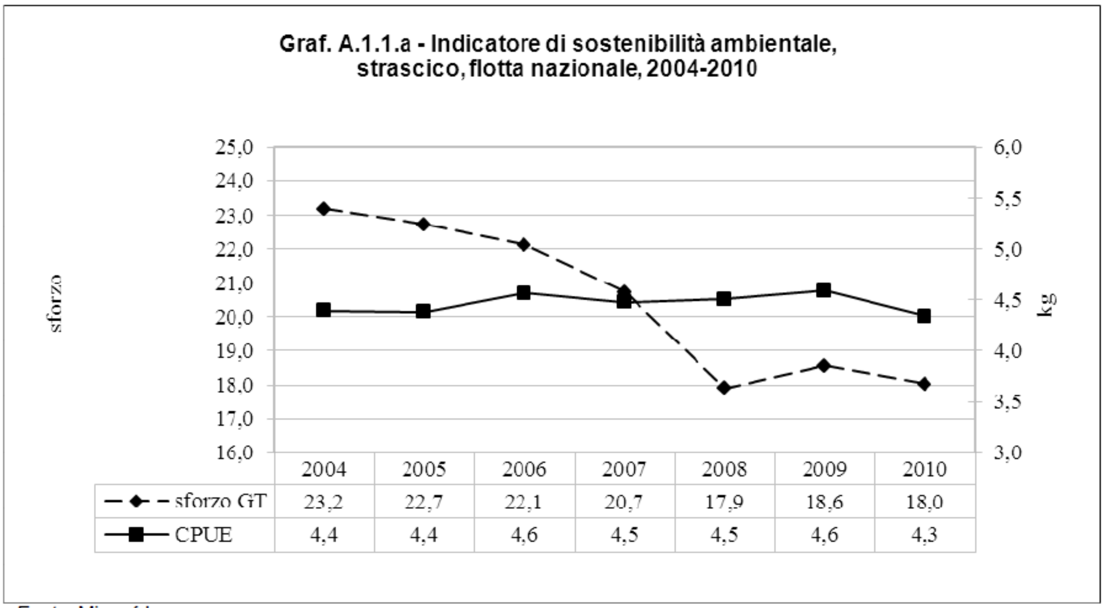


Figure 3-264 environmental indicators for total Italian fishing activities (upper figure) and trawling (lower figure)years 2004-2010 (Source: Mipaaf-IREPA).

In Croatia according to fishery legislation (Ordinance on marine fishing borders, 1996) the Croatian sea has been divided into seven fishing zones (Figure 3-265):

- Fishing Zone A (Western Istria Coast) is placed in the area of the outer fishing sea, from the outer border of the Republic of Slovenia to the Cape Kamenjak (Istria peninsula);
- Fishing Zone B (Outer Northern Adriatic) is placed from the border of Fishing Zone A to the island of Purar;
- Fishing Zone C (Outer Mid Adriatic) is located from the border of Fishing Zone B to the Cape Velo Dance;
- Fishing Zone D (Outer Southern Adriatic) is in the area from Fishing Zone C to the south-east;
- Fishing Zone E (Inner Northern Adriatic) is in the area between the Marler Cape (east coast of the Istria peninsula) to the line connecting the Borji Cape (island of Dugi otok), north cape of the island Tun Veli and Vrulja cape (island of Vir);
- Fishing Zone F (Inner Mid Adriatic) is between the southern border of Fishing Zone E to the line connecting Kriz Cape and Siran Cape (island of Drvnik Veli);
- Fishing Zone G (Inner Southern Adriatic) is in the area between the south border of Fishing Zone F to the Zarubaca Cape (near Cavtat).

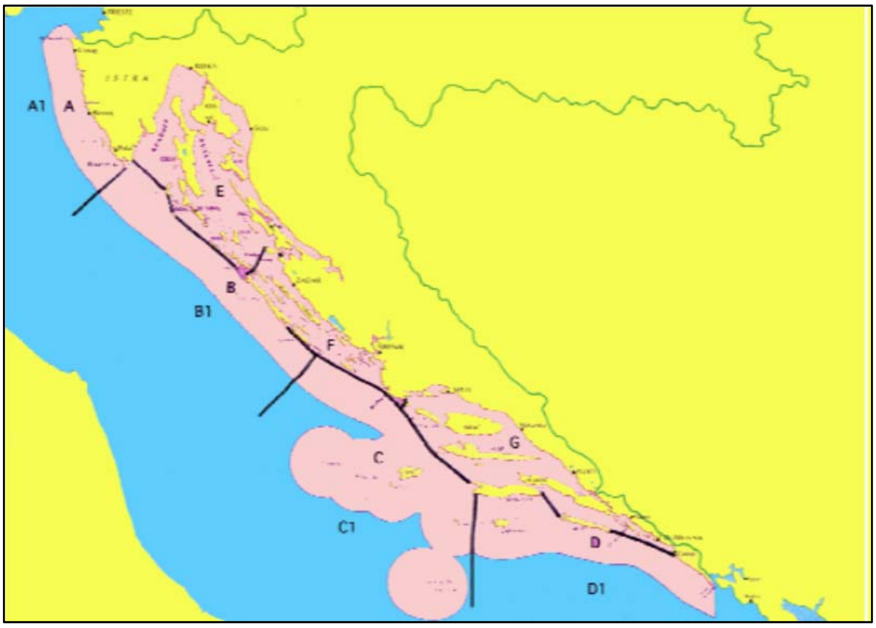
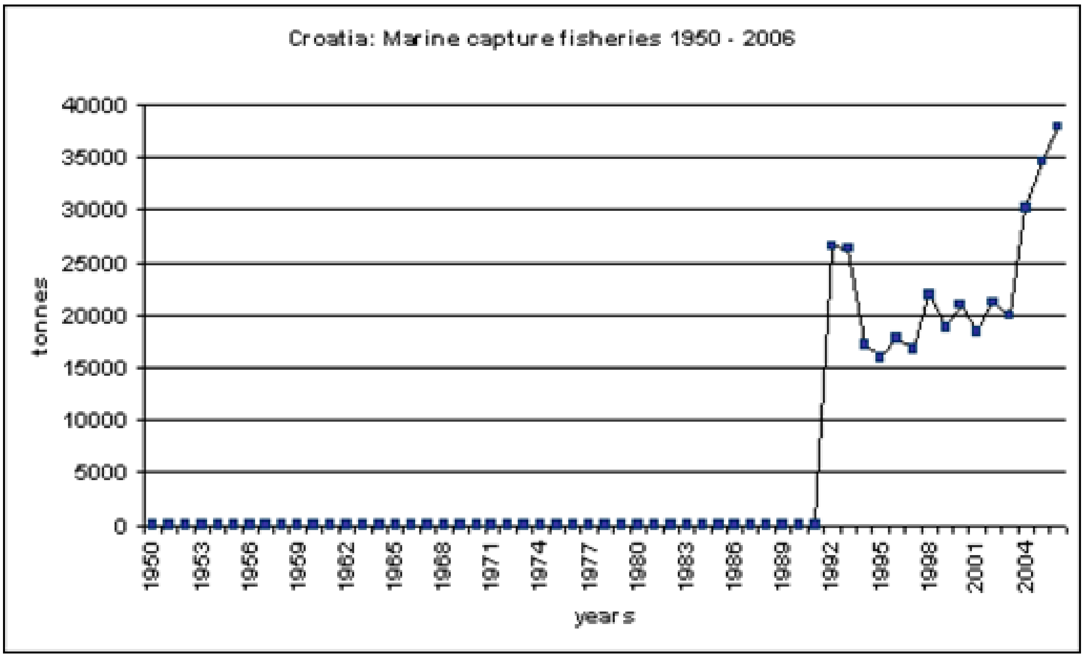


Figure 3-265 Fishing Zones' Borders in the Croatian Adriatic (Source: PAP RAC, 2007).

Regarding domestic fishery production data derived from Adriamed, based on FAO statistics, shows that in 2006 total amount was approximately 37,853 tons and 52,360 tons in 2010 (Janjanin, 2012). 96% of total species captured are fishes (mostly sardines and anchovy), 2% are cephalopods and 2% are crustaceans and shellfish (Janjanin, 2012). The growth trend, shown in the following graphic, from 1995 to 2004 is constantly increasing. For some countries information before year 1992 are lacking.



Source: FAO – FISHSTAT

Figure 3-266 Croatian marine capture fisheries trend (Source: FAO Adriamed http://www.faoadriamed.org/html/country_p/CroCProfile.html, last access 22 November 2012).

An increasing marine capture fisheries trend is also shown for Albania (5,729 ton in 2006), even if during 1987-1995 a marked decrease has been registered.

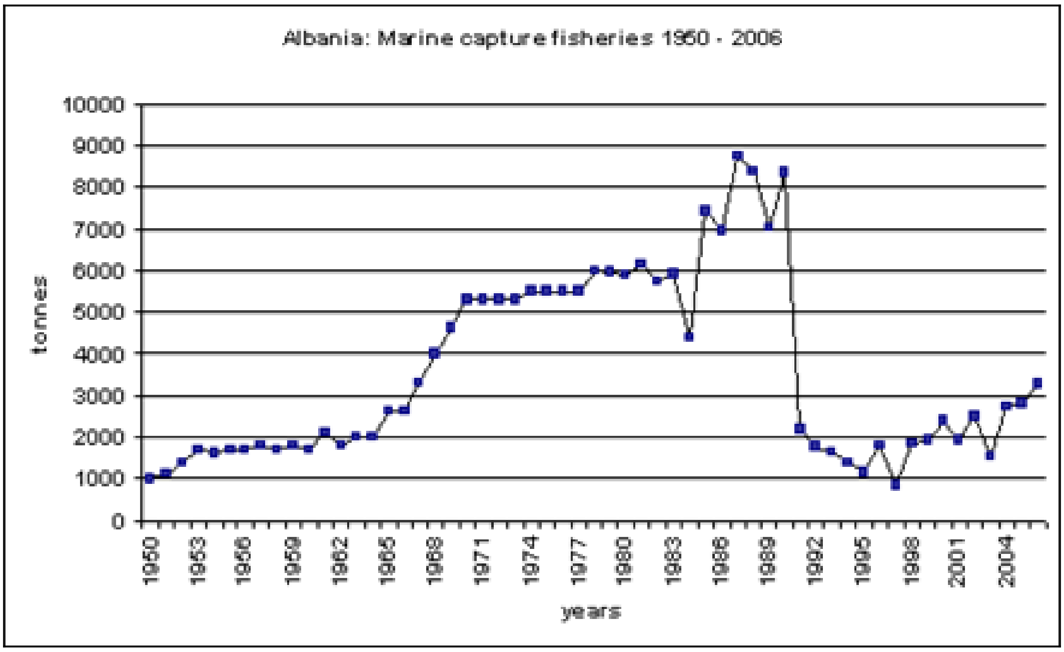


Figure 3-267 Albanian marine capture fisheries trend (Source: FAO Adriamed http://www.faoadriamed.org/html/country_p/CroCProfile.html, last access 22 November 2012).

In Slovenia instead marine fisheries showed an almost constant decrease from 1992 to 2004.

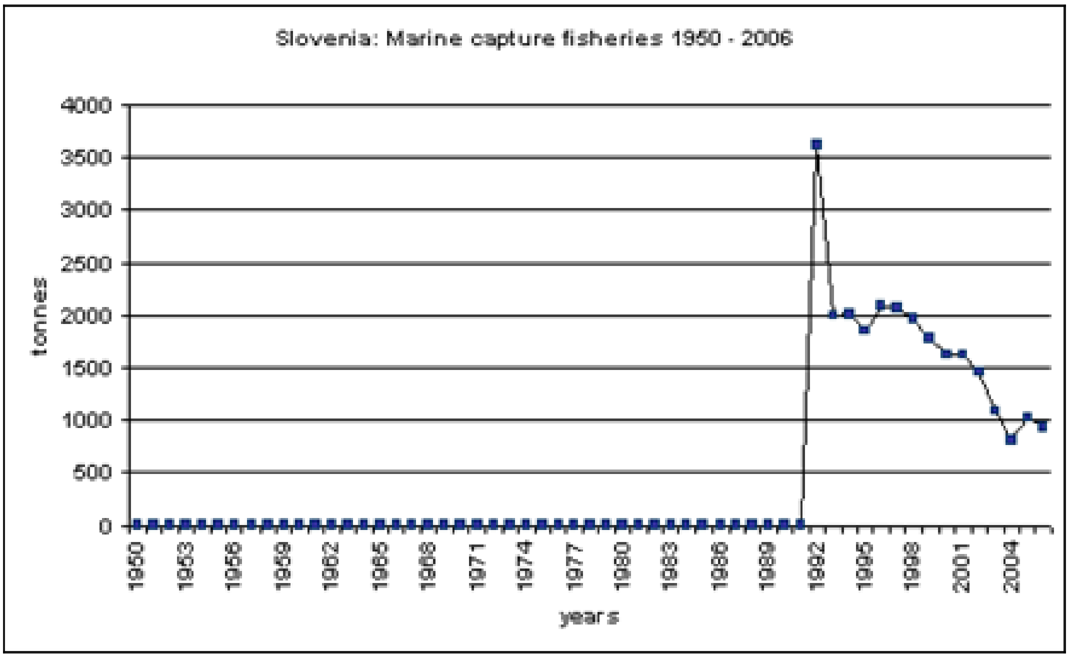


Figure 3-268 Slovenian marine capture fisheries trend (Source: FAO Adriamed http://www.faoadriamed.org/html/country_p/CroCProfile.html, last access 22 November 2012).

In Slovenia pelagic fish catch is predominant (61%), while demersal fish and cephalopods represent 38% of the total artisanal catch (GFCM, FAO, 2009). Among pelagic resources European pilchard *Sardina pilchardus* is the most important fish species with 96% of the industrial catch. Small pelagic species (*Sardina pilchardus, Sprattus sprattus, Engraulis encrasicolus, Scomber scombrus, S. Japonicus, Trachurus trachurus* and *T. mediterraneus*) are caught with purse-seine in territorial waters and midwater trawl in territorial and international waters.

In Montenegro, there are three main types of fishing: a) by bottom trawls of demersal (benthic) resources, b) fishing by entangling nets and pelagic trawls for small pelagic fish, and c) small-scale costal fishing by small tools. Trawling is the most significant fishing activity for crustaceans and cephalopods, and the target and commercially most significant species are: hake, (*Merluccius merluccisus)*, red mullet (*Mullus barbatus)*, rays (*Raja sp*.), musky octopus (*Eledone moscata),* cuttlefish (*Sepia officinalis)*, and deep-water rose shrimp (*Parapaeneus longirostris).* Fishing of pelagic resources by entangling nets and pelagic trawls is done in the open sea and at the entry of the Boka Kotorska Bay (Bays of Herceg Novi and Tivat). The most significant species of this fishing are*:* European pilchard *(Sardina pilchardus),* European anchovy *(Engraulis encrasicolus),* Mackerel *(Scomber scombrus).* Small-scale coastal fishing is done in the Bay of Boka Kotorska and along the Montenegrin coast by small boats and a large number of various tools (nets, angles). Species from the following families are caught with this fishing type: Sparidae, Scombridae, Triglidae, Clupeidae, and Engraulidae.

Figure 3-269 Annual catch (in tons) of saltwater fish in Montenegro (Source: MONSTAT, www.monstat.org; last access 17 June 2013).

YEAR	2011	2010	2009	2008
Pelagic fish	174	206	199	241
Pilchard	32	35	30	32
Sprat	31	38	38	48
Anchovy	12	13	19	15
Mackerel	12	12	10	12
Chub mackerel	13	14	12	21
Mackerel Scad	12	12	13	17
Tuna	13	14	14	9
Other Pelagic fish	49	68	63	87
Other fish	273	291	310	273
Hake	20	27	24	34
Red mullet	14	17	14	21
Dentex	6	5	4	10
Grey mullet	31	42	34	39
Eels	1	1	1	1
Picarel	11	17	15	16
Bogue	12	28	30	27
Dogfish	7	7	5	7
Catfish	7	7	5	10
Other fish types	147	138	143	84
Cephalopods	49	61	47	78
Squid	12	14	10	19
Cuttlefish	11	9	7	15
Octopus	13	16	15	23
Musky octopus	13	22	15	21
Shellfish	198	206	215	205
Crayfish	22	27	21	41
	49	61	47	78
TOTAL	**716**	**810**	**773**	**838**

<u>Mariculture</u>

Mariculture can generate different kind of environmental problems, particularly because of organic enrichment resulting from intensive aquaculture activities. In fact due to high settling velocities of uneaten pellets, much of this material settles out in the immediate vicinity of fish cages. The area of the seabed over which the material is dispersed actually depends on the surface area of the farm, the settling velocity of the uneaten food and feces, current speeds and the depth of water beneath the cage. Two zones can be identified:

- An inner zone which receives uneaten food and feces;
- An outer zone receiving faecal waste only.

This is shown in generalized way in the following figure.

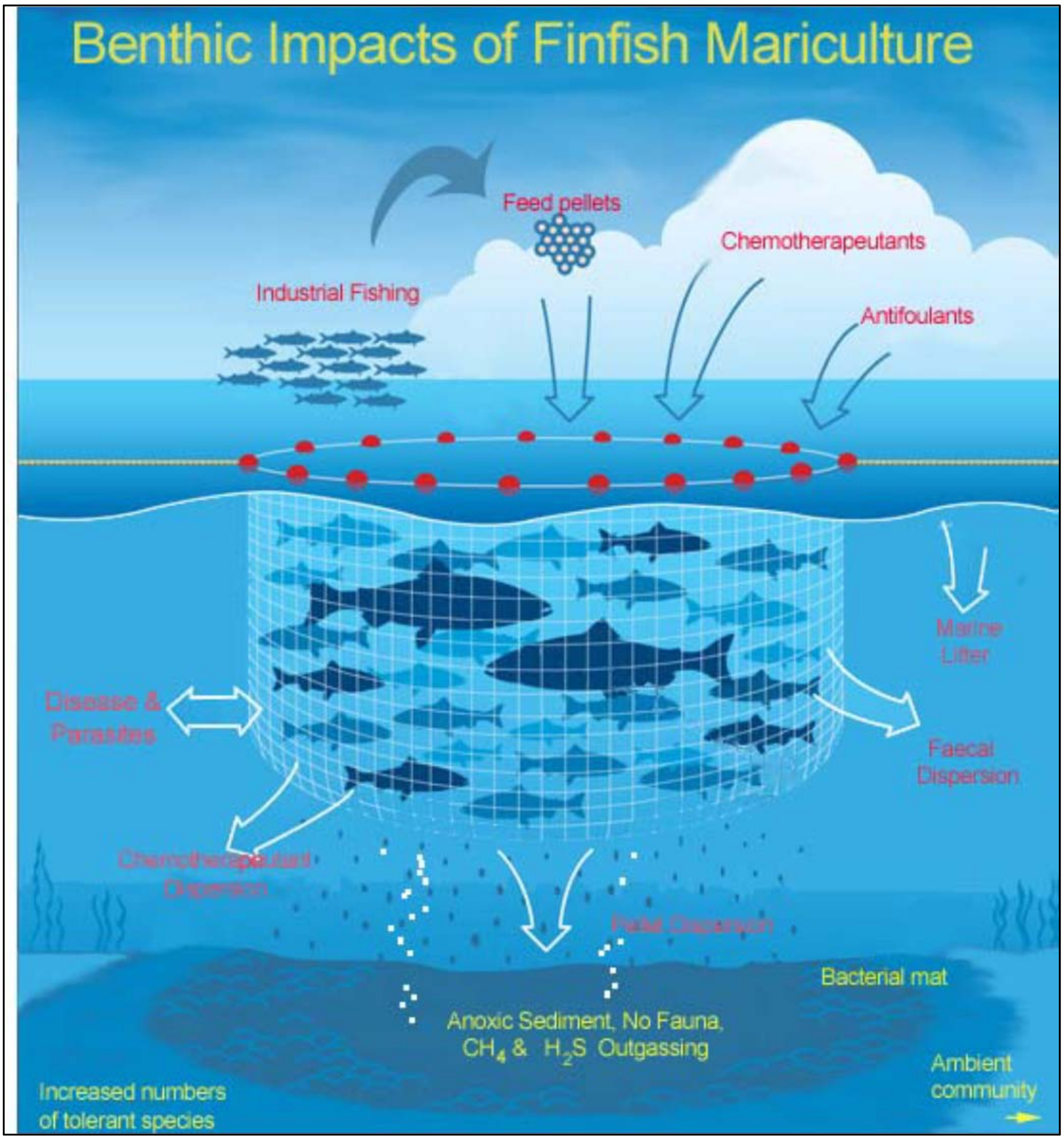


Figure 3-270 Benthic Impacts of Finfish mariculture (Adapted from Pew Oceans Commission) (Source: OSPAR, 2009).

Although loadings beneath fish farms can be high, the scale of effect is, in most cases, localized and restricted to the immediate vicinity of the farm. This effect is usually limited within 20 meters of the cages. Where current velocities are high the impact on the benthos in the vicinity of the farm may not be discernible. Taking as example tuna farming, studies suggests that no significant environmental changes have been noticed in water columns and sediment at a distance of >100 m from the grow-out floating cages for tuna farming located at 45–50 m depth.

The effects of mariculture organic wastes on bottom living animals are similar to those associated with other inputs of organic matter, for example sewage waste. Under high input loadings there may be a loss of sensitive species and an increase in the biomass of more tolerant organisms. Moving away from the source of inputs or under conditions of moderate loadings, there is an enhancement of the natural productivity of the local fauna. Further away or under conditions of low organic inputs, the natural fauna are unaffected.

Shellfish farming tends instead to have a limited impact (compared to finfish farming) primarily because there are no direct inputs of food or chemicals. The impacts of shellfish farming such as mussel, oyster, clam and scallop farming are mostly generic and include ecosystem impacts from the introduction of alien species, physical disturbance from dredging and presence on the foreshore (OSPAR, 2009).

Nevertheless trophic loads are 2-3 magnitude order lower than those deriving from atmospheric pollution or from other anthropic inputs (fertilizers, detergent). Consequently at the Mediterranean level mariculture presently doesn’t affect ecosystem but it can generate a relevant impact at a local scale, with local estimated increases of 73% for nitrogen and 99% for phosphorous (Bianco, 2010).

Concerning Adriatic countries situation, in Italy the production of fish, mussels and clams by aquaculture/mariculture in the northern part of the basin for year 2006 (fish) and 2005 (mussels and clams) is shown in Figure 3-271 and Figure 3-272 (Policy Research Corporation, 2011). Catches from both the Adriatic Sea and the lagoons are taken into account. The majority of mussels and clams are produced in the lagoons (especially the Venice lagoon for clams). In both cases the most important producer is Italy.

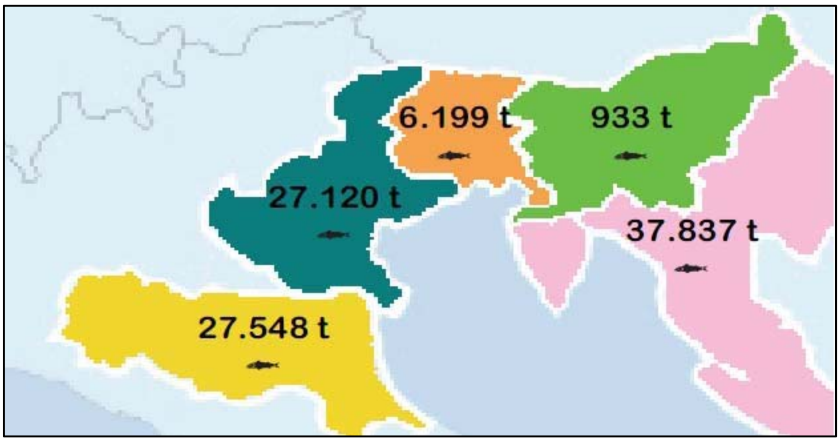


Figure 3-271 Production of marine and lagoon fish in the northern Adriatic regions in 2006 (Source: Policy Research Corporation based on Veneto Agricoltura, 2008).

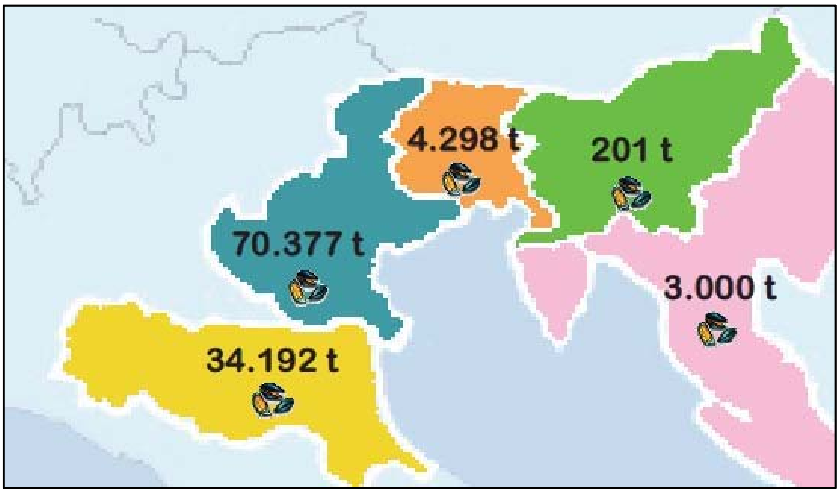


Figure 3-272 Production of mussels and clams in the Northern Adriatic region in 2005. (Source: Policy Research Corporation based on Veneto Agricoltura, 2008).

Particularly relevant is mariculture linked to the production of mussels, especially in Veneto and Emilia Romagna Regions. The following figure shows the distribution of mariculture locations along these two Regions coastline. The most important area is located nearby Po delta. No local impacts deriving from these activities in the area have been registered as testified by studies on culture sites offshore carried out in 2001 by ISMAR-CNR in Ancona, which didn't show the presence of significant quantity of organic waste on the bottom, probably thanks to strong sea currents; nevertheless more evident effects on the environment could instead be observed when farms are situated in closed areas, such as the Gulf of Trieste, or even more in lagoons (FAO).

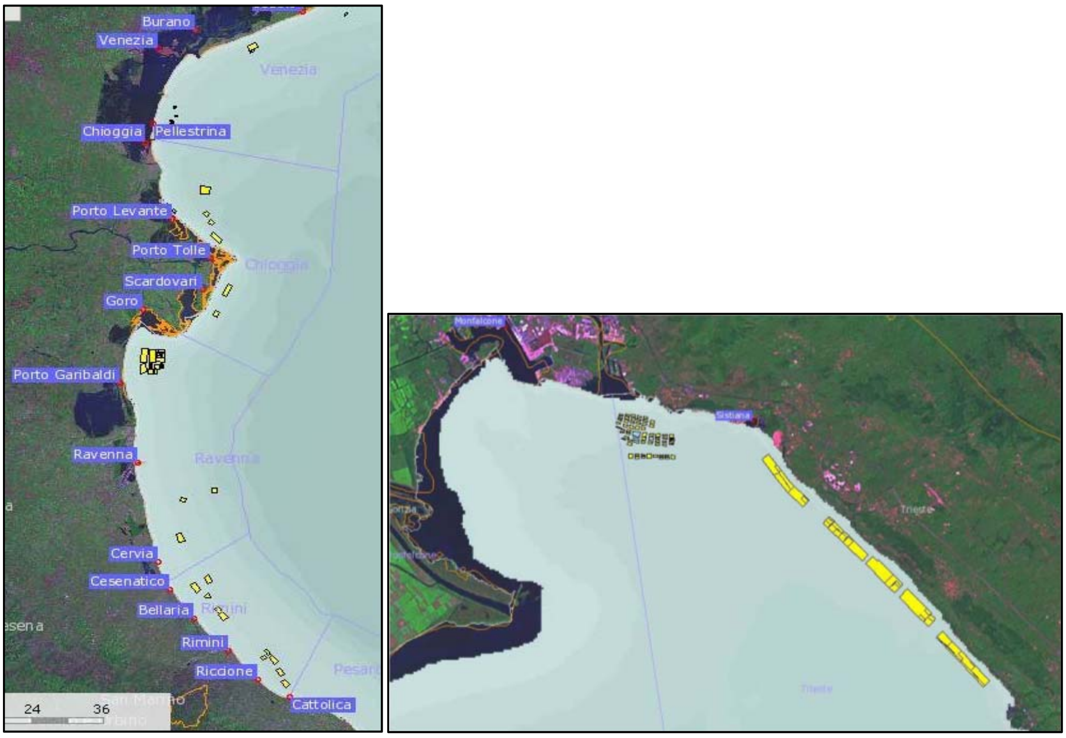


Figure 3-273 Mariculture location in Emilia-Romagna, Veneto and Friuli Venezia Giulia (Policy Research Corporation based on GIS system ARPA Friuli Venezia Giulia, 2011).

In Croatia, compared to fisheries, mariculture has only recently been developed. In 2008 12,000 tonnes of fish were produced through aquaculture. The Zadar county, which detects more than 50% of Croatian marine aquaculture (Janjanin, 2012), developed maps of suitable zones for mariculture, shell-fish farming and zones for demersal fish within the framework of the 'Study of use and protection of the sea and underwater area in the Zadar county'.

Particularly relevant are, along the Dalmatian coast (Figure 3-274), tuna farms activities (in 2001 nine areas used for tuna farming were recorded, Miyake et al., 2003), especially in the sheltered bays of some islands (Drvenik, Braè, and other in Zadar area), with a yearly average production of 4,000 t (Janjanin, 2012).

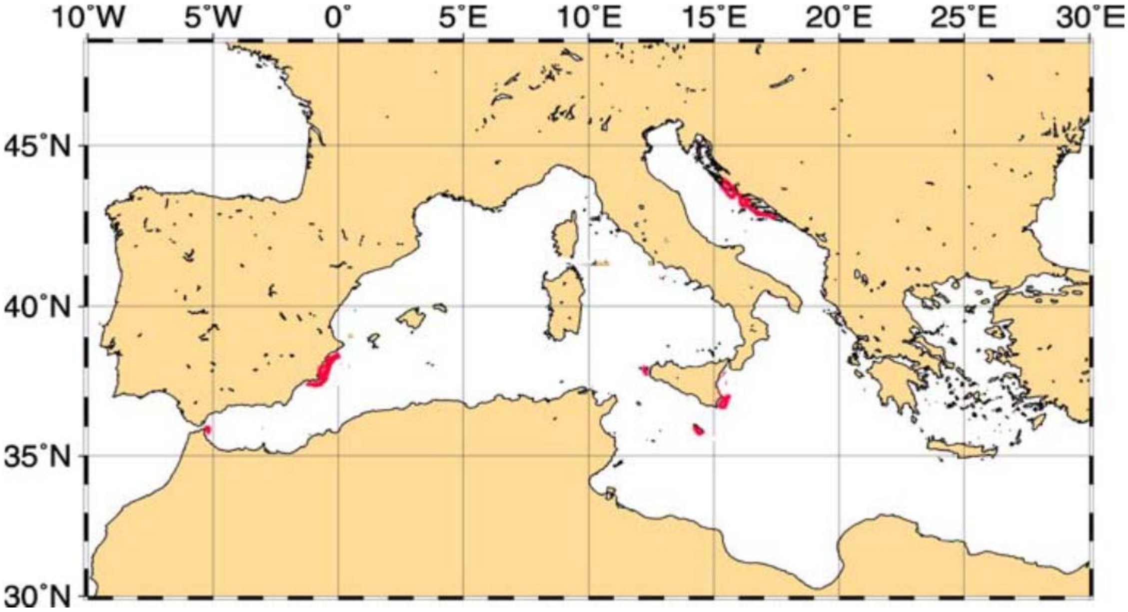


Figure 3-274 Distribution of bluefin tuna farming sites in the Mediterranean Sea (Source: Miyake et al, 2003).

This activity, although it brings enormous financial benefit to those involved in the business, is causing important environmental and social problems (Miyake et al., 2003). In 2003, the Croatian Ministry of Environment has released its annual report that includes a list of facilities hazardous to human health. In this list, tuna farms are mentioned as presenting dangers to underwater ecosystems. The bigger risk comes from the fact that the farms are often located in shallow sea, near the coast, where the rate of water renewal is too low to enable proper clean-up of tuna wastes and of the excess baitfish used to feed tuna.

In addition to tuna farming, there are different other mariculture activities. Namely, the Republic of Croatia is one of the pioneers in marine aquaculture in the Mediterranean, rearing the sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*). Regarding to shellfish farming activities (4,000 t produced yearly - Janjanin, 2012), there are mussel (*Mytilus galloprovincialis*) and oyster (*Ostrea edulis*) that are reared in Croatia. They are mainly placed in Istria, Šibenik-Knin and Dubrovnik-Neretva County (in particular in Mali Ston Bay). In order to mitigate the negative impacts on marine resources, the Croatian Parliament proclaimed the Zone of Ecological Protection and Fisheries (ZEPF) on 3rd October 2003 (Mackelworth et al., 2010).

However, in 2004 the Croatian Parliament decided that the implementation of the zone regime for the EU Member States would only begin after signing a fishery partnership agreement with the EU. Since no such agreement was signed, in 2006 the Croatian Parliament decided that the legal regime of the EFPZ with regard to the EU Member States was to commence as of 1 January 2008 at the latest. Subsequently, a new decision was adopted by which the EFPZ was provisionally not to apply to EU Member States "until a common agreement in the EU spirit was reached". Consequently, so far, the EFPZ only applies to non-EU Member States (Vidas, 2008) (see Final report of Shape Action 4.1 for more details).

Concerning Slovenia, it has an important aquaculture system, dominated by freshwater fish farming. Even if an increase on mariculture activities has been evidenced during the period 2001-2004 (particularly for mussels, close to Piran, and seabass) the maximum percentage reached on total national aquaculture in the same period is 17% of total (277 ton during 2004) (Veneto Agricoltura, Osservatorio socio economico dell'Alto Adriatico). The increasing tendency of mariculture in Slovenia has also been caused by the creation of some protected marine areas with restricted fishing activity together with the general depletion of fishery resources in the Northern Adriatic. However, due to limited Slovenian coast length, there is a problem of restricted space for the development of aquaculture (UNEP, 2007).

In Montenegro the Law on Marine Fishery and Mariculture (Official Gazette of Montenegro 56/09) lays down the conditions for farming of fish and other marine organisms in locations designated by the Spatial Plan for coastal zone in line with the Mariculture Development Plan, and in accordance with the National Fishery Development Strategy. Mariculture activities are carried out in accordance with the principles of Good Manufacturing Practice in mariculture, while adherence to the principles will be taken into account in the procedure of issuing and cancelling the mariculture permits.

The Bay of Boka Kotorska has favourable conditions for mariculture productions. There are 16 mariculture farms mostly for shelfish (mussels) farming using the system of floating bouyis and ropes. The annual production of about 150 tons of mediterranean mussel and about 50 tons of fish (sea bass and sea brim). All mariculutre farm products are sold on domestic market. (Source: Fisheries development Strategy of Montenegro, Ministry of agriculture, water management and forestry, 2006).

3.7 Data and information gaps

The analysis illustrated in the present chapter aims to provide a first contribution to the holistic assessment of the Adriatic Sea according to the requirements set by the Marine Strategy Framework Directive. Being a preliminary contribution, the analysis is surely susceptible of improvements and integration, based on other available information sources and those that will emerge through new studies and projects; including in particular the Croatian-language document "Initial assessment of the state of and pressure on the marine environment of the Croatian portion the Adriatic Sea" issued by the Croatian Ministry of the Environment and Nature Protection in September 2012, that was not possible to take in consideration by the Shape project due to Action 4.2 Work Plan. A great contribution to the understanding of the MSFD related process at the Adriatic scale will also come from the implementation of the same Directive within each single State; actually according to art. 8 Member State are urged to elaborate an initial assessment of their marine waters and to periodically improve it.

Given above consideration, the analysis performed within the Shape project at the Adriatic basin scale enabled to identify a number of data and information gaps that could be covered by future assessment efforts; the following main elements were identified:

- Nitrogen hot spot areas for Eastern Adriatic (cfr par. 3.2.9.1);
- Phosphorous hot spot areas for Eastern Adriatic (cfr par. 3.2.9.2);
- Total Organic Carbon (TOC) for the whole Adriatic basis (cfr par. 3.2.9.3);
- Predominant seabed of central and southern Adriatic (cfr par. 3.3.1);
- Identification and mapping of habitats of particular interest along Eastern Adriatic coastline (cfr par. 3.3.2);
- Seaweed and seagrass species in the Eastern Adriatic (cfr par. 3.4.1.3 and 3.4.1.4);
- More detailed information on the species *Thunnus thynnus* (as for example species abundance in the Adriatic, yearly amounts of fish captured, specific nursery areas, etc.) (cfr. Par. 3.4.2);
- Smothering for Eastern Adriatic countries (cfr par. 3.6.1.1);
- Changes of sedimentation rates for the whole Adriatic (cfr par. 3.6.2.1;
- Scraping for the whole Adriatic (cfr par. 3.6.2.3);
- Marine litter distribution and quantities for the whole Adriatic (cfr par. 3.6.3.1);
- Underwater noise for the whole Adriatic (cfr par. 3.6.3.2);
- Changes in the thermal regime and salinity for Eastern Adriatic countries (cfr par. 3.6.4.1 and 3.6.4.2);
- Introduction of synthetic and non-synthetic substances and compounds and radionuclide for Eastern Adriatic countries (cfr par. 3.6.5.1 and 3.6.5.2);
- Non-indigenous species for Eastern Adriatic countries (cfr par. 3.6.7.2).

4 Preliminary recommendations for the application of MSFD at the Adriatic level

The present chapter illustrates preliminary recommendations for the implementation of the Marine Strategy Framework Directive at the scale of the Adriatic basin, as resulted from the analysis of available documents and the discussion held among partners within the Shape project. Identified recommendations aim to support the coherent implementation of MSFD within the Adriatic Sea, implying among the other the following specific objectives:

- Improve the coordination among Adriatic countries in the implementation of MSFD, including coherence and integration among the MSFD implementation processes developed by each State in terms of approaches, methodologies and results;
- Support exchange/transfer of know-how with and capacity building to no EU Adriatic countries;
- Support the implementation of MSFD beyond country's marine waters (as defined by 2008/56/EC art. 3.1), therefore including marine waters, seabed and subsoil that currently do not fall under the areas where States have and/or exercise jurisdiction rights, in accordance with UNCLOS.

An initial set of recommendations were identified on the basis of the results of the analysis performed for the previous two chapters and the results of Action 4.1 that enabled to depict the legal, policy and planning framework supporting MSP and MSFD implementation in the Adriatic Sea. Moreover, previous relevant experiences and related documents were consulted, including among the others:

- "A guide to implementing the ecosystem approach through the Maritime Strategy Framework Directive" produced by the PISCES project (Partnerships Involving Stakeholders in the Celtic Sea Ecosystem)[40].
- The activities implemented by Italian MATTM and ISPRA for the MSFD implementation (cfr. par. 2.2.1), including in particular the information available in the http://www.strategiamarina.isprambiente.it/ web-site and the document "Strategia per l'Ambiente Marino. La valutazione iniziale dello stato dell'ambiente marino e proposte per la determinazione del buono stato ambientale e la definizione dei traguardi ambientali". This latter document includes a specific chapter focusing on the definition of GES and the related environmental targets.
- UNEP/MAP experiences and documents as described in the following paragraphs.
- The study "Exploring the potential for Maritime Spatial Planning in the Mediterranean Sea"[41] elaborated by European Commission DG MARE (through the consultant Policy Research Corporation) and including a specific case study report on the Adriatic Sea;
- Results of PlanCoast project[42] including in particular the synthesis report "State of the art of coastal and maritime planning in the Adriatic Region" elaborated by PAP/RAC. Both studies mainly focus on MSP and ICZM, however providing also useful sugges-

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40 http://www.projectpisces.eu/; last access July 2013.
41 http://ec.europa.eu/maritimeaffairs/documentation/studies/study_msp_med_en.htm; last access July 2013.
42 http://www.plancoast.eu/; last access July 2013.

tions for the adoption of an ecosystem-based approach in the implementation of MSFD at the Adriatic Sea scale.

The identified initial recommendations were discussed by Shape partners at the Shape meeting held in Pescara (Italy) in April 2013. The discussion led to the definition of the recommendations illustrated in this report, that have been agreed upon by Shaper partners. These recommendations can be considered as a first step aiming to support future discussions about each of the highlighted issues, implying specific technical expertise and know-how. Preliminary recommendations have been grouped in the following categories, also referring to the Plan of Action defined by 2008/56/EC art. 5, paragraph 2:

1. General recommendations;
2. Stakeholder participation;
3. Initial assessment;
4. Determination of good environmental status and establishment of environmental targets;
5. Monitoring programmes;
6. Programmes of measures.

As an overarching recommendation, Shape project stresses the importance of developing an overall and shared Adriatic Marine Strategy according to the plan of action set out in 2008/56/EC article 5, paragraph 2.

The Adriatic Marine Strategy should be coherent with Member State's Marine Strategies under development (Italian and Slovenian ones at the moment). Its elements should be coordinated across and agreed by all Adriatic countries (including no-EU ones) and should take in consideration both the Adriatic as a whole and specificities characterising different areas of the basin. Above elements imply that the Adriatic Marine Strategy should be developed according to a time schedule coherent with Member State's action plans. The following illustrated recommendations aims to support the future and progressive elaboration of the Adriatic Marine Strategy.

4.1 General recommendations

This group includes recommendations that are relevant for all steps of the plan of action set by 2008/56/EC art. 5, and that therefore can be useful in the whole process aiming to develop an Adriatic Marine Strategy:

- Base the development of the Adriatic Marine Strategy on two guiding principle: ecosystem-based approach and adaptive management. The first enables to properly take in consideration the Adriatic basin as a whole system as well as to focus on its (ecological, physical, chemical, biological, etc.) processes and functions. Adaptive management is an essential element of any planning effort dealing with the uncertainty of the future, enabling to progressively adapt decisions and measures on the basis of new knowledge and the verification of the effectiveness of the measures implemented.
- Extend "Marine waters" definition (2008/56/EC art. 3.1) beyond areas under countries' jurisdiction to properly take into account "open sea" specificities and problems. This

issue assume particular relevance in the Adriatic Sea. Shape Action 4.1 showed that UNCLOS provisions are not fully implemented yet in the Adriatic as in the whole Mediterranean Sea; relevant part of this basin is therefore not managed.

- As a consequence of the above recommendation, strengthen the implementation of UNCLOS within the Adriatic through cooperation among countries. This will provide a legal framework to MSFD and Maritime Spatial Planning even for those marine areas that presently do not fall under States' jurisdiction.
- Establish a MSFD Adriatic Working Group in charge of giving concrete implementation to the Directive at the scale of the Adriatic Sea and to develop the Adriatic Marine Strategy. This Working Group should directly involve national and regional authorities competent for the implementation of the MSFD.

  As highlighted by the analysis performed within Action 4.1, cross-border cooperation, in particular on environmental issues, is well advanced in the Adriatic basin. Existing cooperation initiatives (such as in particular the Trilateral Commission for the protection of the Adriatic, the Adriatic - Ionian Initiative, the Adriatic Euroregion, and the same IPA Adriatic Programme) constitutes a fertile substrate for the implementation of joint efforts aiming to improve the protection of the Adriatic Sea environment. In particular, the Trilateral Commission seems to provide the best characteristics to be used as a governance platform for the MSFD Adriatic Working Group; in this perspective the role of the Trilateral Commission could be re-launched through the implementation of the MSFD at the scale of the Adriatic Sea.

  The MSFD Adriatic Working Group should be supported by Adriatic research institutions and agencies and work in close collaboration with the Adriatic MSFD Stakeholder Group (see next point). Figure 4-1 outlines the proposed governance structure for the implementation of MSFD at the Adriatic level.

- Develop mechanisms and tools to facilitate know-how transfer to no-EU Adriatic countries ensuring these are fully part of the MSFD implementation process. Cooperative mechanisms and tools can include for example: joint EC co-funded projects, exchange of best practice, training, technical groups, twinning among technical agencies, side visits, conference and technical workshops, tutoring, etc.
- Establish link and cooperation with MSFD-related initiatives developed by the United Nations Environment Programme (UNEP) Coordination Unit for the Mediterranean Action Plan (MAP). In particular, Decisions IG/17/6 and IG 20/4[43] adopted by the "Contracting parties to the Barcelona Convention" respectively in COP 15 (2008) and COP 17 (2012) articulate a systematic process for moving towards more effective ecosystem-based management in the Mediterranean. Moreover, Decision IG.20/4 decided to establish an Ecosystem Approach Coordination Group (EcAp CG). Among its activities this group is dealing with MSFD aspects in particular in relation to GES definition and related targets identification. It is therefore suggested that the MSFD Adriatic Working Group will establish strict collaborative links with EcAp CG.

[43] Respectively "Implementation of the ecosystem approach to the management of human activities that may affect the Mediterranean marine and coastal environment" and "Implementing MAP ecosystem approach roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetables for implementing the ecosystem approach roadmap".

- Establish link with initiative in other regions and sub-regions, as in particular those developed by Regional Sea Commissions (OSPAR for the North-east Atlantic, Helcom for the Baltic Sea and Black Sea Commission), aiming to share know-how and best practices related to MSFD implementation at the regional and sub-regional sea level.
- Define a clear commitment to ensure continuity in the MSFD implementation process at the Adriatic scale. This would enable the Adriatic Marine Strategy to be kept up to date and the MFSD process at the scale of Adriatic alive.
- Commit to periodically notify progress of MSFD implementation at the Adriatic scale to the European Commission. This will be essential to formally establish a link between the process aiming to design the Adriatic Marine Strategy and the European Commission.

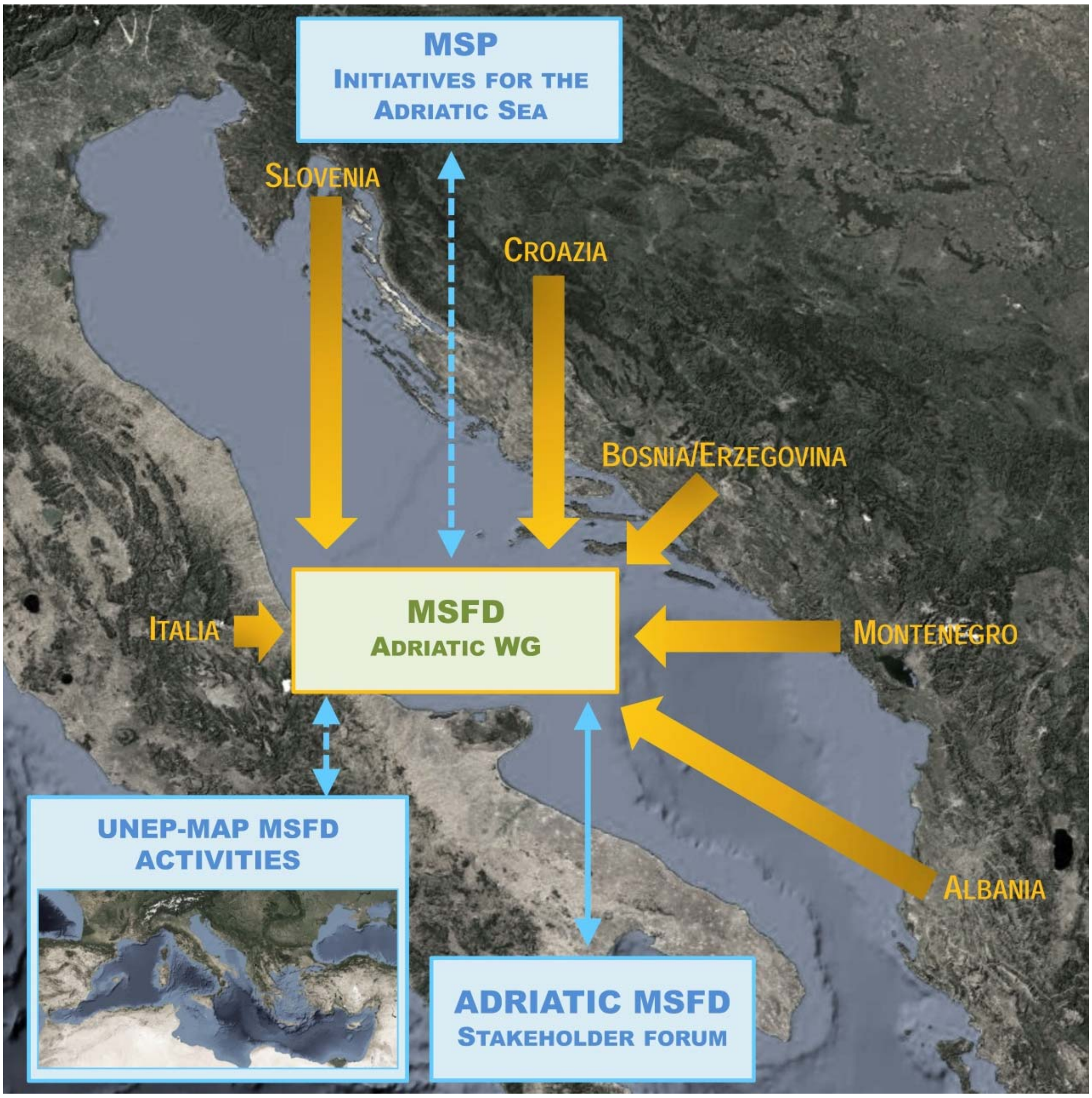

Figure 4-1 Proposed governance structure for the implementation of MSFD at the scale of the Adriatic Sea.

4.2 Stakeholder participation

In line with the general approach promoted by the European Union, 2008/56/EC stresses the importance of ensuring that all interested parties (stakeholders) are given effective opportunities to concretely participate in the implementation of MSFD. Shape recognises the relevance of stakeholder participation in all the phases of the Adriatic Marine Strategy development; in addition to the actions identified by 2008/56/EC art. 19 Shape recommends to establish and Adriatic MSFD Stakeholder Forum that will work in close collaboration with the MSFD Adriatic Working Group. The Forum shall involve a wide spectrum of stakeholder typologies, including:

- International organisations, as for example: European Commission, European Environment Agency, UNESCO IOC, Plan Blue, UNEP-MAP MEDPOL and Adriatic cooperation initiatives;
- National authorities directly responsible for the MSFD implementation in the single Adriatic States (principally Ministry of the Environment and related Environment Agency);
- Regional authorities, involving in particular representative of Adriatic coastal regions and Regional Environment Agencies;
- Other interested public authorities, as for example bodies managing marine and/or coastal protected areas;
- Representative of economic sectors assuming relevance in relation to MSFD issues, as for example aquaculture and fishing, oil and gas extraction, maritime transportation, port activities, other land-based activities, etc.
- Research and scientific institutions;
- Civil Society, including in particular representative of associations dealing with environmental and nature protection, sustainable development, coastal and marine management, information sharing and public participation, etc.

Given the wide spectrum of Adriatic stakeholders, it is important that the MSFD Stakeholder Forum will ensure representativeness to all stakeholder typologies, as well as balance among the same.

Wide and continuous stakeholder participation can support MSFD implementation in all phases of the processes, as in particular for:

- Data acquisition and data sharing, recognising the growing value of stakeholder knowledge and competence;
- Contribution to the initial assessment;
- Scenario building, based on the interpretation of the present state and future expectations;
- Definition on measures to be implemented to reach the Good Environmental Status. Stakeholder experience may be also useful to evaluate feasibility, effectiveness, cost-benefit, environmental impacts of identified measures.

The already mentioned “Guide to implementing the ecosystem approach through the Marine Strategy Framework Directive” elaborated by the PISCES project can be used to shape in details stakeholders’ role and contribution and to define mechanism supporting their participation to the definition of the Adriatic Marine Strategy. Stakeholder participation can occur in different modalities, including:

- Consultation; mainly providing feedback during various steps of the process;
- Collaboration; establishing partnership with the decision making level;
- Involvement; focusing on direct work throughout the process, ensuring that stakeholder concerns are duly taken in consideration in decision making;
- Empowerment; aiming to have decision making, at least part of it, places in the hands of stakeholders.

As stressed by the guide delivered by the PISCES project, MSFD requires more than just consultation. Involvement and collaboration are essential part of the MSFD process, in particular in relation to the value of stakeholder knowledge. There is also a growing interest in the role of empowerment and in giving responsibility to stakeholders in the identification and implementation of measures. Effective stakeholder participation should begin as early as possible; early involvement is more likely to result in targets and measures that are effective, agreed and supported. Shape project agrees on above PISCES key messages and recommends that stakeholders are proactively engaged in all steps of the processes with a real involvement/collaboration role.

4.3 Initial assessment

As a first step (2008/56/EC art. 8) an initial assessment of the current status of the marine system and of environmental impact of human activities has to be developed. Chapter 3 of the present reports aims to provide an overview, at the Adriatic basin scale, of the state of the current environmental marine region, thus representing a contribution to the initial assessment required by the MSFD for this basin. This first contribution surely needs to be improved, as even highlighted in paragraph 3.7 identifying data and information gaps. To this regard the following recommendations were identified by Shape:

- Based on chapter 3 contents, focus future assessment on those elements of 2008/56/EC Annex III list representing key processes and aspects of the Adriatic Sea, also completing most relevant information gaps (cfr. par. 3.7)[44].
- Ensure that key selected characteristics, pressures and impacts are representative of the whole Adriatic basin, i.e.:
    - Cover the whole Adriatic Sea, therefore also including water space not subject to national jurisdiction;
    - Enable to analyse transboundary problems;

[44] To this regard, the Croatian-language document “Initial assessment of the state of and pressure on the marine environment of the Croatian portion the Adriatic Sea”, issued by the Croatian Ministry of the Environment and Nature Protection in September 2012, appears to be particularly useful for the further evolution and integration of the initial assessment at the Adriatic scale and to fulfil some of the identified gaps.

  - Are able to depict sub-regional differences (between north and south or west and east Adriatic);
  - Possibly, can be represented through maps showing differences within the Adriatic Sea.
- Focus on Annex III elements that can be concretely represented and analysed; i.e. data must be available or easily acquirable in particular through data sharing among Adriatic States.
- Give particular attention and space in the assessment report to Annex III elements that can be directly or indirectly monitored in the other MSFD steps; thus defying a link with qualitative descriptors of the good environmental status (2008/56/Annex I) and related environmental targets.
- Improve data sharing among Adriatic States, also developing common data protocol. This can imply supporting the development of data sharing web platform, as the GIS Atlas that will be realised within Shape WP 5.
- Constantly scan on-going projects and programmes focusing on the Adriatic environment to incorporate latest research results (as for example those that will be provided by the Italian Ritmare research project on the Sea)[45] and assessment reports (as those periodically issued by the UNEP/MAP Plan Bleu/RAC[46] for the Mediterranean Environment).
- The analysis performed within Shape Action 4.2 (cfr. chapter 3) highlighted the difficulties in responding to two specific requirements set by 2008/56/EC art. 8: (i) analysis of cumulative and synergic effects; (ii) economic and social analysis of the use of marine waters and the cost of degradation of the marine environment. To this regard Shape recommends to support research effort aiming to develop common methodologies focusing on the above two assessment issues.
- As a final recommendation, Shape project stresses the importance to regularly update the initial assessment based on progress of research and monitoring.

4.4 Determination of Good Environmental Status and target definition

2008/56/EC art. 9 establishes that Member States shall determine a set of characteristics for good environmental status, on the basis of the qualitative descriptors listed in Annex I. To this regard, Member States shall take into account the indicative list of elements set out in Table 1 of Annex III and the pressures or impacts of human activities indicatively listed in Table 2 of Annex III. 2008/56/EC art. 10 requires Member States to establish a comprehensive set of environmental targets and associated indicators for marine waters to guide progress towards the achievement of the good environmental status in the marine environment.

45 http://www.ritmare.it/; last access July 2013
46 http://planbleu.org/en/le-plan-bleu/qui-sommes-nous; last access July 2013.

Commission Decision 2010/477/EU identifies general conditions for the application of the criteria for good environmental status (Part A of Annex). Part B of Annex to the same Decision specifies the criteria for assessing the extent to which GES is being achieved in relation to each descriptors set out in Annex I to Directive 2008/56/EC; the criteria are integrated by a list of indicators that aims to make the same criteria operational and measurable through monitoring.

In relation to the implementation of above steps at the Adriatic Sea scale, Shape identifies the following preliminary recommendations:

- As a short-term step, share among Adriatic (EU and no-EU) countries the results of the on-going Member States' process addressing GES definition and environmental target identification;
- Establish links with the on-going UNEP/MAP initiative, referring in particular to EcAp CG[47] and the Correspondence Group on GES and Targets (COR-GEST). This latter is composed of national experts designed by the Contracting Parties to the Barcelona Convention and is coordinated by UNEP/MAP Coordination Unit. CORE-GEST works to ensure efficient coverage and analysis of all Ecological Objectives (EO) and is made up of three clusters:
    - Pollution and litter related EOs (5, 9, 10 and 11);
    - Biodiversity and Fisheries related EOs (1, 2, 3, 4 and 6);
    - Coast and Hydrography related EOs (7 and 8).

  EOs basically correspond to the 11 Descriptors included in MSFD Annex 1 (Table 4-1). Besides slights difference in the definition, major differences are: (i) EO9 corresponds to both descriptors 8 and 9 dealing with contamination; (ii) EO8 deals with natural dynamics of coastal areas which is not directly considered by MSFD descriptors.

  The three clusters met in 2012-2013 and produced a first set of operational objectives, GES definitions and related indicators and targets; these are summarised in the document "The EcAp Implementation Progress and the draft list of GES and Targets for the Mediterranean Sea" discussed at the 2nd Meeting of the EcAp CG (Athens, 24 April 2013).

[47] EcAp Coordination Group is composed by MAP focal points, the UNEP/MAP Coordination Unit, the MAP components and MAP partners.

Table 4-1 Comparison of GES descriptors according to MSFD and Ecological Objectives define by UNEP/MAP.

	Qualitative descriptors for determining GES – 2008/56/EC Annex I		**Ecological Objectives considered by EcAp CG and COR-GEST of UNEP/MAP**
1	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions	EO1	Biodiversity is maintained, including both species and habitats
2	Non-indigenous species introduced by human activities are at levels that do not adversely alter ecosystems	EO2	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems
3	Population of all exploited fish and shell-fish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock	EO3	Population of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock
4	All element of the marine food-webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring long-term abundance of the species and the retention of their full reproductive capacity	EO4	Alterations to components of marine food webs caused by resource extraction or human-induced environmental changes do not have long-term adverse effects on food-web dynamics and related viability
5	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters	EO5	Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters
6	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected	EO6	Sea-floor integrity is maintained, especially in priority benthic habitats
7	Permanent alteration of hydrographic conditions does not adversely affects marine ecosystems	EO7	Alteration of hydrographic conditions does not affect coastal and marine ecosystems
8	Concentrations of contaminants are at levels not giving rise to pollution effects	EO8	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
9	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards	EO9	Contaminants cause no significant impact on coastal and marine ecosystems and human health
10	Properties and quantities of marine litter do not cause harm to the coastal and marine environment	EO10	Marine and coastal litter do not adversely affect coastal and marine environment
11	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment	EO11	Energy and noise from human activities causes no significant impact on marine and coastal ecosystems

- Following the previous points, implement actions enabling to define common and shared characteristics (criteria) of the GES descriptors for the Adriatic basin and consequently establish common and shared environmental targets and associated indicators for the same marine sub-region. As highlighted in the previous point, this should capitalise on-going experience; even based on the Italian and UNEP/MAP initiatives the following specific suggestions can be identified[48]:
    - Current information gaps (cfr. par. 3.7) makes quantitative definition of GES and environmental targets difficult, at least for some of the descriptors. It is therefore suggested to start defining common Adriatic GES criteria, environmental targets and indicators qualitatively. Moreover, a qualitative approach makes discussion and agreement easier; quantitative elements could be defined having reach a consensus on qualitative GES and target definition and as soon as information and data are available;
    - Whenever possible build the definition of GES characteristics and related environmental targets to existing legal obligations, as those set by WFD (2000/60/EC), Habitat Directive (92/43/EEC), Bird Directive (2009/147/EC), instruments developed in the framework of the Common Fishery Policy. For example WFD can represent the basis to define environmental targets for Descriptor 5 – human induced eutrophication, while CFP can be a starting point for Descriptor 3 – fish and shellfish;
    - Environmental targets should be also coherent with other regional environmental goals defined by international agreements and policies, with particular concern for those under definition by EcAp CG of UNEP/MAP. Other relevant initiatives to be investigates are those promoted by GFCM, ACCOBAMS, IUCN Mediterranean, etc.
    - Develop a conceptual framework linking descriptors, environmental targets and indicators. The Italian experience highlighted that some GES descriptors are characterised by overlapping, even due to their complexity; in such cases same environmental targets can be referred to more than a descriptors. According to the Italian experience, this is the case of descriptors: 1 (biodiversity), 4 (marine food webs) and 6 (sea-floor integrity).

      The conceptual framework should highlight links among the different GES descriptors. Biodiversity and fisheries resources are for example directly and indirectly linked with criteria and targets related to other descriptors. This framework should aim to enhance integration among GES descriptors and ensure harmonisation of targets;
    - Organise GES and environmental targets definition according to a common and easy-to-understand structure, as the one proposed by the document developed by the Italian experience that for each descriptor illustrates: (i) background; (ii) proposals for GES definition (criteria), environmental targets and indicators, to be possibly summarised in tables; (iii) approach used in the def-

48 See the document "Proposte per la definizione del GES e dei traguardi ambientali" (Proposals for the definition of GES and environmental targets); available at http://www.strategiamarina.isprambiente.it/consultazione/documenti-per-la-consultazione; last access July 2013.

inition of environmental targets; (iv) effects of environmental targets; (v) information gap and future needs;

- o The Adriatic basin is characterised by different environmental conditions and human pressures (from North to South and from West to East). Shape project suggests to assess whether GES definition, environmental targets and indicators should be geographically differentiated to better present the heterogeneous and dynamic nature of the Adriatic Sea;

- "Determination of good environmental status may have to be adapted over time, taking into account the dynamic nature of marine ecosystems, their natural variability, and the fact that the pressures and impacts on them may vary with the evolution of different patterns of human activity and the impact of climate change" (Commission Decision 2010/477/EU art. 4). Shape project stresses the importance to periodically review and adjust the definition of GES characteristics, according to an adaptive management approach.
- Following the previous point, GES and environmental targets definition shall highlight any climate change implication, as also required by Commission Decision 2010/477/EU, Part A of Annex point 10. This assumes particular relevance in the Northern Adriatic Sea due to its recognised high vulnerability to climate change impacts.
- Develop a framework linking GES descriptors, environmental targets and associated indicators to key elements of the initial assessment (i.e. links among 2008/56/EC Annex I and Annex III), thus enabling to use monitoring data for the periodical upgrade of the assessment.
- The definition of criteria for GES, related environmental targets and associated indicators at the scale of the Adriatic Sea requires detailed knowledge of marine processes and human (marine and land-based) pressures. Within the MSFD Adriatic Working Group, Shape suggests to activate a Focused Group for each GES descriptors pooling together best expertise and competence available in Adriatic countries.

4.5 Monitoring programs

Following the previous steps (initial assessment, GES definition, environmental targets identification), Member States will have to establish and implement a monitoring programme (2008/56/EC art. 11) supporting assessment and regular updating of environmental targets. The overall and long-term goal is to develop a common and shared monitoring program at the scale of the Adriatic Sea. To this regard the following recommendations can be highlighted in a pan-Adriatic perspective:

- Capitalise any previous experience of joint monitoring program, as the experience developed within the "Osservatorio Alto Adriatico" (Northern Adriatic Observatory), i.e. a network involving environmental experts from Northern Adriatic countries and regions.
- Shape national monitoring programs in a way they can be (easily) integrated in an Adriatic perspective.

- Ensure continue support to move towards standardised or at least better comparable monitoring and reporting methods.
- Ensure continue support in terms of capacity building to no-EU countries, to enable them to develop monitoring programs coherent with MSFD requirements.
- To cover the whole Adriatic it is essential that monitoring programs are extended to “open sea” water and take in due consideration transboundary problems. However, these actions are time and resource demanding and cannot be simply delegated to Adriatic countries. Proper tools have to be identified and put in place to active needed resources, including economic ones.
- Vertical (physical, chemical, biological and ecological) dynamics assume particular importance in the Adriatic basin; future monitoring programmes should take this aspect in due consideration, thus enabling to monitor both the horizontal and vertical distribution of main indictors.
- Annex V of 2008/56/EC identifies a list of relevant elements for MSFD monitoring programs. Some of them assume particular relevance in relation to cooperative effort at the Adriatic Sea level, e.g.:
    - Need to aggregate information on the basis of marine regions or subregions (point 7), that implies that data are collected in a way the enable to depict an overall picture at the Adriatic Sea level;
    - Need to ensure compatibility of assessment approaches and methods within and between marine regions and/or sub-regions (point 8);
    - Need to develop technical specifications and standardized methods (point 9), to improve data sharing and integration;
    - Need to ensure, as far as possible, compatibility with existing programs developed at regional (and sub-regional) level with a view to fostering consistency between programmes and avoiding duplication of efforts (point 10).
- Monitoring programmes in the Adriatic Sea should be coherent and integrate with programmes at the scale of the Mediterranean Sea, in particular promoted by UNEP/MAP MEDPOL.

4.6 Programs of measures

As a final step of the iterative plan of actions, Member States will have to develop and put in operation a programme of measures aiming to achieve or maintain the good environmental status (2008/56/EC, art. 13). The overall and long-term goal is to develop a common and shared program of measures at the scale of the Adriatic Sea. To this regard the following recommendations have been highlighted by Shape in a pan-Adriatic perspective:

- Develop a catalogue of measures and best practices for the Adriatic basin, based on categories identified by Annex VI of MSFD.
- The plan of measures for the Adriatic basin will have to be developed on the basis of the on-going and/or future countries’ specific experience and programs. Much effort

should be therefore put to ensure coherence and integration among national programs of measures.

- In addition to the previous point, to cover the whole Adriatic it is essential that the Adriatic program of measures will also include the “open sea” and approach trans-boundary problems. As highlighted for monitoring programs, these actions are time and resource demanding and cannot be simply delegated to Adriatic countries. Proper tools have to be identified and put in place to active needed resources, including economic ones.
- Highlight the role and relevance of measures that can contribute to goals and targets set by other synergic policies or directives, including WFD, Habitat and Birds Directives, Bathing Waters Directive, IMP and MSP, ICZM, CFP. Synergies will also enable to optimize use of resources and expertise.
- In relation to the previous point, Shape suggests to analyse in details links among MSP and MSFD in the Adriatic Sea and identify how MSP can become part of or contribute to the programme of measures to be defined. Some preliminary examples are described in the following points:
    - MSP provides the overarching framework for integrated management of human activities at the sea required by the ecosystem approach that is at the base of MSFD implementation, as well.
    - MSP can provide (based on available data) accurate mapping of maritime uses. To reinforce links with MSFD it is essential that mapping is also extended to main elements of GES definition (i.e. Annex I descriptors) as in particular: distribution of most important habitat, nursery areas, distribution of fish and shellfish stocks, area of particular importance for target species, environmental (land-based and marine-based) pressures and hot-spots.
    - Based on thematic mapping and stakeholder participation, MSP enables to identify clear links among pressures, state of the environment and impacts. Mapping is also used to identify major conflicts among uses and between uses and areas with high naturalistic and ecological relevance.
    - Analysis of future conditions is an essential step of MSP; this can surely contribute to identify the evolution of future pressures and impacts that can affect GES of marine waters.
    - Scenario building and spatial planning are the essential core of MSP. In relation to MSFD goals this can positively contribute to: (i) eliminate or reduce pressures and impacts on the marine environment, (ii) eliminate or reduce conflicts between uses and areas with high naturalistic and ecological relevance, (iii) clearly identify areas to be protected to preserve processes and functions that are essential in achieving the GES, (iv) identify environmental hot-spot areas where more intense measures are necessary, (v) define synergies among uses that can provide win-win solutions for socio-economic development and environmental protection, i.e. sustainable management of marine resources (as for example among marine protected areas, fishing activities that can beneficiate in terms of improvement of fish stocks, sustainable tourism).

  - Stakeholder involvement is essential in MSP, as in other process dealing with the management and planning of complex systems. Public participation is an essential part of MSFD too. Approaching the analysis at the Adriatic scale, the two participation processes could converge in periodical joint initiatives, to further explore links among MSP and MSFD.

- 2008/56/EC (art. 13, comma 3) stresses the importance to assess social and economic impacts of planned measures. Generally, environmental effects are duly taken in consideration while socio-economic aspects are poorly addressed. Shape recommends identifying methods enabling to carry out socio-economic impacts assessment of MSFD related measures, also in relation to links with MSP.

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Annex 1 - MSFD data and information available at Shape partners involved Action 4.2