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MEDITERRANEAN SYMPOSIUM ON CORALLIGENOUS

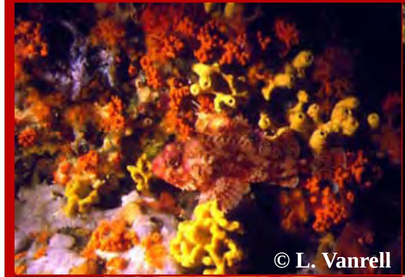
United Nations Environment Programme
Mediterranean Action Plan
Regional Activity Centre for Specially Protected Areas

PROCEEDINGS OF THE 1ST MEDITERRANEAN SYMPOSIUM ON THE CONSERVATION OF THE CORALLIGENOUS AND OTHER CALCAREOUS BIO-CONCRETIONS

15 – 16 January 2009 – Tabarka

ACTES DU 1ER SYMPOSIUM MEDITERRANEEN SUR LA CONSERVATION DU CORALLIGENE ET AUTRES BIOCONCRETIONS CALCAIRES

15 – 16 Janvier 2009 - Tabarka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January 2009

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PNUE – PAM – CAR/ASP, 2009. Actes du 1er symposium méditerranéen sur la conservation du coralligène et autres bio concrétions calcaires (Tabarka, 15-16 Janvier 2009), C. Pergent-Martini & M. Brichet édits., CAR/ASP publ., Tunis : 273p.

AVANT-PROPOS

Suite à une recommandation du Plan d'Action pour la Conservation de la Végétation Marine en mer Méditerranée (adopté par les Parties contractantes à la Convention de Barcelone, en 1999), une série de symposiums scientifiques, dédiée à la végétation marine méditerranéenne, a été initiée en 2000. Cette initiative vise essentiellement à faire le point sur les données scientifiques disponibles et à promouvoir la coopération entre les spécialistes méditerranéens.

Le premier symposium méditerranéen sur la végétation marine (Ajaccio, Octobre 2000) a réuni 43 participants de 15 pays méditerranéens et s'est traduit par 32 communications orales et posters. Lors des tables rondes des sujets d'importance, tels que la taxonomie dans la région et l'utilisation de la végétation marine comme outil de gestion de la zone côtière, ont été abordés. Les recommandations ont permis de promouvoir, dans le cadre du Plan d'Action pour la Méditerranée, une initiative méditerranéenne sur la Taxonomie, s'inspirant de la démarche développée, dans le cadre de la Convention sur la Diversité Biologique, au plan mondial.

Le deuxième symposium (Athènes, Décembre 2003), organisé en collaboration avec le Centre Grec pour la Recherche Marine, a regroupé 67 participants issus de 15 pays méditerranéens. 40 communications orales et posters ont été présentés à cette occasion. Les groupes de travail qui se sont réunis ont mis l'accent sur la nécessité de standardiser les techniques de cartographie et de développer des outils pour la taxonomie de la végétation marine, à l'échelon méditerranéen.

Le troisième symposium, programmé à Marseille, du 27 au 29 Mars 2007, en partenariat avec la Région Provence-Alpes-Côte d'Azur et l'Association Seagrass 2000 (associée au Plan d'Action pour la Conservation de la Végétation Marine en mer Méditerranée), a vu l'inscription de 120 participants provenant de 17 pays méditerranéens. Ce ne sont pas moins de 60 communications orales et posters qui devraient y être présentés.

Le CAR/ASP a souhaité profiter de la présente session pour faire permettre la diffusion des résultats obtenus dans le cadre du programme Interreg III B "Mise en cohérence, développement, harmonisation et validation de méthodes d'évaluation de la qualité du milieu littoral par le suivi de l'herbier à *Posidonia oceanica* - POSIDONIA" à la communauté scientifique méditerranéenne.

Des tables rondes permettront d'aborder des thèmes d'actualité tels que :

- Quelles méthodes de cartographie et de surveillance, pour quels objectifs de gestion ?
- La végétation marine de Méditerranée constitue-t-elle un outil d'évaluation de l'efficacité des stratégies (Directive Cadre sur l'Eau, Directive Stratégie Maritime) et des grands enjeux environnementaux (Horizon 2012, Initiative Horizon 2020) ?
- Comment mettre en place une conservation efficace des « hots-spot » de biodiversité que représentent les formations coralligènes et autres bioconcrétionnements calcaires de Méditerranée ?

Le Directeur du CAR/ASP
Abderrahmen GANNOUN

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Premier Symposium sur la Conservation du Coralligène et autres bio concrétions de Méditerranée

Tabarka, Hôtel Iberostar

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Jeudi 15 Janvier 2008

09h00 – 09h30 **Ouverture officielle du Premier Symposium sur la Conservation du Coralligène et autres bio concrétions de Méditerranée (PNUE/PAM-CAR/ASP)**

09h30 – 10h30 **Session 1- L'état des connaissances sur les formations coralligènes**

Etat des connaissances – introduction par Prof. G. GIACCONE

- «*Overview on the sponges diversity in the Mediterranean*» par : A.V. ERESKOVSKY, J. IVANISEVIC & T. PÉREZ
- «*Calcherb, an inforodormation system about Calcareous red algae of the Coralligenous*» par : S. KALEB, G. BRESSAN & S. MARTELLOS

Discussion

10h30 – 11h00 *Pause café.*

11h00 – 13h00 **Session 1 - L'état des connaissances sur les formations coralligènes (suite)**

- «*Effective larval dispersal of corraligenous species: connectivity and relevant scales for conservation*» par : M. ABBIATI, F. COSTANTINI & C. FAUVELOT
- «*Trophic structure and functioning of vermetid reef community based on carbon and nitrogen stable isotope analysis*» par : F. COLOMBO, V. COSTA, A.E. ALEO, C. TRAMATI, A. MAZZOLA & S. VIZZINI.
- «*Role of a* Paramuricea clavata *forest in modifying the coralligenous assemblages*» par : A. SCINTO, M. BERTOLINO, B. CALCINAI, C. HUETE-STAUFFER, M. PREVIATI & C. CERRANO.
- «*Demographic dynamics over decades in Coralligenous benthic communities*» par : N. TEIXIDÓ, J. GARRABOU & J-G. HARMELIN.

Discussion

- «*Analysis on the Coralligenous assemblages in the Mediterranean Sea: a review of the current state of knowledge in support of future investigations*» par : S. AGNESI, A. ANNUNZIATELLIS, M.L. CASSESE, T. DI NORA, G. LA MESA, G. MO, C. PERGENT MARTINI & L. TUNESI.
- «*Remarkable benthic communities on the Coralligenous in the National Park of Al Hoceima (Mediterranean Cost, Morocco)*» par : S. BENHISSOUNE, C. RAIS, L. TUNESI, H. BAZAIRI, S. HADDI, O. BENZAKOUR, I. SADKI, C. FRANZOSINI & D. NACHITE.

Discussion

13h00 – 14h30 *Pause déjeuner*

14h30 – 15h30 **Session 1 - L'état des connaissances sur les formations coralligènes (suite)**

- «*Three- dimensional distribution of* Gerardia savaglia *in relation to depth, orientation and slope of the substrata in the South Tyrrhenian Sea*» par : M. GIUSTI, S. CANESE, M. ANGIOLILLO, M. BO, E. SALVATI, A. CARDINALI & S. GRECO.
- «*Bryozoans and Serpuloideans from coralligenous bottoms off SE Sicily*» par : A. ROSSO & R. SANFILIPPO.
- «*An important component of the coralligenous asssemblages: the precious Mediterreanean red coral*» par : G. SANTANGELO, M. IANNELLI, L. BRAMANTI & L. VIELMINI.

Discussion

15h30 – 16h30 **Présentation des Posters par le Comité scientifique**

- Présentation des posters de la session 1 « Fonctionnement du coralligène » par Dr. K. BEN MUSTAPHA, Prof. G. BITAR et Prof. S. BENHISSOUNE
- Présentation des posters de la session 2 « Méthodologies » par Prof. R. SEMROUD
- Présentation des posters de la session 3 « Gestion » par Prof. A. RAMOS ESPLA

16h30 – 17h00 *Pause café*

17h00 – 18h30 **Session Posters**

Session 1

- «*Distribution of* Acanthogorgia sp. *along the Calabrian coast (Southern Tyrrhenian Sea, Italy)*» par : M. ANGIOLILLO, S. CANESE, M. GIUSTI, M. BO, A. CARDINALI, E. SALVATI & S. GRECO.
- «*Challenges and perspectives of calcareous bio-concretions inventory in Croatia*» par : T. BAKRAN-PETRICIOLI, D. PETRICIOLI & J. RADOVIC.
- «*Les bio-concrétions de la Wilaya de Tipaza (Algérie)*» par : M. BENALI, A. KARALI & C. REBZANI ZAHAF.
- «*Données préliminaires sur la répartition et la composition de la biocénose du coralligène du littoral d'El Kala (Algérie)*» par : S. BELBACHA, R. SEMROUD, R. DUPUY DE LA GRANDRIVE & M FOULQUIE.
- «*Coralligenous formations in the marine protected area of Tavolara Punta Coda Cavallo (NE sardinia, Italy)*» par : C.N. BIANCHI, R. CATTANEO-VIETTI, C. MORRI, A. NAVONE, P. PANZALIS & P. ORRÙ

- «*Les formations de type "coralligène de plateau" dans les eaux agathoises (Hérault, France). Site Natura 2000 FR 910 1414 "Posidonies du Cap d'Agde"*» par : S. BLOUET, R. DUPUY DE LA GRANDRIVE, M. FOULQUIE & P. LENFANT.
- «*Coralligenous assemblages in the marine habitats atlas of Liguria region (ITALY)*» par : S. COPPO & G. DIVIACCO.
- «*Les gorgonacea et les alcyonacea des cotes de l'Est algérien : Diversité et état d'exploitation du Corail Rouge,* Corallium rubrum» par : F. DERBAL & M.H. KARA.

- «*Description sur les côtes Nord de la Tunisie, d'un site comprenant des encorbellements à* Lithophyllum lichenoides *ainsi que des formations de maerl à* Lythophyllum dentatum» par : A. DJELLOULI & Z. EL ASMI-DJELLOULI.
- «*Coralligenous assemblages in the northern Adriatic continental shelf*» par : F. FAVA, M. PONTI & M. ABBIATI.
- «*The "pink mile": benthic assemblages of rhodolith and mäerl beds (corallinales) off the island of Ischia (Tyrrhenian Sea)*» par : M.C. GAMBI, M.C. BUIA, A. MASSA-GALLUCCI, M. CIGLIANO, L. LATTANZI & F.P. PATTI.
- «*Contribution to the knowledge of coralligenous communities in the NE Aegean Sea*» par : V. GEROVASILEIOU, M. SINI, D. POURSANIDIS & D. KOUTSOUBAS.
- «*Review of coralligenous algal assemblages in Turkish coasts of Mediterranean Sea*» par : A GÜMÜŞOĞLU & Y. AKTAN
- «*Bioconstructional features of the temperate coral* Cladocora caespitosa *(Anthozoa, Scleractinia) in Veliko jezero (Mljet National Park, Adriatic Sea)*» par : P. KRUŽIĆ & A. PEIRANO.
- «*A Mediterranean coral species in the Dardanelles (Marmara Sea – Turquey)*» par : H.B. ÖZALP & M. ALPARSLAN.
- «*Preliminary data on red coral* Corallium rubrum *(Linneo, 1758) population of Sardinia sea (Western Mediterranean)*» par : C. PEDONI,M.C. FOLLESA, R. CANNAS, G. MATTA, P. PESCI & A. CAU.
- «*Some Observations on the Structure and Distribution of several Gorgonian Assemblages in the Eastern Mediterranean Sea*» par : M. SALOMIDI, C. SMITH, N. BELLOU, P. PANAYOTIDIS & V. PAPATHANASSIOU.

- «*Biogenic stalactites in submarine caves at the Cape of Otranto (South East Italy): dating and hypothesis on their formation*» par : G. BELMONTE, G. INGROSSO, M. POTO, G. QUARTA, M. D'ELIA, R. ONORATO & L. CALCAGNILE.
- «*The north adriatic coralligenous habitats in pelicular environmental conditions?*» par : S. CASELLATO, S. SORESI, L. MASIERO & A. STEFANON.
- «*Population strucutres of red coral (*Corallium rubrum *Linnaeus, 1758) in the area of the Dugi Otok Island (Eastern Adriatic)*» par : P. KRUŽIĆ & A. POPIJAČ.
- «*The biodiversity of macrobenthos within the coralligenous community dominated by the red gorgonian* Paramuricea clavata *in the central part of the Eastern Adriatic Sea (Croatia): preliminary results*» par : S. KIPSON, M. NOVOSEL, I. RADIĆ, P. KRUŽIĆ & A. POŽAR-DOMAC.
- «*The bioconstructional bryozoan* Pentapora fascialis *(Pallas)*» par : C. LOMBARDI, S. COCITO & M. NOVOSEL.

- «Polysiphonia *perforans* Cormaci, G. Furnari, Pizzuto *&* Serio *and* Bonnemaisonia hamifera *Hariot, two new records from the Mediterranean coasts of the Iberian Peninsula*» par : J. SILVA, N. SAMVCADOR & J. RULL LLUCH.
- «*Crustacean diversity of the coralligenous beds on the Aegean Sea coast of Turkey*» par : M. SEZGIN, K. BAKIR, T. KATAĞAN, A. SUAT ATEŞ & F. KIRKIM.
- «*Diversity, density and morphometry of a* Errina aspera *facies in the Messina Strait*» par : E. SALVATI, S. CANESE, M. ANGIOLILLO, M. GIUSTI, A. CARDINALI & S. GRECO.
- «Meadows of antipathella subpinnata (antipatharia, myriopathidae) in the calabrian coralligenous (southern italy, tyrrhenian sea)» M. BO, G. BAVESTRELLO, S. CANESE, M. GIUSTI, M. ANGIOLILLO & S. GRECO

Session 2

- «*Deep-sea coralligenous and red algae concretions' communities observed in the western Mediterranean by using ROV*» par : R. AGUILAR, X. PASTOR, A. TORRIENTE & S. GARCIA.
- «*Caractérisation des concrétions coralligènes par micro-tomographie à rayons X*» par : G. BRESSAN, S. KALEB, N. SODINI & G. TROMBA.
- «*Observation of fish assemblages in coralligenous habitats along the Calabrian coast by means of a Remotely Operated Vehicle*» par : A. CARDINALI, S. CANESE, M. GIUSTI, M. ANGIOLILLO, E. SALVATI, S. DI MUCCIO & S. GRECO.
- «*Une revue des méthodes d'étude des processus dynamiques au sein des bioconcrétionnements marins*» par : S. SARTORETTO & C. MARSCHAL.
- «*Twenty years monitoring of coralligenous and bioconstructional organisms in the Eastern Ligurian Sea (NW Mediterranean)*» par : A. PEIRANO , S. SGORBINI, R. CUPIDO, C. LOMBARDI & S. COCITO.

Session 3

- «*Warming trends, regional fingerprints and future trajectories of NW Mediterranean coastal waters*» par : N. BENSOUSSAN, J.C. ROMANO, J.G. HARMELIM, J. PASCUAL & J. GARRABOU.
- «*MEDCHANGE project**:** Evolution and conservation of marine biodiversity facing global change: the case of Mediterranean communities dominated by long-lived species*» par : J. GARRABOU, D. AURELLE, M. BALLY, C. LINARES, J-B. LEDOUX, O. BIANCHIMANI, K. MOKHTAR JAMAÏ, E. CEBRIAN, M. LA RIVIERE, J-G. HARMELIN, M. FOURT, C. MARSCHAL, F. ZUBERER, J-C. ROMANO, N. BENSOUSSAN, P. DRAP, R. COMA, E. SERRANO, N. TEIXIDO, P-L. MERLE, D. FORCIOLI, D. ALLEMAND, S. TAMBUTTÉ, C. FERRIER-PAGES & M. ZABALA.
- «*Assessing the diving effect on bryozoans community*» par : B. LUNA PEREZ, C. VALLE PEREZ & J.L. SANCHEZ LIZASO.
- «*The future of Mediterranean scleractinians corals in a warming Mediterranean Sea*» par : R. RODOLFO-METALPA, A. PEIRANO & C. FERRIER-PAGÈS.
- «*Evaluation de l'état écologique des bio concrétionnements de coralligène autour de l'archipel des Embiez (Var, France)*» par : E. ROUANET, P. LELONG, C. LECALARD & Y. MARTIN.

20h00 *Repas de gala offert par le CAR/ASP*

Vendredi 16 Janvier 2008

09h30 – 11h30 **Session 2 - Les méthodes d'étude des formations coralligènes et autres bioconcretions calcaires et Discussion**

Introduction de la session 2 - Le coralligène, un patrimoine exceptionnel : comment l'évaluer et le surveiller ? par Prof. J.G. HARMELIN

- « *Presence of* Corallium rubrum *on coralligenous assemblages below 50 m*» par : M. ANGIOLILLO, S. CANESE, M. GIUSTI, A. CARDINALI, M. BO, E. SALVATI & S. GRECO.
- «*Integration of different methodologies into a Geographic Information System (GIS) to study coralligenous habitat in Calabrian coastal waters (South Italy)*» par : S. CANESE, M. GIUSTI, ROSSI, M. ANGIOLILLO, E. SALVATI,A. CARDINALI, M. BO & S. GRECO.
- «*Contribution to the conservation of coralligenous communities through studies on population ecology of Mediterranean gorgonians*» par : C. LINARES, R. COMA, J. GARRABOU, O. BIANCHIMANI, P. DRAP, E. SERRANO & M. ZABALA.
- «*Interest and application of genetic markers for the study and conservation of Mediterranean sessile invertebrates*» par : K. MOKHTAR-JAMAÏ, J-B. LEDOUX, J. GARRABOU & D. AURELLE.
- «*Le récif à* Neogoniolithon brassica-florida *de la lagune des Bibans (Tunisie)*» par : G. PERGENT, M. BESSIBES, A. DJELLOULI, A. EL ABED, H. LANGAR, R. MRABET & C. PERGENT-MARTINI.

Discussion

10h50 – 11h20 *Pause café*

11h20 – 13h00 **Session 3 - La gestion des habitats coralligènes et autres bio concrétions calcaires**

Introduction de la session 3 - Threats and conservation of coralligenous assemblages par Prof. E. BALLESTEROS

- «*Spatial and temporal variations of assemblages in Mediterranean corraligenous reefs*» par : M. ABBIATI, L. AIROLDI, F. CONSTANTINI, F. FAVA & M. PONTI
- «*Biological interactions affecting the growth rates of red coral (*Corallium rubrum*) colonies*» par : G. BAVESTRELLO, C. CERRANO & R. CATTANEO-VIETTI R
- «*Environmental and conservation relevance of the punta manara corraligenous beds (Eastern Ligurian Sea)*» par : S. COPPO, G. DIVIACCO & L. TUNESI.
- «*Mortality and resilience: a ten-year monitoring of gorgonian population trends in the Eastern Ligurian Sea (NW Mediterranean)*» par : R. CUPIDO, S. COCITO, A. PEIRANO & G. SANTANGELO.

Discussion

13h00 – 14h30 *Pause déjeuner*

14h30 – 16h00 **Table ronde « Les changements climatiques consituent-ils une menace pour les formations coralligènes ? »**

Animateurs : Dr. J. GARRABOU & Dr. L. TUNESI
Rapporteurs : Dr. C. RAIS & Prof. G. PERGENT

16h00 – 16h30 *Pause café*

16h30 – 17h00 **Conclusions & Clôture du Symposium**

- **Bilan et recommandations du Premier Symposium sur la Conservation du Coralligène et autres bio concrétions de Méditerranée** par C. PERGENT-MARTINI

17h30 *Départ de Tabarka vers Tunis*

First Mediterranean Symposium on Coralligenous conservation and other calcareous bio-concretions

Tabarka, Hôtel Iberostar

PROGRAMME

Thursday 15 January 2008

09h00 – 09h30 **First Mediterranean Symposium on Coralligenous conservation and other calcareous bio-concretions (UNEP/MAP-RAC/SPA) Official Opening**

09h30 – 10h30 **Session 1 - Knowledge of the Coralligenous communities and ioter bioconstructions**

Current knowledge – introduction by Prof. G. GIACCONE

- «*Overview on the sponges diversity in the Mediterranean*» by: A.V. ERESKOVSKY, J. IVANISEVIC & T. PÉREZ
- «*Calcherb, an information system about Calcareous red algae of the Coralligenous*» by: S. KALEB, G. BRESSAN & S. MARTELLOS

Discussion

10h30 – 11h00 *Coffee Break*

11h00 – 13h00 **Session 1 - Knowledge of the Coralligenous communities and ioter bioconstructions (continued)**

- «*Effective larval dispersal of corraligenous species: connectivity and relevant scales for conservation*» by: M. ABBIATI, F. COSTANTINI & C. FAUVELOT
- «*Trophic structure and functioning of vermetid reef community based on carbon and nitrogen stable isotope analysis*» by: F. COLOMBO,V. COSTA, A.E. ALEO, C. TRAMATI, A. MAZZOLA & S. VIZZINI.
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- «*Demographic dynamics over decades in Coralligenous benthic communities*» by: N. TEIXIDÓ, J. GARRABOU & J-G. HARMELIN.

Discussion

- «*Analysis on the Coralligenous assemblages in the Mediterranean Sea: a review of the current state of knowledge in support of future investigations*» by: S. AGNESI, A. Annunziatellis, M.L. CASSESE, T. DI NORA, G. LA MESA, G. MO, C. PERGENT MARTINI & L. TUNESI.
- «*Remarkable benthic communities on the Coralligenous in the National Park of Al Hoceima (Mediterranean Cost, Morocco)*» by : S. BENHISSOUNE, C. RAIS, L. TUNESI, H. BAZAIRI, S. HADDI, O. BENZAKOUR, I. SADKI, C. FRANZOSINI & D. NACHITE.

Discussion

13h00 – 14h30 *Lunch Break*

14h30 – 15h30 **Session 1 - Knowledge of the Coralligenous communities and other bioconstructions (continued)**

- «*Three- dimensional distribution of* Gerardia savaglia *in relation to depth, orientation and slope of the substrata in the South Tyrrhenian Sea*» by: M. GIUSTI, S. CANESE, M. ANGIOLILLO, M. BO, E. SALVATI, A. CARDINALI & S. GRECO.
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- «*An important component of the coralligenous asssemblages: the precious Mediterreanean red coral*» by: G. SANTANGELO, M. IANNELLI, L. BRAMANTI & L. VIELMINI.

Discussion

15h30 – 16h30 **Poster Session : Presentation by Scientific Committee**

- Session 1 Posters' presentation «Knowledge» by Dr. .K. BEN MUSTAPHA, Prof. G. BITAR et Prof. S. BENHISSOUNE
- Session 2 Posters'presentation « Methods » by Prof. R. SEMROUD
- Session 3 Posters'presentation « Management » by Prof. A. RAMOS ESPLA

16h30 – 17h00 *Coffee Break*

17h00 – 18h30 **Poster Session**

Session 1

- «*Distribution of* Acanthogorgia sp. *along the Calabrian coast (Southern Tyrrhenian Sea, Italy)*» by: M. ANGIOLILLO, S. CANESE, M. GIUSTI, M. BO, A. CARDINALI, E. SALVATI & S. GRECO.
- «*Challenges and perspectives of calcareous bio-concretions inventory in Croatia*» by: T. BAKRAN-PETRICIOLI, D. PETRICIOLI & J. RADOVIC.
- «*Les bio-concrétions de la Wilaya de Tipaza (Algérie)*» by*:* M. BENALI, A. KARALI & C. REBZANI ZAHAF.
- «*Données préliminaires sur la répartition et la composition de la biocénose du coralligène du littoral d'El Kala (Algérie)*» by: S. BELBACHA, R. SEMROUD, R. DUPUY DE LA GRANDRIVE & M FOULQUIE.

- «*Coralligenous formations in the marine protected area of Tavolara Punta Coda Cavallo (NE sardinia, Italy)*» by: C.N. BIANCHI, R. CATTANEO-VIETTI, C. MORRI, A. NAVONE, P. PANZALIS & P. ORRÙ

- «*Les formations de type "coralligène de plateau" dans les eaux agathoises (Hérault, France). Site Natura 2000 FR 910 1414 "Posidonies du Cap d'Agde"*» by: S. BLOUET, R. DUPUY DE LA GRANDRIVE,M. FOULQUIE & P. LENFANT.
- «*Coralligenous assemblages in the marine habitats atlas of Liguria region (ITALY)*» by: S. COPPO & G. DIVIACCO.
- «*Les gorgonacea et les alcyonacea des cotes de l'Est algérien : Diversité et état d'exploitation du Corail Roug,* Corallium rubrum» by: F. DERBAL & M.H. KARA.

- «*Description sur les côtes Nord de la Tunisie, d'un site comprenant des encorbellements à* Lithophyllum lichenoides *ainsi que des formations de maerl à* Lythophyllum dentatum» by: A. DJELLOULI & Z. EL ASMI-DJELLOULI.
- «*Coralligenous assemblages in the northern Adriatic continental shelf*» by: F. FAVA, M. PONTI & M. ABBIATI.
- «*The "pink mile": benthic assemblages of rhodolith and mäerl beds (corallinales) off the island of Ischia (Tyrrhenian Sea)*» by: M.C. GAMBI, M.C. BUIA, A. MASSA-GALLUCCI, M. CIGLIANO, L. LATTANZI & F.P. PATTI.
- «*Contribution to the knowledge of coralligenous communities in the NE Aegean Sea*» by: V. GEROVASILEIOU, M. SINI, D. POURSANIDIS & D. KOUTSOUBAS.
- «*Review of coralligenous algal assemblages in Turkish coasts of Mediterranean Sea*» by: A GÜMÜŞOĞLU & Y. AKTAN
- «*Bioconstructional features of the temperate coral* Cladocora caespitosa *(Anthozoa, Scleractinia) in Veliko jezero (Mljet National Park, Adriatic Sea)*» by: P. KRUŽIĆ & A. PEIRANO.
- «*A Mediterranean coral species in the Dardanelles (Marmara Sea – Turquey)*» by: H.B. ÖZALP & M. ALPARSLAN.
- «*Preliminary data on red coral* Corallium rubrum *(Linneo, 1758) population of Sardinia sea (Western Mediterranean)*» by: *C.* PEDONI, M.C. FOLLESA, R. CANNAS, G. MATTA, P. PESCI & A. CAU.
- «*Some Observations on the Structure and Distribution of several Gorgonian Assemblages in the Eastern Mediterranean Sea*» by: M. SALOMIDI, C. SMITH, N. BELLOU, P. PANAYOTIDIS & V. PAPATHANASSIOU.

- «*Biogenic stalactites in submarine caves at the Cape of Otranto (South East Italy): dating and hypothesis on their formation*» by: G. BELMONTE, G. INGROSSO, M. POTO, G. QUARTA, M. D'ELIA, R. ONORATO & L. CALCAGNILE.
- «*The north adriatic coralligenous habitats in pelicular environmental conditions?*» by: S. CASELLATO, S. SORESI, L. MASIERO & A. STEFANON.
- «*Population strucutres of red coral (*Corallium rubrum *Linnaeus, 1758) in the area of the Dugi Otok Island (Eastern Adriatic)*» by: P. KRUŽIĆ & A. POPIJAČ.
- «*The biodiversity of macrobenthos within the coralligenous community dominated by the red gorgonian* Paramuricea clavata *in the central part of the Eastern Adriatic Sea (Croatia): preliminary results*» by: S. KIPSON, M. NOVOSEL, I. RADIĆ, P. KRUŽIĆ & A. POŽAR-DOMAC.

- «*The bioconstructional bryozoan* Pentapora fascialis *(Pallas)*» by: C. LOMBARDI, S. COCITO & M. NOVOSEL.
- «Polysiphonia *perforans* Cormaci, G. Furnari, Pizzuto *&* Serio *and* Bonnemaisonia hamifera *Hariot, two new records from the Mediterranean coasts of the Iberian Peninsula*» by: J. SILVA, N. SAMVCADOR & J. RULL LLUCH.
- «*Crustacean diversity of the coralligenous beds on the Aegean Sea coast of Turkey*» by: M. SEZGIN, K. BAKIR, T. KATAĞAN, A. SUAT ATEŞ & F. KIRKIM.
- «*Diversity, density and morphometry of a* Errina aspera *facies in the Messina Strait*» by: E. SALVATI, S. CANESE, M. ANGIOLILLO, M. GIUSTI, A. CARDINALI & S. GRECO.
- «Meadows of antipathella subpinnata (antipatharia, myriopathidae) in the calabrian coralligenous (southern italy, tyrrhenian sea)» M. BO, G. BAVESTRELLO, S. CANESE, M. GIUSTI, M. ANGIOLILLO & S. GRECO

Session *2*

- «*Deep-sea coralligenous and red algae concretions' communities observed in the western Mediterranean by using ROV*» by: R. AGUILAR, X. PASTOR, A. TORRIENTE & S. GARCIA.
- «*Caractérisation des concrétions coralligènes par micro-tomographie à rayons X*» by: G. BRESSAN, S. KALEB, N. SODINI & G. TROMBA.
- «*Observation of fish assemblages in coralligenous habitats along the Calabrian coast by means of a Remotely Operated Vehicle*» by: A. CARDINALI, S. CANESE, M. GIUSTI, M. ANGIOLILLO, E. SALVATI, S. DI MUCCIO & S. GRECO.
- «*Une revue des méthodes d'étude des processus dynamiques au sein des bioconcrétionnements marins*» by : S. SARTORETTO & C. MARSCHAL.
- «*Twenty years monitoring of coralligenous and bioconstructional organisms in the Eastern Ligurian Sea (NW Mediterranean)*» by: A. PEIRANO , S. SGORBINI, R. CUPIDO, C. LOMBARDI & S. COCITO.

Session 3

- «*Warming trends, regional fingerprints and future trajectories of NW Mediterranean coastal waters*» by: N. BENSOUSSAN, JC. ROMANO, JG. HARMELIM, J. PASCUAL & J. GARRABOU.
- «*MEDCHANGE project**:** Evolution and conservation of marine biodiversity facing global change: the case of Mediterranean communities dominated by long-lived species*» by: J. GARRABOU, D. AURELLE, M. BALLY, C. LINARES, J-B. LEDOUX, O. BIANCHIMANI, K. MOKHTAR JAMAÏ, E. CEBRIAN, M. LA RIVIERE, J-G. HARMELIN, M. FOURT, C. MARSCHAL, F. ZUBERER, J-C. ROMANO, N. BENSOUSSAN, P. DRAP, R. COMA, E. SERRANO, N. TEIXIDO, P-L. MERLE, D. FORCIOLI, D. ALLEMAND, S. TAMBUTTÉ, C. FERRIER-PAGES & M. ZABALA.
- «*Assessing the diving effect on bryozoans community*» by: B. LUNA PEREZ, C. VALLE PEREZ & J.L. SANCHEZ LIZASO.
- «*The future of Mediterranean scleractinians corals in a warming Mediterranean Sea*» by: R. RODOLFO-METALPA, A. PEIRANO & C. FERRIER-PAGÈS.

- «*Evaluation de l'état écologique des bio concrétionnements de coralligène autour de l'archipel des Embiez (Var, France)*» by: E. ROUANET, P. LELONG, C. LECALARD & Y. MARTIN.

20h00 *Social Dinner offered by RAC/SPA*

Friday 16 Janvier 2008

09h30 – 11h30 **Session 2 – Methods to study the Coralligenous community and others bioconstructions and Discussion**

Introduction of the session 2 - Coraligenous, exceptionnal heritage: How does assess it and monitore it ? by Prof. J.G HARMELIN

- « *Presence of* Corallium rubrum *on coralligenous assemblages below 50 m*» by: M. ANGIOLILLO, S. CANESE, M. GIUSTI, A. CARDINALI, M. BO, E. SALVATI & S. GRECO.
- «*Integration of different methodologies into a Geographic Information System (GIS) to study coralligenous habitat in Calabrian coastal waters (South Italy)*» by: S. CANESE, M. GIUSTI, ROSSI, M. ANGIOLILLO, E. SALVATI,A. CARDINALI, M. BO & S. GRECO.
- «*Contribution to the conservation of coralligenous communities through studies on population ecology of Mediterranean gorgonians*» by: C. LINARES, R. COMA, J. GARRABOU, O. BIANCHIMANI, P. DRAP, E. SERRANO & M. ZABALA.
- «*Interest and application of genetic markers for the study and conservation of Mediterranean sessile invertebrates*» by: K. MOKHTAR-JAMAÏ, J-B. LEDOUX, J. GARRABOU & D. AURELLE.
- «*Le récif à* Neogoniolithon brassica-florida *de la lagune des Bibans (Tunisie)*» by: G. PERGENT, M. BESSIBES, A. DJELLOULI, A. EL ABED, H. LANGAR, R. MRABET & C. PERGENT-MARTINI.

Discussion

10h50 – 11h20 *Coffee Break*

11h20 – 13h00 **Session 3 – Threats, Conservation & Management of the Coralligenous community and other bioconstructions**

Introduction of the session - Threats and conservation of coralligenous assemblages by Prof. E. BALLESTEROS

- «*Spatial and temporal variations of assemblages in Mediterranean corraligenous reefs*» by: M. ABBIATI, L. AIROLDI, F. CONSTANTINI, F. FAVA & M. PONTI
- «*Biological interactions affecting the growth rates of red coral (*Corallium rubrum*) colonies*» by: G. BAVESTRELLO, C. CERRANO & R. CATTANEO-VIETTI R
- «*Environmental and conservation relevance of the punta manara corraligenous beds (Eastern Ligurian Sea)*» by: S. COPPO, G. DIVIACCO & L. TUNESI.
- «*Mortality and resilience: a ten-year monitoring of gorgonian population trends in the Eastern Ligurian Sea (NW Mediterranean)*» by: R. CUPIDO, S. COCITO, A. PEIRANO & G. SANTANGELO.

Discussion

13h00 – 14h30 *Lunch Break*

14h30 – 16h00 **Roundtable "Are climatic changes a real threat for Coralligenous assemblages ?"**

Facilitators : Dr. J. GARRABOU & Dr. L. TUNESI
Rapporteurs : Dr. C. RAIS & Prof. G. PERGENT

16h00 – 16h30 *Coffee Break*

16h30 – 17h00 Conclusions & Recommandations

- **Outcome and recommandations of the First Mediterranean Symposium on Coralligenous conservation and other calcareous bio-concretions** by C. PERGENT-MARTINI

17h30 *Departure from Tabarka to Tunis*

ORAL COMMUNICATIONS

COMMUNICATIONS ORALES

INTRODUCTION DE LA SESSION 1

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THE STATUS OF KNOWLEDGE OF THE CORALLIGENOUS AND OTHER CALCAREOUS BIO-CONCRETIONS

The Coralligenous and other calcareous bio-concretions seascape, besides its primary aspect with predominance of calcareous algae of the *Lithophyllo-Halimedetum tunae*, of the *Phymatolitho-Lithothamnietum corallioidis*, of the *Lithothamnietum byssoidis* assemblages, can appear with a predominance of bio-constructor animals, forming various facies. The algal species mainly responsible for the bio-construction are of the Halimeda, Lithophyllum, Lithothamnion, Mesophyllum, Neogoniolithon, Phymatolithon, Peyssonnelia, Spongites genders. The principal facies with animal or vegetal dominance are characterized by: 1 – big Branched Bryozoans (Platform Coralligenous); 2 – colonial Madrepores and Asteroidea (Coralligenous of the inferior horizon of the littoral rock); 3 – Gorgonians on rocky formations with different inclination, depth and hydro-dynamism; 4 – Rhodolith beds in the Coastal Detritic assemblage; 5 – Platforms with Vermetids an Corallinaceae. Coralligenous and other calcareous bio-concretions are the result of the dynamic equilibrium between the building organisms and the destroying organisms; their composition is summarized for Coralligenous by Ballesteros (2006), for rhodolith beds by Barbera et al.(2003) and for other bio-concretions by others researchers. Monumental bio-concretions, but in the surface sea belts, are too calcareous platforms with Vermetids and Corallinaceae. The study of the bio-concretions assemblages along the Italian coasts has some precursors such as Bacci (1947), Tortonese (1958), Rossi (1958, 1961), Parenzan (1960, 1983a-b). The synecologic study with a bionomic and/or phytosociologic approach has been performed by Giaccone and colleagues (1965, 1966, 1967, 1968a-b, 1970, 1971, 1994, 1997, 2001, 2003a-b, 2004) from the University of Palermo and Catania, by Sarà and colleagues (1968, 1969, 1970, 1971, 1972, 1977, 1978, 1990, 1999) from the University of Genoa and Bari; calcareous platforms are study by Chemello, Mannino, Bressan, Giaccone and colleagues from the University of Palermo, Trieste and Catania. Rhodolith beds are studied by Basso and colleagues from University of Milano-Bicocca, by Bressan and T. Giaccone from the University of Trieste and Catania, by Gambi and colleagues from Stazione Zoologica di Napoli. Even though taxonomy of Corallinaceae and Peyssonneliaceae among vegetables and taxonomy of various faunal groups such as Porifers, Molluscs, Polychaetes, Bryozoans, Anthozoans, etc. contributed to the study of the Coralligenous an of the Rhodolith beds biotic component and has excellence study centres in Italy in places such as Trieste, Milan, Genoa, Bari, Lecce, Pisa, Naples and Catania, it is not examined carefully in the present overview. The synthesis of Ballesteros on Coralligenous reports that there are 1666 (315 algae, 1241 invertebrates, 110 fishes) registered species in this formation and Barbera et al. on rhodolith beds report that there are about 100 algae and 400 animals: two hot spos of biodiversity of the Mediterranean Sea. The age of bio-concretioning varies from 8000 to 600 years BP, measurements have been performed on bio-concretions developed from 10 to 60 meters depth. Moreover, an actual concretioning growth rate has been estimated as being 0,006/0,83 mm/year. According to palaeontologic data it seems that the more active period (0,20-0,83 mm/year) for the coralligenous bio-construction in the Mediterranean Sea went from 8000 to 5000 years BP. Production of vegetable species calcium carbonate varies from 465 to 100 g per sm/year, while for animal species it can reach 660 g per sm/year (Ballesteros 2006). Coralligenous hosts numerous vegetal associations and animal facies listed in the documents published by the RAC/SPA in application of the SPA/BD Protocol of the Barcelona Convention and of the SAP/BIO for the Mediterranean. The natural environment built by limestone fixing organisms is the more repetitive view both in emerged (Landscape of formations with organogenous calcareous rocks) and submerged territories (Seascape of live and fossil bio-constructions) of the Mediterranean Region. “Landscape represents the whole human environment in its visual and spatial integrity, where integration among geography, biosphere and human artifacts is performed” (Naveh et al., 1984). This classic definition of landscape can be used for the environments of all living beings and not only for that of human beings and of the integration between sub-aerial, sub aqueous environments and bio-constructions in general. The study of Landscape needs various research fields (Pignatti 1994) pertaining to multidisciplinary experiences and notions referring to competences on science of the earth (especially oceanography, geomorphology, geology, etc.) of life (biogeography, phytosociology, ecology, biology, etology, etc.) of building (engineering, architecture etc.) of the human being (psychology, economy, sociology, ethics, history, archeology, etc.). In the multi-disciplinary ecosystemic approach, it is fundamental, according to professional ethics, to insert the vision of the existential relations present in the cultures and religions that characterized the deep soul of these cultures. This is a Depth Ecology of cultures, which contrary to the Deep Ecology which felt the effects of New Age, keeps the distinction (not the separation) among the components and acknowledges the synergic diversity in the relational roles of organisms inserted in the trophoenergetic networks of the natural ecosystems. The landscape is a common patrimony of humanity protected by international agreements. When landscape protection and fruition become part of the legislative proceedings of the various Nations, social relationality must be inserted in the concept of landscape. In Italy this legislative aspect dates back to 1939 with the Bottai law and was then improved in the Constitution of the Italian Republic and in all the environmental body of legislation developed in Europe while enforcing numerous EEC lines and international agreements promoted by various U.N.O. agencies. Social relationality is clearly expressed in the Panizza’s definition of landscape (1988): “The Landscape is a geodynamic expression integrated of multiple natural and anthropic components”. So, Panizza and Pacenti (2003) added the following notes: “This means affirming a continuity among nature, history, traditions, culture, socioeconomic activities and developments perspectives; it also means expressing the human being-nature relation in terms of constant evolution and reciprocal entreaties in time and space. (…). The human being can regain his central position in nature, but with a really different role in comparison with the past; not any more with a problem of responsibility towards the external world only, but with a problem of responsibility towards himself, because it was humanity through its own development, that is to say its history and culture (not its nature) who triggered the environmental problems”.Ethic teaches that an environmental fracture is always a fracture between man and nature and to re-establish the relational balance is not only a technical-scientific problem, an administrative or criminal law matter, but also a moral responsibility pertaining to everybody’s consciousness both in the horizontal dimension (natural) and in the vertical one (supernatural). On the one hand, this represents an antidote against the onset of religious and environmentalist fanaticisms and on the other it represents an obstacle to the occurrence of technocratic powers leading to a degradation both of nature and of the human dignity (Giaccone, 2008).

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INTRODUCTION DE LA SESSION 2

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LE CORALLIGENE, UN PATRIMOINE EXCEPTIONNEL : COMMENT L'EVALUER ET LE SURVEILLER ?

INTRODUCTION

Le coralligène est un ensemble de communautés qui ont une grande valeur patrimoniale en raison d'abord de leur diversité exceptionnelle en espèces, qui forment des réseaux complexes d'interactions. Beaucoup d'espèces caractéristiques de ces communautés, en particulier celles qui ont un rôle clé, ont une sensibilité particulière à cause d'une croissance lente, un recrutement faible et très grande longévité potentielle. Certaines de ces espèces sont très recherchées pour leur forte valeur commerciale. Une autre ressource exploitée du coralligène est la qualité paysagère apportée par les peuplements fixés et mobiles, qui attire une fréquentation touristique croissante. Le statut du coralligène doit donc faire l'objet d'une attention particulière avec des méthodes fiables d'évaluation et de suivi.

CONTEXTE

Le concept de coralligène est toutefois très large (biohermes construits par les corallinacées vs parois peu éclairées dominées par une couverture d'invertébrés). Cette hétérogénéité conceptuelle et la complexité intrinsèque du coralligène, ainsi qu'une large distribution verticale, une distribution en taches des espèces, une variabilité géographique importante (bassin occidental vs bassin oriental) et des objectifs différents avec des échelles spatiales très variables impliquent des méthodes d'étude très diverses.

La surveillance de l'état du coralligène est indissociable de la surveillance des causes potentielles de son altération. Ces causes sont multiples : pollution, avec des effets physiques (turbidité, accroissement de la sédimentation), chimiques (élimination d'espèces sensibles) et biologiques (monopolisation de l'espace par des espèces tolérantes, augmentation de la bioérosion par les organismes foreurs et rongeurs, agressions mécaniques (engins traînants, filets, mouillages, plongeurs), anomalies thermiques, envahissement par des espèces exotiques invasives, pêche excessive (corail rouge, grands crustacés, poissons).

OBJECTIFS

Le monitoring du coralligène a deux objectifs principaux : (i) l'évaluation immédiate de la qualité de ses états locaux selon un référentiel, (ii) le suivi de l'évolution de son état dans le temps sur des stations permanentes. Dans les deux cas, il se pose un problème d'échelle spatiale pour la surveillance : placettes ou paysages du secteur ?

Il y a un grand besoin d'outils simples d'évaluation de l'état du coralligène et de son évolution pour la caractérisation des sites et pour leur gestion. Une classification selon des échelles de valeur implique la définition d'états de référence. Les critères définissant le caractère exemplaire des différents aspects du coralligène doivent donc être identifiés et caractérisés pour une utilisation pratique. La richesse spécifique du coralligène devrait être l'objectif premier de la surveillance. Toutefois, la quantification de ce paramètre implique un très gros effort de recensement faisant intervenir de nombreux spécialistes, impossible à mettre en œuvre pour une surveillance. Il est donc nécessaire de sélectionner des indicateurs et des groupes d'espèces significatifs.

QUELQUES METHODES UTILISEES OU EN COURS DE DEVELOPPEMENT

(1) Recensement visuel direct (plongée) ou indirect (ROV) de groupes significatifs d'espèces macroscopiques (eg, grandes algues pérennes, scléractiniaires, grands bryozoaires dressés, échinodermes, grands crustacés, poissons). Données acquises : richesse spécifique du groupe, fréquence des espèces.

(2) Evaluation de la diversité des peuplements cryptiques par approche expérimentale : colonisation de capteurs standardisés (testée pour bryozoaires). Données acquises : richesse spécifique, fréquence des espèces, indication de déséquilibre par la structure taxonomique du peuplement.

(3) Evaluation de l'état des populations locales d'espèces représentatives soumises à des altérations (eg, gorgonaires, éponges, bryozoaires, poissons) par mesures directes ou par méthodes photographiques. Données acquises : densité, structure démographique, taux de nécroses ou mortalité.

(4) Indicateurs de biodiversité par méthodes photographiques 2D à 3D (photogrammétrie) à différentes échelles (des placettes aux paysages) sur des sites de référence. Données acquises : structure et dynamique de la couverture biologique, évolution à moyen et long terme de l'épibiose, mémoire paysagère.

(5) Dynamique du concrétionnement. Taux de couverture et vitalité des corallinacées constructrices. Fréquence des différentes morphoses des éponges *Cliona*. Bilan construction/destruction (adaptation au coralligène de la méthodologie mise au point dans les récifs coralliens, en cours d'élaboration).

(6) Evaluation de l'impact sur le coralligène des espèces invasives (e.g., *Caulerpa racemosa cylindracea*, *Wormesleyella setacea*).

(7) Qualification des sites par cartographie de la qualité environnementale de secteurs déterminée par la cotation positive ou négative d'espèces significatives (à développer d'après la méthode appliquée aux algues photophiles, cf. Ecological Quality Ratio : Ballesteros *et al.*, 2007).

(8) Qualification et suivi des sites par une veille environnementale des facteurs physico-chimiques : régime thermique, taux de sédimentation, turbidité, nutriments, contaminants, etc.

CONCLUSION

De nombreuses méthodes d'évaluation et de suivi sont déjà appliquées localement dans le coralligène, avec des contraintes dues à la profondeur des sites. Il y a un besoin évident d'une formalisation des principes de sélection des critères de qualité des sites pour l'établissement d'un référentiel. La variabilité des aspects locaux et régionaux du coralligène implique que la composition des pools d'espèces indicatrices ne peut être figée et doit être adaptée à chaque cas. Une veille environnementale des sources d'altération devrait être généralisée.

INTRODUCTION DE LA SESSION 3

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THREATS AND CONSERVATION OF CORALLIGENOUS ASSEMBLAGES

ABSTRACT

Major threats affecting coralligenous assemblages are identified and described. Trawling, artisanal and recreational fishing, anchoring, alien species invasions, direct and indirect effects of CO_2 increase (acidification, warming), waste water discharges, aquaculture, changes in land use and coastal infrastructure construction and urbanization, diving activities, and blooming of mucilaginous and filamentous algal aggregates are currently affecting the biodiversity and structure of some coralligenous outcrops. Some conservation measures may be implemented in order to protect the coralligenous environment such as the inclusion of coralligenous concretions as a priority natural habitat type in the EU Habitats Directive, the banning of trawling, sediment removal and waste water dumping over coralligenous bottoms or at their vicinity, a correct management of artisanal fisheries and diving activities, the creation of Marine Protected Areas specifically devoted to protect coralligenous bottoms, and the enactment of suitable legislation concerning the introduction of alien species. The recently created RAC/SPA Action Plan for the Conservation of the Coralligenous and other Calcareous Bioconcretions in the Mediterranean Sea should foster the implementation of at least some of these conservation measures and may be pivotal in public awareness and in the coordination of international initiatives.

KEY-WORDS: Coralligenous assemblages; threats; conservation; degradation; disturbances.

INTRODUCTION

Marine coastal environments are severely affected by human disturbances and those thriving in the highly populated Mediterranean Sea are specially prone to degradation (Boudouresque, 2003). *Posidonia oceanica* meadows have been usually considered as a threatened ecosystem and most conservation efforts have been focused on them. However these seagrass meadows are not the only Mediterranean ecosystem that needs protection and recent concern has been raised for the protection of coralligenous assemblages, a unique calcareous formation of biogenic origin from the Mediterranean benthic environments that is produced by the accumulation of encrusting algae growing in dim light conditions (Ballesteros, 2006). A special Action Plan for the protection of coralligenous and maërl assemblages has been recently adopted by RAC/SPA and a proposal of a Work Programme has been elaborated (Ballesteros, 2007). One of the aims of this Work Programme was the organisation of a periodical workshop devoted to coralligenous concretions and maërl beds. Here, in the framework of the First Workshop, we present the major threats affecting the conservation of these assemblages, propose some conservation measures to be implemented, and highlight the importance of RAC/SPA in order to foster all kind of conservation initiatives and public awareness.

THREATS

Main threats affecting coralligenous assemblages have been already partially reviewed by Boudouresque *et al.* (1990) and Ballesteros (2006, 2007). Trawling is the most destructive impact affecting coralligenous communities by destroying the calcareous outcrops, modifying the environmental conditions of microhabitats, killing most of the engineering, dominant, long-lived species, capturing target fish and crustacean species and negatively affecting algal growth and suspension feeding due to increased turbidity and sedimentation. Artisanal fishing is able to decimate some fishes, mainly elasmobranchs, if fishing pressure is outstanding; trammel nets can also exert an important impact on gorgonian populations and other erect species. High anchoring and diving operations can be critical for the survival of certain large and fragile suspension feeders. Waste water discharges and aquaculture facilities situated over coralligenous outcrops inhibite coralline algal growth, increase bioerosion rates, decrease species richness and densities of the largest individuals of the epifauna and increase the abundance of tolerant species. Changes in land use and coastal infrastructure construction and urbanization involve an increase in water turbidity and/or sediment removal that affect coralligenous communities. Anomalous high water temperatures trigger large scale mortalities of suspension feeders, mortalities that are expected to increase if the current pattern of global warming continues. Ocean acidification due to increased CO_2 levels should affect coralligenous concretions as the abundance of scleractinian corals and calcareous algae is severely reduced in pH-lowered environments (Hall-Spencer *et al.*, 2008). Finally, the proliferation of unwanted organisms such as mucilaginous or filamentous algal aggregates or invasive species can cause severe damage over the main engineering species, such as calcareous algae or gorgonians.

CONSERVATION MEASURES

Coralligenous assemblages should be included in the EU Habitats Directive (92/43/EEC) as a priority natural habitat type, which would enable at least EEC countries to set up an ecological network of conservation areas in the framework of Natura 2000; similar actions should be encouraged in non EEC countries through the existing tools of the Barcelona Convention. Marine Protected Areas (MPAs) have to be established in order to protect representative coralligenous assemblages by applying the protection and management measures recommended by Articles 6 and 7 of the SPA protocol.

Regarding legislation measures, there is already a Council Regulation (EC) Nº 1967/2006 that specifically prohibits fishing with trawl nets, dredges, shore seines or similar nets above coralligenous habitats and maërl beds. Future legislation has to be developed in order to protect both endangered and engineering species of coralligenous bottoms; appropiate, scientifically-based management plans have also to be implemented for the exploitation of natural resources inhabiting these environments.

There is also an urgent need for regulation of anthropogenic activities being performed above, in or at the vicinity of coralligenous assemblages to make it compatible with the sustainability of the assemblages and their populations. These regulations might include (1) the direct physical destruction of coralligenous assemblages by trawling, artisanal fishing or diving, (2) the banning of waste water dumping over or at the vicinity of coralligenous assemblages, (3) the prohibition of any activity involving an increase in water turbidity or sediment removal (e.g. trawling, dredging, beach regeneration, aquaculture facilities, coastline modification), (4) to correctly manage traditional and recreational fisheries to prevent stock depletion of target fish and invertebrates and to avoid unintentional pulling up of long-lived erect invertebrates and macroalgae, (5) to limit diving activities in order to make it compatible with the conservation of the most vulnerable species and (6) to enact a suitable legislation concerning the introduction of alien species.

Public awareness is also important in order to generate a social claim for protection of coralligenous assemblages. RAC/SPA can play a pivotal role in this aspect as well as in fostering the implementation of some of the conservation measures explained above and in the coordination of international initiatives through the Action Plan for the Conservation of the Coralligenous and other Calcareous Bioconcretions in the Mediterranean Sea. RAC/SPA can also hold the leadership for the elaboration of guidelines for the assessment of environmental impact studies on coralligenous assemblages and in the development and implementation of management and monitoring plans devoted to the conservation of coralligenous assemblages.

SCIENTIFIC KNOWLEDGE

Although the scientific knowledge concerning several aspects of coralligenous assemblages (e.g. taxonomy, processes, functioning, biotic relationships, dynamics) is currently increasing, it is still far away from the knowledge we have from other coastal ecosystems (e.g. intertidal zone, kelp beds, seagrass meadows, shallow coastal rocky areas, rockpools), hindering the selection of adequate conservation measures and management plans. Thus, more basic and applied research is needed both at the ecosystem level and at the level of populations of engineering and dominant organisms. Moreover, there is an urgent need for studies dealing with the vulnerability of coralligenous assemblages and their populations to several kind of disturbances mentioned above. Although mortality events related to water temperature anomalies are relatively well studied (see references in Ballesteros, 2006, and communications in this workshop), other very important impacts are mainly disregarded: waste water dumping, proliferations of harmful blooming algae and invasive species, artisanal fishing impact, and the effects of increased sedimentation and turbidity levels. All these threats are being extensively covered by scientific research in Mediterranean shallow rocky bottoms and seagrass meadows, and the difficulty of sampling in the deep waters where coralligenous assemblages usually develop should not hamper the study of the effects of all these disturbances.

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CONSERVATION OF CORALLIGENOUS REEFS: EFFECTIVE LARVAL DISPERSAL, SCALES OF CONNECTIVITY AND RESILIENCE

ABSTRACT

Most coastal coralligenous habitats are under threat and abundance of many species has been reduced to a level, which is critical for their persistence. Moreover, biological studies have shown that larvae of coralligenous species often disperse only over short distances. Such limited dispersal of larvae suggests that gene flow is often limited; accordingly, connectivity among coralligenous outcrops and their recovery ability are limited. Up to now only few experimental studies have investigated patterns of connectivity among populations in coralligenous reefs, despite the relevant implication of connectivity for conservation. We provide a review of population genetic studies on coralligenous species, showing that larval dispersal is often limited to few tens of meters, supporting the hypothesis of limited effective dispersal of the larvae. The occurrence of isolated breeding units and differences in genetic diversity among samples at scales of tens of meters suggest that strategies for conservation and restoration of coralligenous species and habitats should include a range a scales form the local or finer to the regional.

KEY-WORDS: coralligenous, larval dispersal, genetic structuring, spatial scales, conservation

INTRODUCTION

In the past decades a dramatic increase of human-induced disturbance (e.g. habitat loss and fragmentation, global environmental change, overexploitation and other effects due to fishing, pollution and tourism) occurred in marine coastal habitats (Airoldi & Beck, 2007). Owing primarily to this disturbance, coastal coralligenous habitats have suffered long-term degradation affecting both species and genetic diversities (Palumbi, 2004; Ballesteros, 2006). Sustainable exploitation and conservation of marine species are among the priorities of modern bio-resource management. In this context, estimating connectivity among populations is essential since dispersal is a key element warranting population resilience following disturbance (Palumbi, 2004). Size and interconnectivity of genetic breeding units are important parameters to identify for conservation strategies, since small and isolated populations are vulnerable to inbreeding depression, which might reduce their evolutionary potential and increase their risk of extinction (Saccheri *et al.*, 1998). In marine systems, there is an apparent lack of physical barriers, opportunities for moderate to high gene flow is expected to be the rule also in species with sessile adult stage, relying on larval and/or gamete transport in the water column for their dispersal. Nevertheless, biological studies have shown that larvae of marine species often disperse only over short distances (Uriz *et al.*, 1998; Goffredo & Zaccanti, 2004). Moreover, effective larval dispersal can be affected by physical barriers, lack of suitable habitats for settlement, larval viability and stochasticity of reproductive success. These factors, either singly or in combination, appear crucial in determining the spatial scales of genetic structuring in marine invertebrates. Despite the relevant implication of connectivity patterns for conservation, only limited experimental evidences are available on patterns of gene flow in coralligenous species. Here, we summarize the most recent literature (2001-2008) on genetic structuring in coralligenous sessile invertebrates, to identify 1) what are the investigated spatial scales and 2) if there are recurrent patterns of larval dispersal and scales of genetic structuring. Moreover, we reveal gaps in the data and how to address these gaps. We also discuss the implications of these findings for sustainable management and conservation of coralligenous assemblages.

MATERIALS AND METHODS

International literature from 2001 to 2008 on genetic variation and population structure of marine sessile invertebrates in the Mediterranean Sea has been surveyed (sources: Web of Science Data Base, and special focus on Molecular Ecology, Marine Biology and Marine Ecology Progress Series). For each publication, the taxa analysed, the sampling area considered, and the molecular markers used have been recoded. The collected literature has been divided in three major groups, based on the magnitude of the spatial scale analysed. Many papers used the large scale phylogeographic approach, while only three papers focused on genetic structuring at very fine spatial scales. Spatial scales analysed in each study have been ranked in three groups: regional scale (hundreds of kilometres), local scale (tens of kilometres) and small scale (tens of meters and less). To understand what the relevant scales of genetic structuring are, occurrence of isolated breeding units has been tested by comparing the observed F_{IS} values. Moreover, in each species the genetic divergence among samples (significance of the F_{ST} estimator) at the smallest analysed spatial scale have been compared to obtain estimates of the scales of effective larval dispersal.

RESULTS

Despite the relevant implication of connectivity for conservation, between 2001 and 2008 only 24 papers addressing this topic on coralligenous have been published. The 24 papers refer to 14 species typical of the coralligenous assemblages (Tab. 1). The data set refers to 6 major taxonomic groups: Porifera, Cnidaria, Crustacea, Ophiuroidea, Echinoidea, Tunicata. The most studied taxa are the Tunicata, with six species analyzed, and Cnidaria with four species analysed (Tab. 1).

Tab. 1: List of the coralligenous species considered in this study, with inference on potential dispersal, spatial scales investigated in the paper, genetic markers used and reference to the publication. Spatial scales are referred as regional - hundred of kilometres; local - tens of kilometres; small - tens of meters and less.

Species	Dispersal potential	Spatial scale	Genetic marker	References
Porifera				
Crambe crambe	low	regional	micro	Duran *et al.* (2004a)
Crambe crambe	low	regional	ITS	Duran *et al.* (2004b)
Crambe crambe	low	regional	mtDNA	Duran *et al.* (2004c)
Crambe crambe	low	small	micro	Calderon *et al.* (2007)
Cnidaria				
Corallium rubrum	low	small, local	micro	Costantini *et al.* (2007a)
Corallium rubrum	low	regional	micro/ITS	Costantini *et al.* (2007b)
Corallium rubrum	low	local	mtDNA	Calderon *et al.* (2006)
Eunicella sp.	low	local	mtDNA/ITS	Calderon *et al.* (2006)
Paramuricea clavata	low	local	mtDNA	Calderon *et al.* (2006)
Balanophyllia europaea	low	local, regional	allozyme	Goffredo *et al.* (2004)
Crustacea				
Hemimysis margalefi	low	local, regional	mtDNA	Lejeusne & Chevaldonne (2006)
Ophiuroidea				
Amphipholis squamata	low	small	mtDNA	Le Gac *et al.* (2004)
Amphipholis squamata	low	local	mtDNA/introns/micro	Boissin *et al.* (2008a)
Amphipholis squamata	low	small	micro	Boissin *et al.* (2008b)
Echinoidea				
Paracentrotus lividus	high	local	mtDNA/ITS	Iuri *et al.* (2007)
Paracentrotus lividus	high	regional	mtDNA/ANT	Calderon *et al.* (2008)
Paracentrotus lividus	high	regional	mtDNA	Duran *et al.* (2004d)

Tunicata				
Cystodytes dellechiajei	low	regional	mtDNA	Lopez-Legentil & Turon (2006)
Pseudodistoma crucigaster	low	regional	mtDNA	Tarjuelo *et al. (*2004)
Clavelina lepadiformis	low	regional	mtDNA	Tarjuelo *et al. (*2001)
Botryllus schlosseri	low	small	micro	Paz *et al.* (2003)
Botryllus schlosseri	low	local	mtDNA	Lopez-Legentil *et al.* (2006)
Microcosmus squamiger	low	regional	mtDNA	Rius *et al.* (2008)
Pycnoclavella communis	low	local	mtDNA/micro	Perez-Portela & Turon (2008)

In the other taxa only one species per taxon has been studied. Five species out of the 14 (C*rambe crambe, Corallium rubrum, Amphipholis squamata*, *Paracentrotus lividus* and *Botryllus schlosseri*) have been analysed by several authors including different spatial scales and using molecular markers with different levels of polymorphism. Six authors have used a combination of two or three markers: mitochondrial DNA sequencing and microsatellite loci or sequencing of nuclear and mitochondrial DNA. One authors have used allozyme markers (Goffredo *et al.,* 2004). Four species (*C. crambe, C. rubrum*, *A. squamata, B. schlosseri)* have been analysed at the small spatial scale (tens of meters) using microsatellite loci.

Despite all the investigated species have a wide geographic distribution in the Mediterranean Sea, most of the investigated populations are located along the North Western Mediterranean coast of France, Spain and Italy. *C. rubrum*, *B. elegans* and *H. margalefi* have been sampled also along the Adriatic coast of Croatia, *P. lividus* has been sampled in Greece and *C. dellechiajei* in Tunis. Paz *et al.* (2003) are the only authors that have worked on *B. schlosseri* along the Israel coast (Fig. 1).

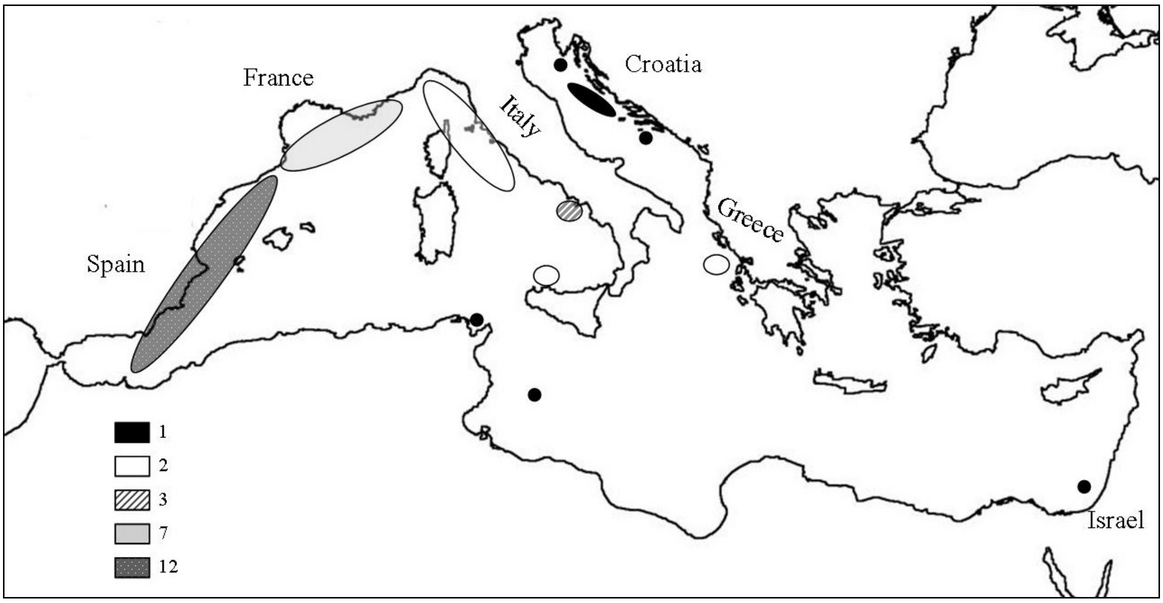

Fig. 1: Location of the areas where the genetic studies have been done in the Mediterranean Sea. The colour refers to the number of species sampled in the area (see the legend in the figure). The size of the ovals is an approximation of the number of population sampled.

Among the investigated species, *P. lividus* present a high gene flow at Mediterranean scale, as shown by different molecular marker varying in their level of polymorphism (Iuri *et al.* 2007; Calderon *et al.* 2007; Duran *et al.* 2004). Rius *et al.* (2008) found no genetic structuring among Mediterranean samples of *M. squamiger* using mitochondrial DNA. Similarly, Lopez-Legentil & Turon (2006) have found a genetic structuring at scale of hundreds kilometres in *C. dellechiajei*. Spatial structuring in the gorgonians *Eunicella sp.* and *P. clavata* have not been investigated in detail due to the low resolution of the mitochondrial DNA in Cnidaria, that makes this markers unsuitable for population genetic studies (Costantini *et al*,. 2003, Calderon *et al.*, 2006). In this study recurrent spatial patterns of genetic structuring in coralligenous species have been analysed to infer on their effective larval dispersal. *C. crambe, C. rubrum, B. elegans, A. squamata, B. schlosseri* and *P. communis* showed significant deviations from genotype frequencies expected under Hardy-Weinberg equilibrium. Multilocus estimates of F_{IS} were all positive, showing heterozygote deficiencies in all these species. Estimated scales of genetic dispersal in species showing genetic structuring are reported in Fig. 2. *C. crambe* showed the most fine-scale genetic structure at distances of tens of centimetres. Alike *A. squamata,* showing significant genetic structuring within one-meter distances. *C. rubrum* and *B. schlosseri* showed significant levels of genetic differentiation at spatial scales of 10s of metres. The crustacean *H. margalefi,* the cnidarian *B. elegans* and three tunicata (*P. communis, P. crucigaster* and *C. lepadiformis*) showed significant genetic structuring at scale of tens of kilometres (Fig. 2).

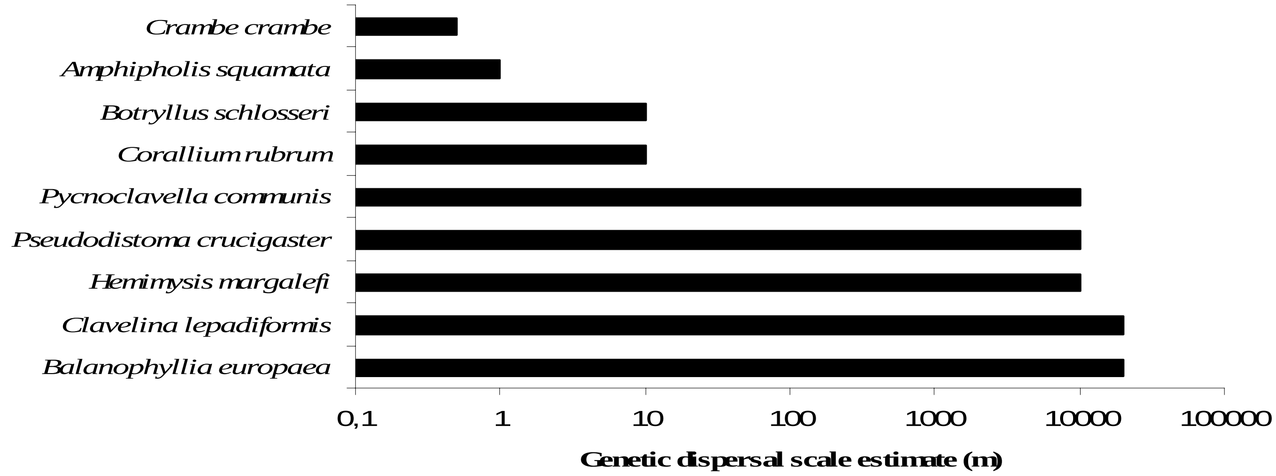

Fig. 2: Estimates of larval dispersal in 9 coralligenous species based on spatial scale of genetic structuring. Only species showing significant genetic structuring within 20 km have been included (see text for explanation).

DISCUSSION AND CONCLUSIONS

The present study showed that, despite the relevant implication of connectivity for conservation (Palumbi, 2004), only few studies have addressed patterns of spatial genetic structuring in Mediterranean coralligenous species. Not all the ecologically relevant taxonomic groups characterising the coralligenous assemblages are represented. No studies on genetic structure were found for same of the most abundant and relevant bio-constructors of the coralligenous reefs, e.g. macroalgae, polychaetes, and bryozoans (Ballesteros, 2006). This scarcity of work could be due to the technical diving constrains in working in deep marine subtidal environment. Moreover, it could happen that species that are the easiest to sample are the most difficult to analyse using molecular methods (Selkoe *et al.*, 2008). Some of the analysed species have a commercial value, such as *Corallium rubrum*, *Crambe crambe* or *Paracentrotus lividus,* while all are ecologically valuable, such as ascidians that are an important component of the fouling assemblages and indicators of the water quality (Tarjuelo *et al.,* 2001). Despite the broad Mediterranean distribution of the coralligenous assemblages and the complexity of the fragmentation patterns of these bioconstructors, in most investigated species very low dispersal capability of larvae and gametes has been detected. In six species significant deviation from Hardy-Weinberg equilibrium was observed, as a deficit of heterozygosity. Deficits of heterozygotes have frequently been observed in marine invertebrates (Addison & Hart 2004 for a review) and may be the result of biological factors, e.g. mixing of differentiated gene pools (Wahlund effect) and high levels of consanguineous mating (inbreeding). In coralligenous species the heterozygosity deficits may reflect the life history traits, the reproductive features (gonochorism *vs* hermaphroditism), restricted (e.g. *C. rubrum*, Costantini *et al.*, 2007; *C. crambe,* Duran *et al.,* 2004) or null larval dispersal (e.g. *A. squamata,* Boissin *et al.*, 2008b). However, seven species showed a genetic structuring at scales of tens of kilometres, suggesting that the spatial scales of connectivity may vary considerably among coralligenous species, and that dispersal range up to few kilometres may be common (Palumbi, 2004). Strong patterns of genetic divergence observed over the north western Mediterranean Sea mainly result from the interaction between the biological characteristic of the species (Duran *et al*., 2004a, b; Costantini *et al*., 2007) and hydrodynamic and geomorphologic characteristics of this basin (Lejeusne & Chevaldonné 2006). These results, together with studies on demography and reproductive structure have important consequences for coralligenous species resilience. Indeed, an increase of natural and anthropogenic mortality, such as harvesting, trawling or water temperature anomalies (Cerrano *et al*., 2000), could lead to deep changes in the specific composition and structure of coralligenous communities (Ballesteros 2006). The major lacks found in the reviewed studies are related to the low number of sampling sites and to their limited geographic distribution along the Mediterranean coasts. Despite the broad geographic distribution of all the investigated species, mainly populations from the north western Mediterranean coasts have been analysed, with the only exception of sporadic samples collected in Croatia, Tunis and Greece. The scarcity of sampling efforts along the Southern and Eastern Mediterranean coasts suggest the need to develop effective collaborations among all the courtiers facing the Mediterranean Sea, and to overcome the difficulties in planning sampling trips. Filling these gaps should be among the priorities of the Coralligenous scientific community, and international initiatives promoting collaboration could greatly contribute to this aim (e.g. RAC/SPA meeting on coralligenous and bio-concretions). Establishing a Mediterranean network between people working on different aspects of the ecology of coralligenous species would be also beneficial. The occurrence of structured breeding units and genetically differentiated populations at scale of kilometres or less suggest that strategies for sustainable management and conservation of coralligenous assemblages should be defined at a local or finer scale. Moreover, these results provide a starting point for future studies to gather data providing a clearer picture of larval dispersal in coralligenous species at a range a scales, form the local to the Mediterranean.

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SPATIAL AND TEMPORAL VARIATION OF ASSEMBLAGES IN MEDITERRANEAN CORALLIGENOUS REEFS

ABSTRACT

The structure, distribution and temporal changes of epibenthic assemblages of Mediterranean coralligenous reef in the Ligurian and Adriatic Sea were investigated by using a multifactorial sampling design. The distribution of taxa were analysed at scales ranging form hundred of meters to tens of kilometres. Temporal variations were analysed among different years. Percentage cover of conspicuous species have been analysed by means of photographic sampling. Strong spatial patterns of taxa distribution were found among coralligenous outcrops in the Adriatic, while in the Ligurian Sea a strong small scale pattern related to habitat orientation was found. There was some temporal fluctuation in abundance of taxa, but no clear patterns were observed. These results suggest that coralligenous assemblages are a patchy habitat where changes in species composition and abundance can occur at a range of spatial scales, down to few meters, moreover, validate the assumption of the limited temporal variability in Mediterranean coralligenous reefs, possibly related to the slow growth rates of the most abundant taxa and the reduced seasonality of physical conditions.

KEY-WORDS: coralligenous reefs, spatial patterns, temporal variation, Northern Adriatic Sea, Ligurian Sea.

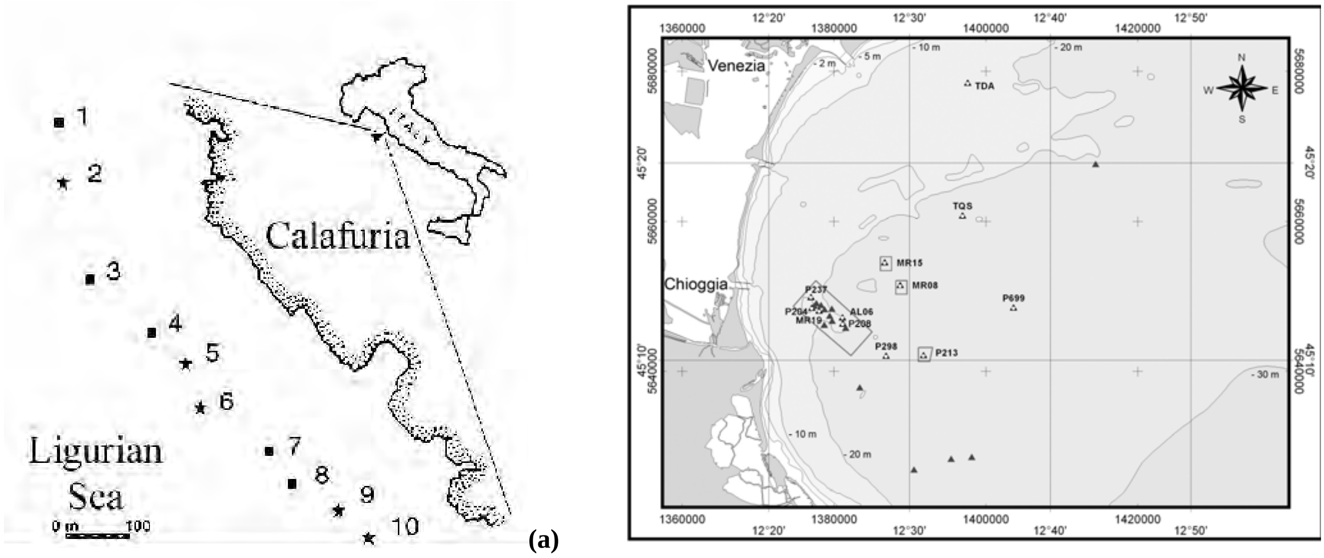
INTRODUCTION

The Mediterranean Sea has been recognised as a hot-spot for marine biodiversity (Bianchi & Morri, 2000). Several Mediterranean habitats and ecosystems, including the coralligenous subtidal biogenic rocky reefs, are unique, extremely reach in species and complex in structure. Biogenic subtidal rocky bottoms also include some of the most economically valuable assemblages of the world (UNEP, 1995). These habitats play a relevant role in terms of carbonate production in the marine coastal environment. Moreover, they host a number of species that have been extensively exploited since very long time (e.g. red coral), and are playing a key nursery role for commercially valuable fish species (sea bas, sea breams, various grouper species, etc.). however, only minor shifts have been observed among seasons. As most coastal habitats (Airoldi & Beck, 2007) coralligenous reefs (Ballestreros, 2006) are impacted by human activities and disturbances. Important causes of threats to coralligenous habitats are represented by harvesting and fishing activities, particularly trawling and the highly destructive ‘St. Andrew Cross’, used to harvest precious red coral and sponge, which can physically destroy the biogenic structures and alter the quality of the surrounding water masses by increasing turbidity and sediment deposition rates. The state of the knowledge on coralligenuos reefs has been provided in a recent review (Ballestreros, 2006). From the analyses clearly emerged that these reefs are intrinsically valuable for their biological diversity and for the ecological processes that they are supporting. Since the ’60 a bulk of data on species composition of the assemblages dwelling on these biogenic reefs has been collected, while much limited is the knowledge on scales and patterns of species distributions and on their trends of seasonal/temporal variability. The need to quantify patterns of variability in benthic assemblages at a range of spatial and temporal scales is nowadays generally accepted (e.g. Fraschetti *et al.*, 2001; Benedetti-Cecchi *et al.*, 2003). Understanding of natural patterns of distribution is a crucial basic need for any conservation or management initiatives. Drivers of species diversity patterns change with the spatial scales considered, going from species interactions and substrata morphology at the small scale, to changes in species pools and oceanography features at the regional scale. Indeed, for long time coralligenous reefs have been associated to the idea of stability in space and time due to the slow growth rate of the reef building species, as well as to the relatively steady environmental conditions associated with the deeper rocky subtidal. A few quantitative studies have recently investigated patterns of spatial distribution and temporal changes (Garrabou *et al.*, 1998; Ferdeghini *et al.*, 2000; Piazzi *et al.*, 2002; Balata *et al.*, 2005; Garrabou *et al.*, 2002; Balata *et al.*, 2006; Virgilio *et al.*, 2006; Ponti *et al.*, 2007). These studies revealed an unexpected complexity in pattern of spatial variation, with most of the variation at the smallest investigated scales, while at the scale of habitats; assemblages appeared to be more homogeneous. Similarly, temporal dynamics of the whole assemblages have been only rarely investigated. Same seasonal patterns of single or groups of algal and animal species have been described,

In the present study we compare species assemblages in two different types of coralligenous habitats: Ligurian rocky cliffs and Adriatic bottom outcrops. In each region structured multi-scale sampling designs have been used to detect shifts and patterns in species distributions. Moreover, in both regions observed patterns of variability have been compared in time over several years.

MATERIALS AND METHODS

The researches were carried out in the Ligurian Sea and the northern Adriatic Sea. In the Ligurian Sea the study location was a wave-exposed reef, south of Livorno, Italy (Ligurian Sea, 43°30'N, 10°20'E, locality Calafuria). The general environmental characteristics of the study area are described in Piazzi et al. (2002), and the references therein. The sea-bottom consists of a gently sloping sandstone platform extending 200–300 m from the coastline to a depth of about 20 m. The platform is dominated by turf-forming seaweeds (Airoldi & Virgilio, 1998) and is characterised by high rates of sediment deposition and movement (Airoldi *et al.*, 1996). At the platform edge, there is a steep cliff, with the depth dropping from 20 m to about 45 m. For over 10 km in length, the cliff consists of nearly vertical walls scattered with crevices and overhangs, which host a rich coralligenous assemblage. The area is a popular site for scuba divers and commercial fishermen of *Corallium rubrum* (Santangelo & Abbiati, 2001). Epibenthic assemblages on ten randomly selected sampling sites hundreds of metres apart along 2 km of the reef were investigated. Samples have been collected both on vertical and down-facing surfaces of crevices and overhang, at 25 m approximate depth. Sampling was done in two periods 1) April 1995 to March 1996 (hereafter 1995–1996) and 2) April 1997 to March 1998 (hereafter 1997–1998); 4 four sampling dates where randomly extracted for each period (Fig.1a) and 9 replicated samples have been collected in combination sampling date per site.



(a)

(b)

Fig. 1: Maps of the study sites: a) ten sampling sites along the Tyrrhenian coast; b) twelve investigated outcrops scattered in the Northern Adriatic Sea.

In the northern Adriatic Sea the study area covers approximately 500 km^2 of the continental shelf offshore Chioggia and Venice (Lat. 45° 24' - 45° 04' N; Lon. 12° 23' - 12° 43' E). In the area numerous coralligenous rocky outcrops 1 to 4 meters high emerge form a silty/sandy bottom, between 10 and 40 m in depth. These rocky outcrops, ranging in size from few to several thousands of square metres, are biogenic reef made predominantly by calcareous algae and characterized by very diverse epibenthic assemblages. Epibenthic assemblages have been quantitatively studied on twelve randomly selected outcrops, at a depth ranging between 19.4 and 27.0 m and a distance from the coast ranging between 6.6 and 23.9 km. From 2003 until 2006, on each outcrop, 10 replicated samples have been collected during annual field trips in month of August (Fig. 1b).

In both regions sampling was done using a non-destructive photographic method (Roberts *et al.*, 1994). Underwater images have been collected using a frame of 0,04 m^2. Images have been analysed by projecting them on a grid of 100 quadrates to estimate the relative percentage cover of the most abundant taxa using the visual method (Benedetti-Cecchi *et al.*, 1996). Taxa were identified to the lowest possible taxonomic level. During sampling voucher specimens were collected to help identification. The filamentous turf-forming seaweeds (mainly red seaweeds belonging to the order Ceramiales), that could not be consistently identified from the photographs, were grouped as "algal turf"' (Airoldi & Virgilio, 1998).

Multivariate procedures were used to analyse the spatial and temporal variability in the distribution of taxa. The data were fourth-root transformed, in order to reduce differences in scale among variables, while preserving information about the relative abundance of taxa among replicates. Non-metric multi-dimensional scaling (MDS) and clustering techniques were used to produce an ordination replicates.

RESULTS

Epibenthic assemblages developing on the Tyrrhenian coralligenous reefs were characterised by 18 conspicuous taxa that could be identified. These included turf-forming seaweeds, three prostrate seaweeds, nine sponges, the cnidarian *C. rubrum*, and four bryozoans. Three were the most abundant taxa: turf-forming algae, *Peyssonnelia rubra*, and *Corallium rubrum*. The remaining 15 taxa identified, showed relatively low average percentage cover, ranging from <0.1 to 5.5% on vertical surfaces and from 0.3 to 2.6% on down-facing surfaces. All taxa were found on both vertical and down-facing surfaces, but were generally abundant at one orientation only. Clear differences between assemblages living on vertical and down-facing surfaces were observed (Fig. 2). In particular, seaweeds were most abundant on vertical surfaces, with turf-forming seaweeds and *P. rubra* as the dominating taxa, while invertebrates were generally most abundant on down-facing surfaces.

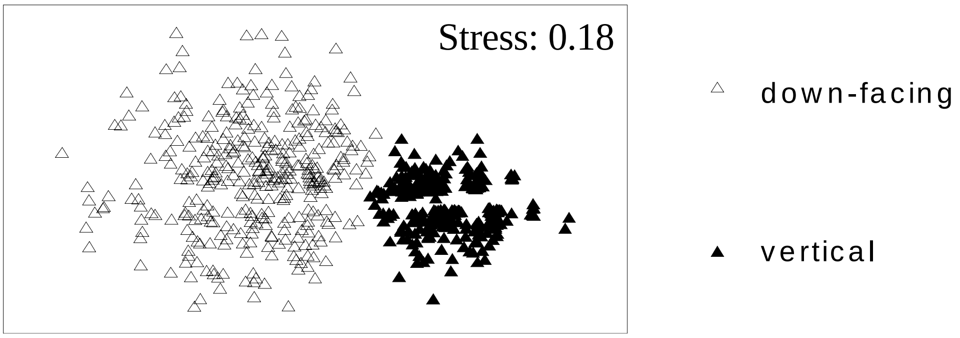


Fig. 2: Non-metric multidimensional scaling ordination of assemblages developing on down-facing (white triangles) and vertical surfaces (black triangles) in the Tyrrhenian Sea. Ordinations were based on the rank orders of similarities among replicate plots (n = 720) sampled at 10 sites (5 sites sampled on vertical surfaces and 5 sites on down-facing surfaces) at 8 times (from 1995 to 1998). The matrix of similarities between each pair of replicate plots was based on the Bray-Curtis similarities after 4th root transformation.

Significant differences in multivariate patterns of distribution of taxa between orientations and periods were found. The significant interaction of these factors suggested that temporal variations were not consistent between vertical and down-facing surfaces (Fig. 3). Furthermore, the significant interaction of time and site showed that the short-term temporal fluctuations varied from site to site.

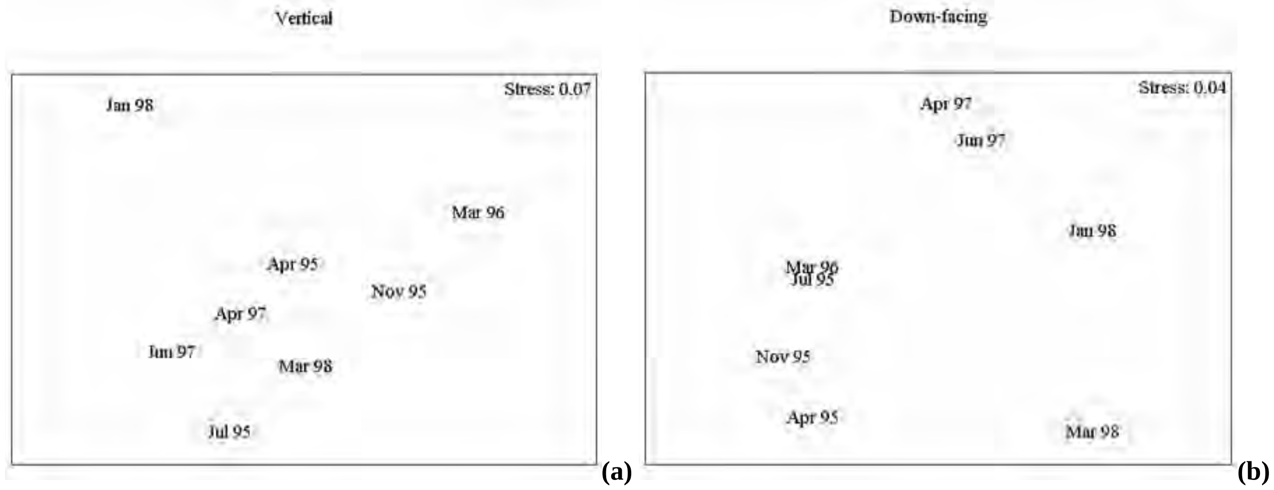


Fig. 3: Non-metric multidimensional scaling ordination of assemblages developing on (a) down-facing and (b) vertical surfaces in the Tyrrhenian Sea. At each orientation, data from April 1995 to March 1998 were averaged across plots in order to obtain a centroid for each of the 8 sampling times (from 1995 to 1998). The matrix of similarities between each pair of centroids was based on the Bray-Curtis similarities after 4th root transformation.

Epibenthic assemblages developing on the northern Adriatic coralligenous outcrops were characterised by the abundance of algal taxa accounting for about 56% of the total cover (algal turf, calcareous algae: mainly *Lithophyllum stictaeforme*, *Lithothamnion minervae*, *Peyssonnelia polymorpha*). Sponge were the most abundant animal taxa (encrusting: e.g. *Dictyonella incisa* and *Antho incostans*; massive and tubular: e.g. *Geodia cydonium*, *Ircinia variabilis*, *Dysidea avara*, *Chondrosia reniformis*, *Tedania anhelans*, *Ulosa stuposa*, *Axinella damicornis*, *Axinella polypoides*, *Aplysina aerophoba*; boring: e.g. *Cliona* spp), together with anthozoans (*Cereus pedunculatus*, *Cornularia cornucopiae*, *Epizoanthus* spp., *Parazoanthus axinellae*) and colonial ascidians (e.g. *Polycitor adriaticus*, *Aplidium conicum* and *A. tabarquesins*) (Fig. 4).

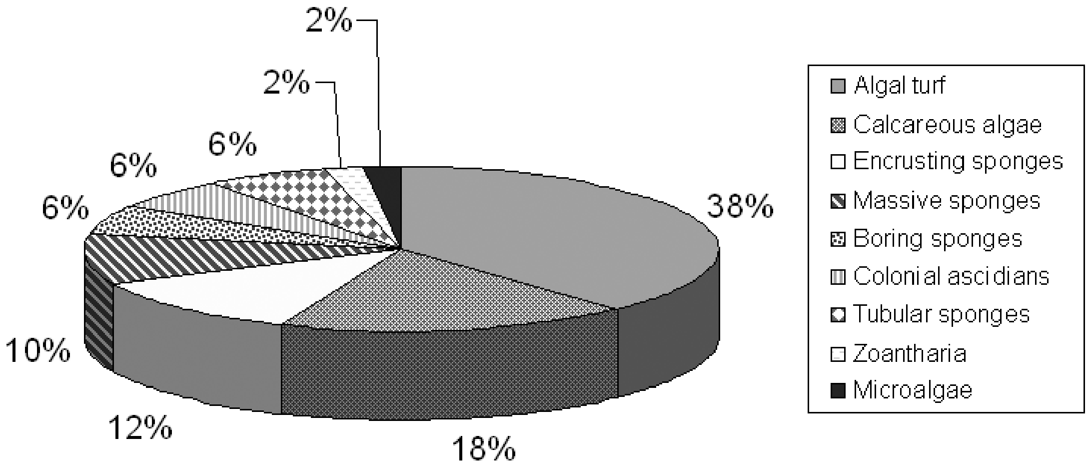


Fig. 4: Relative mean abundance of the main ecological and taxonomical groups developing on the northern Adriatic outcrops.

The species showed a complex distribution patterns. Spatial variation overcame temporal changes in the structure of the assemblages. The cluster analysis clearly separated the epibenthic assemblages in three main spatial groups. These spatial groups of outcrops were persistent in time form 2003 to 2006 (Fig. 5). Species composition of the assemblages characterising the biogenic outcrops in different areas was consistent in time. Observed temporal variation was mostly related to changes in the relative abundance of the most common taxa, rather then to changes in species composition. Variation of assemblages among the areas appeared strongly correlated with the morphological features and geographical location of the outcrops, while hydrological conditions that changed over time seem to be less relevant.

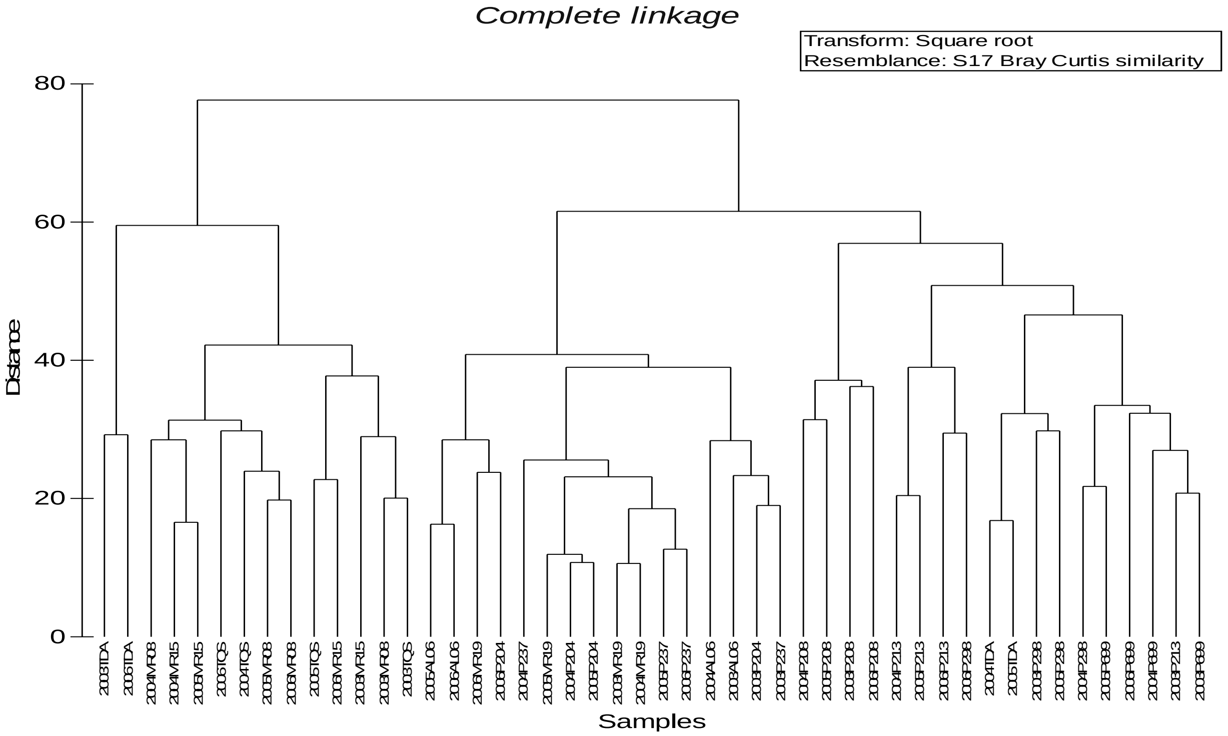


Fig. 5: Cluster analysis of assemblages developing on northern Adriatic coralligenous outcrops. The matrix of similarities between each pair of centroids was based on the Bray-Curtis similarities after 4th root transformation.

DISCUSSION AND CONCLUSIONS

The two types of coralligenous reef that have been investigated (Calafuria, Ligurian Sea, and tegnue, Northern Adriatic Sea) differ in both composition and relative abundances of taxa. Moreover, they noticeably differ also from coralligenous reefs described in other Mediterranean areas (Ros *et al.* 1985; Garrabou *et al.* 1998; Ferdeghini *et al.* 2000). The reef at Calafuria is characterised by high densities of algal turfs, *Peyssonnelia rubra* and *C. rubrum*, while Nothern Adriatic reefs host a very rich and variable assemblage of turf-forming and calcareous algae, sponges and colonial ascidians. Low abundances of calcareous sponges and bryozoans were found in both reefs. These results support the model proposed by Sarà (1969), suggesting that the Mediterranean coralligenous reefs may encompass a number of markedly different biogenic formations.

Scales of spatial structuring of the assemblages differed between the two sites. In Calafuria a very strong gradient of small-scale differentiation was found in relation to the orientation of the substratum, leading to a shift in the abundance of the most common species. In the Northern Adriatic shifts in species composition and in most abundant taxa were found among outcrops in relation to the distance form the coast and to the depth gradient.

Concerning patterns of temporal variation, within Calafuria reefs some fluctuations in the abundance of taxa at both the temporal scales investigated (between- and within-periods) were found. Differences between the orientations were striking and consistent over time, and the assemblages on down-facing surfaces were more heterogeneous than those on vertical surfaces. Some short-term temporal variations (within-periods) arise, but these changes were not consistent across sites and did not suggest the occurrence of clear trends. Temporal variation in the Northern Adriatic outcrops was limited, mainly related to inter-annual fluctuations in abundance of taxa, but no obvious patterns were observed. These results support the model of limited temporal variability in Mediterranean coralligenous reefs, possibly related to the slow growth rates of the most abundant taxa and the reduced seasonality of physical conditions. However, further studies analysing patterns of spatial and temporal variation in coralligenous biogenic reefs are needed to develop a general model for the dynamics of these valuable habitats.

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ANALYSIS ON THE CORALLIGENOUS ASSEMBLAGES IN THE MEDITERRANEAN SEA: A REVIEW OF THE CURRENT STATE OF KNOWLEDGE IN SUPPORT OF FUTURE INVESTIGATIONS

ABSTRACT

The present contribution synthesises the results of a process of review of the scientific publications available on the Mediterranean coralligenous assemblages to give quantitative information about their number per specific thematic category and Mediterranean sub-region. This analysis was conducted in the framework of a specific RAC/SPA project, conceived to support the UNEP/MAP "Action Plan for the protection of the coralligenous and other calcareous bio-concretions in the Mediterranean". In particular the project's activities were devoted to the creation of a specific GIS layer hosting all the available scientific cartographies. More than 500 scientific articles on this subject were screened and classified according to the geographical distribution and to the thematic category of investigation. The studies supplying geo-referred maps, functional to the creation of a specific GIS layer for the Mediterranean, were only 5 %. Considering the location of the studied sites, the western Mediterranean results to be the most widely studied sub-region with a higher contribution deriving from Italy, France and Spain. Ecological and conservation aspects result to be the most studied themes, followed by taxonomy and age and growth, while very few studies were found on biological features. The present work allows to identify the thematic and geographic areas needing more research efforts in the next future. The study stresses the urgent need to plan cartographic initiatives for understudied areas such as the North African Mediterranean and Aegean-Levantine waters.

KEY-WORDS: coralligenous assemblages; bibliographic review; geographic distribution; Mediterranean

INTRODUCTION

Mediterranean coralligenous assemblages and several other biogenic calcareous formations are considered Mediterranean benthic habitats of high conservation value and needing protection given their exposure to several man-made threats (Ballesteros, 2006). Over the course of the last decades, various EC and international instruments have identified special protection measures to protect such assemblages whether it is through the establishment of marine protected/conservation areas or through the banning of specific fishing gears. The protection of a specific habitat type cannot however, be put in place without the enforcement of specific control and monitoring plans.

Among the numerous initiatives, formulated during the last decade within the framework of the United Nations Environment Programme Mediterranean Action Plan (UNEP-MAP-RAC/SPA), the recently approved "Action Plan for the Protection of the Coralligenous and other Calcareous Bio-concretions in the Mediterranean" (UNEP, 2007) highlights the need to conduct specific conservation activities on the coralligenous habitats intended as the coralline algal frameworks that grow in dim light conditions and in relatively calm waters (Ballesteros, 2006). The Action Plan includes the various facies and associations of the coralligenous biocoenosis as well as maërl beds, which represent calcareous formations thriving in the same or similar light conditions as the coralligenous assemblages. Amongst its priority actions, the Action Plan identifies the need to compile all existing information at all levels and scales on the distribution of coralligenous assemblages and maërl beds in the Mediterranean Sea.

The present contribution synthesizes part of the activities conducted, within the framework of a RAC SPA – ICRAM project, on coralligenous habitats and other calcareous bioconcretions in the Mediterranean, as defined by the above mentioned Action Plan. The objective of this project consisted in carrying out a Mediterranean census of the bibliographic and cartographic information of such habitats and the creation of a specific Geographical Information System (GIS) containing all the available cartographic data on such assemblages with the aim of identifying their distribution on a regional scale. The results of the bibliographical census and a review of the contents of the available literature and cartographies are hereby presented.

MATERIALS AND METHODS

Data collection

The bibliographic search was performed by consulting the ASFA (Aquatic Sciences and Fisheries Abstracts) database, containing scientific publications since 1971, and the CASPUR (*Consorzio Interuniversitario per le Applicazioni di Supercalcolo Per Università e Ricerca*) service, which lists a large number of the marine biological journals edited by the principal scientific publishing houses. A search was also carried out with the internet research motors (Google and Google scholar) so as to collect any "grey literature" missing from the main scientific bibliographic databases. The bibliographic search was performed using a trilingual (Italian, English and French) approach consisting in a list of keywords and taxa. The list of documents collected through the bibliographic search was then integrated with that produced by Ballesteros (2006) and Giaccone (2007) and one which is contained within a previously existing RAC/SPA database. Members of the coralligenous working group of the *Società Italiana di Biologia Marina* (SIBM) and scientists of the International Commission for the Scientific Exploration of the Mediterranean (CIESM) as well as the network of managers of Marine Protected Areas in the Mediterranean (MedPAN) were also contacted to census and collect pertinent bibliographic and cartographic data.

Data analysis

The studies contained in the bibliographic documents were analysed so as to identify the location of each study area and thereby provide additional information on the distribution of the coralligenous assemblages and bioconcretions. The geographical distribution of the studies was then considered according to Mediterranean sub-regions (western Mediterranean, Adriatic, Ionian, Aegean-Levantine) (Fig. 1) and to country of occurrence. Mediterranean sub-regions were identified on the basis of the three ICES Mediterranean eco-regions (ICES, 2004) with the addition of a fourth region resulting from the split of the Adriatic-Ionian ecoregion which was dictated on the basis of the peculiar oceanographic features of the Adriatic Sea (Cushman-Roisin *et al.*, 2001).

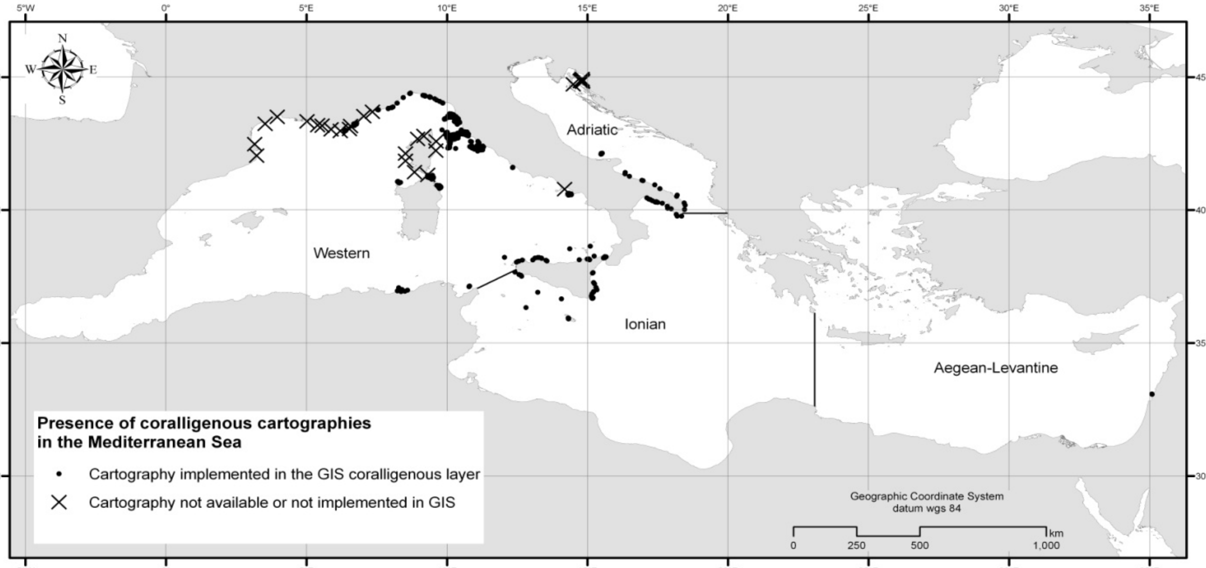

Fig. 1: Distribution of sub-regions and location of the censused coralligenous cartographies in the Mediterranean Sea.

The documents were also analysed in terms of the thematic category on which the study was based so as to allow a better overall understanding of the type of research conducted on such habitat types.

In some cases the thematic category and the location of the investigated area were inferred only by their title, keywords and abstracts.

The following 9 thematic categories (the respective themes attributed to each category appear in parenthesis) were used to classify the documents: Taxonomy (species identification and description, taxonomic revision, nomenclature), Ecology (population dynamics, community structure, species composition and diversity, spatio-temporal variations and distributions, habitat use, feeding behaviour, interspecific relationships, environmental factors, recovery, ecosystem resilience), Distribution (coralligenous species and/or biocoenosis geographical distributions, at various spatial scales, with or without cartography), Physiology and biochemistry (biochemical composition, enzymatic activity, biogeochemical cycle, energy flow, molecular structure, ecophysiology, biological rhythms, biological stress), Genetics (genetic drift, population genetics, racial studies, gene expression; genetic diversity, genetic structure, phylogeny, endemic species, genetic markers, inbreeding, genetic isolation), Threats, management and conservation (Marine Protected Areas, ecosystem disturbance, chemical pollution; ecosystem management; human impact; resource management, overexploitation, extinction), Reproduction (individual recruitment, sexual and asexual reproduction, sex ratio, reproductive cycle, fecundity), Age and growth (colonies and individuals morphology, population growth, age, morphometry).

The total number of studies according to Mediterranean sub-region and country distribution and thematic categories was calculated so as to highlight the distribution pattern of their geographical location and thematic area. The studies' distribution per sub-region and thematic category was also obtained. Furthermore, since the assessment of the assemblages' distribution and their threats, management and conservation are indeed of primary importance in the implementation of the RAC/SPA Action Plan, special attention was placed to identify the country distribution for these two specific thematic categories.

RESULTS

Overall, the bibliographic data set is composed of 522 scientific documents, of which 44 contain cartographic information, that is maps, some of them implementable on the GIS. The distribution of these cartographies is indicated (Fig. 1) Four hundred and one documents (77 %) provided information on the study areas allowing to locate their sub regional (Fig. 2) and country distribution Fig. 3). The western Mediterranean appears to be the most largely studied sub-region, with Italy, Spain and France contributing with the largest number of studies while the Ionian sub-region has been subject to an intermediate number of studies, mostly carried out in Italian waters. Very few studies were censused in the Adriatic and Aegean-Levantine sub-regions. Scientific research in the latter occurs in Greek, Turkish, Cypriot and Israeli waters.

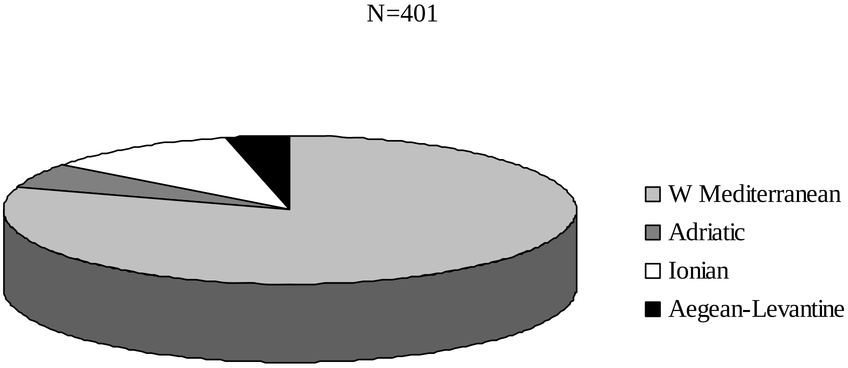

Fig 2: Distribution of studies per sub region. N=total number of studies.

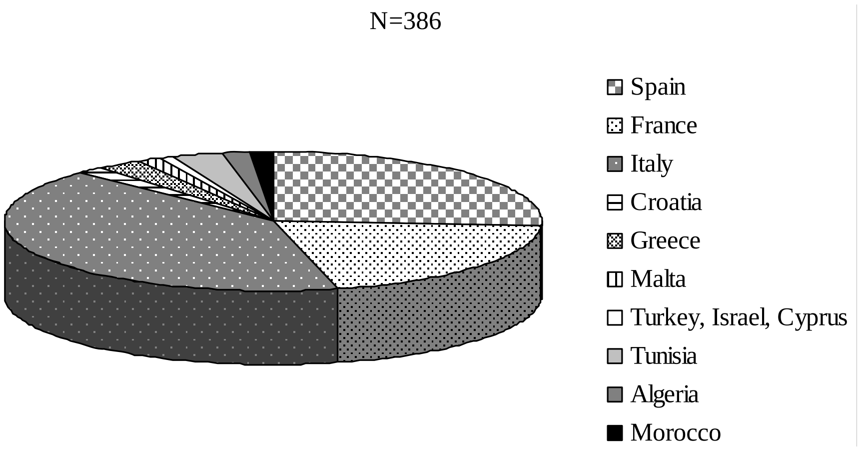

Fig 3: Distribution of studies per country. N=total number of studies.

Figure 4 indicates the quantitative distribution of the studies *per* thematic category and sub-region. When summed up, the number of studies *per* thematic category is higher than that of the whole bibliographic data set due to the multi-disciplinary nature of most studies. The majority of studies focused on ecological themes. Much scientific data was also collected on “Species distribution” and “Threats, management and conservation”. Contributions on “Taxonomy” and “Age and growth” were moderately abundant, whereas little interest was devoted to “Reproduction”, “Physiology and biochemistry” and mostly “Genetics”. It is noteworthy that “Reproduction” and “Genetic” were themes studied only in the western Mediterranean.

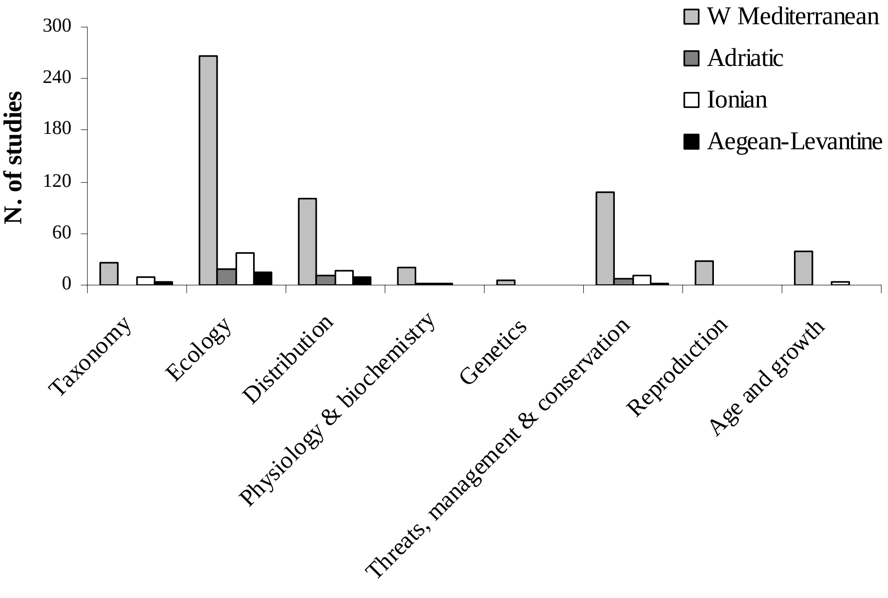

Fig 4: Number of studies per thematic category and sub-region.

Much of work dealing with the coralligenous distribution and its threats, management and conservation, RAC/SPA priority themes, was carried out in Italy, France and Spain and other western Mediterranean countries, such as Tunisia, Algeria and Morocco, whereas almost negligible number of contributions were recorded from the other Mediterranean sub-regions (Fig. 5).

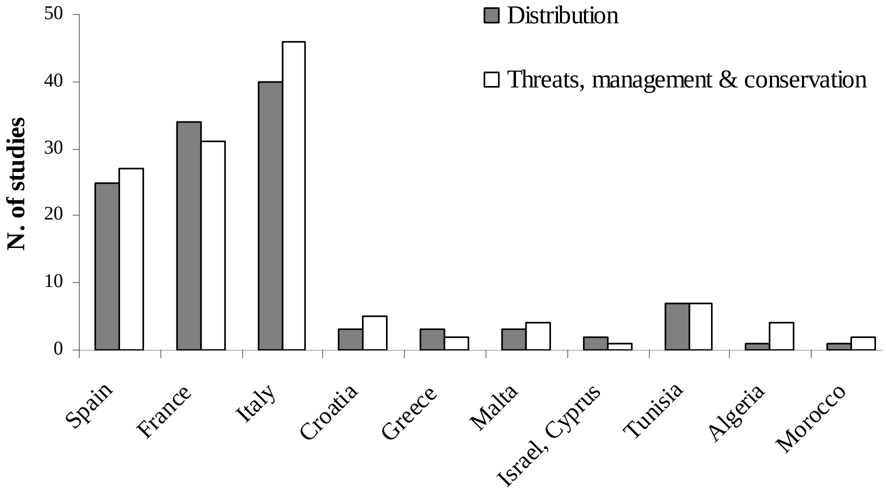

Fig. 5: Number of studies per Country, taking into account the two most studied thematic categories.

DISCUSSION AND CONCLUSION

The presently outlined census indicates that though qualitatively valuable, the collected cartographic data are limited in number and distribution. It is important to point out however, that deficiency of cartographic information for many areas doesn't necessary imply that the coralligenous and other bio-concretions are actually absent. In fact, the absence of cartographic information on the distribution of coralligenous and other bio-concretions can be sometimes partially attributed to other factors than a knowledge gap. Just to give an example several documents containing biocoenotic map are "grey literature" (e.g. technical or final reports, posters, unpublished manuscripts) which are usually not included in the most comprehensive bibliographic databases. This implies that many unpublished documents, edited by researchers operating outside the main Mediterranean scientific networks, are likely to have been excluded from our census and will continue to be so unless a specific Mediterranean reporting system is devised in the future.

Our main bibliographic results demonstrated that, the majority of studies on coralligenous biocoenosis and the other bio-concretions is located along the coasts of western Mediterranean. Despite the high study effort in this sub region the availability of public cartographic data for some countries, like Spain for instance, is surprisingly low. Conversely the bibliographical search allowed to highlight areas where this issue is generally understudied (southern and eastern part of the basin) which is in accordance with the low cartographic data availability. A large study effort gap was in fact, observed on the coralligenous formations of the Aegean-Levantine sub-region, which is unexpected given the known presence and development of these assemblages in the Aegean Sea (Laborel, 1961). The above considerations are in line with what has been illustrated already by Ballesteros (2006). An analysis of the censused bibliographic documents published after 2005, in terms of their distribution in the Mediterranean, shows that the same geographical knowledge gaps are still present.

In addition to providing an idea of the geographical location of the investigated areas, the present work also analysed the ecological value so as to define what areas are of special interest for the presence of these biocoenosis and to plan future cartographic studies. In an analogous way to what was stated above, the distribution of such studies indicates that there is a conspicuous ecological and conservation-linked knowledge gap in the Adriatic, Ionian and Aegean-Levantine sub-regions. Action plan priorities would therefore seem to be best geared at solving this gap by foreseeing specific studies not only on the identification of the presence of these assemblages but also on aspects concerning biological details and threats which can help to identify the most critical conservation measures which need to be enacted.

In light of all of the above, it would seem most advisable to promote specific new research programmes focusing on:

a. The completion of the cartography of the coralligenous assemblages at Mediterranean scale, enhancing in particular the knowledge on their distribution in the less studied areas, to identify areas of particular interest;
b. The conduction of studies on ecological and physiological aspects, considering also specific inventories, along the eastern and the southern Mediterranean coasts as to identify/evaluate the possible presence of differences / trends related to oceanographic aspects;
c. Urgent start-up of monitoring activities in the most relevant sites (SPAMIs, Natura 2000 sites and other MPAs), both to monitor possible changes due to the effects of the management (on waste water discharges, anchoring, fishing, diving) and to evaluate trend in the long term evolution of the assemblages to assess the effects of the global warming (i.e. the deepen of the summer thermocline) and of the invasive species.
d. Stringent start-up of procedures for the future establishment of protected/conservation areas, identified as a consequence of point a) and b) above, capable of mitigating the different threats to which the various assemblages are known to be exposed to.

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PRESENCE OF *CORALLIUM RUBRUM* ON CORALLIGENOUS ASSEMBLAGES BELOW 50 M ALONG CALABRIAN COAST (SOUTH ITALY)

ABSTRACT

The presence of red coral, Corallium rubrum *(Coralliidae, Gorgonacea) was reported during a monitoring study on biodiversity of hard bottom substrata along the coast of Calabria. A total of 52 transects at depths ranging between 50 and 200 m were surveyed by means of a Remotely Operated Vehicle (ROV). The ROV was equipped with a digital camera and with two laser pointers placed 10 cm apart and used as metric scale. We found colonies in 20% of the surveyed areas. Red coral is endemic to the Mediterranean Sea and it is one of the key engineering species of coralligenous assemblages. Due to its high commercial value it has been long overexploited and it is now a protected species. Although mixed-gas diving systems can extend the SCUBA range to slightly more than 100 m, there were very little quantitative information on populations deeper than 50 m. Quantitative data on the spatial distribution and population structure of the red coral along the southern Tyrrhenian and Ionian coasts of Calabria were collected. Colonies have been photographed and filmed. Presence, patch frequency, density, and parameters describing colony morphology were recorded. Red coral was observed between 70 and 130 meters depth. On rare occasions the presence of larger colonies (about 20 cm high) was recorded. More often we found smaller colonies (about 1 - 6 cm high), which showed only rudimentary branching patterns (primary and secondary branches). The presence of some dead colonies was also recorded.* C. rubrum *colonies were generally single or grouped in small patches of 3 – 4 specimens. Only in the southernmost area we found that this species was the dominant component of the coralligenous zone with a maximum density of ~ 90 colonies/m^2.*

KEY-WORDS: *Corallium rubrum,* coralligenous, ROV, Southern Tyrrhenian and Ionian Sea.

INTRODUCTION

Octocorals play an important role in marine ecosystems as they add three dimensional complexity to the habitat and consequently increase biodiversity (Thrush & Dayton, 2002). The Mediterranean red coral (*Corallium rubrum*, L. 1758) is a characteristic gorgonian living in the coralligenous assemblages, even if belonging to the semi dark caves biocoenosis (Ros *et al.;* 1985). It is a sessile cnidarian whose polyps formed arborescent colonies, which can reach a height of 50 cm (Garrabou & Harmelin, 2002). This long-lived species has been commercially harvested (for the use of its red calcium carbonate skeleton in the jewelry industry) since ancient times (Tescione, 1973), and during the last decades it has become evident that it was overexploited (Santangelo & Abbiati, 2001; Cicogna *et al.*, 1999). Due to its commercial and ecological value, the biological information on the species increased noticeably during the last decades, but its ecolological information was still limited (Santangelo & Abbiati, 2001). Although it was well known that red coral was an eurybathic species dwelling between 5 m (within caves) down to 400 m depth (Zibrowius *et al.*, 1984; Chintiroglou & Dounas-Koukouras, 1989), there was little quantitative information on distribution and population structure deeper than 50 m. (Rossi *et al.*, 2008). Few ecological studies of these deep-water environments have been conducted because of the logistical difficulty of working at greater depths (Genin *et al.*, 1992; Spalding *et al*., 2003). Most coral reef science was performed well within the depth limit of recreational scuba diving (Kahng & Kelley, 2007). The recent use of enriched air Nitrox SCUBA to extend sampling time at 50 m and the advent of Remotely Operated Vehicles (ROVs) with high-resolution images and the capability to collect samples, provided an opportunity for controlled sampling in situ and detailed observation of specific deep-water habitats. (Mortensen & Mortensen, 2004; Spalding *et al.*, 2003).

This study was part of a marine biodiversity monitoring project on hard bottom macrozoobenthos in the 50-200 m depth range conducted by ICRAM in the coastal waters of Calabria (South Italy) by means of a ROV. The lack of studies on deeper populations limited our understanding of coral ecology and the possibility of proposing a realistic management plan for harvesting this species (Rossi *et al.*, 2008). Thus the objective of this study was to increase the knowledge on the, distribution and ecology of red coral, giving information about presence, density, and morphometry of red coral colonies below 50 m.

MATERIALS AND METHODS

Twelve sites along Tyrrhenian and Ionian coast of Calabria were investigated by means of ROV during summer 2007 and 2008. A total of 52 ROV transects on hard substrate were realized between 50 and 200 m depth. Data were carried out by a photographic sampling along random transects. Every distinct group of colonies (patch) encountered were photographed by the ROV's digital camera (Nikon D80, 10 megapixel). In the case of patches larger than 1 square meter (visual estimation) more replicates were taken. The number of photos collected was proportional to the number and extension of patches. The photos were processed with Image J software (http://*rsbweb.nih.gov/nih-image*), using as scale reference two red laser dots distant 10 cm apart, to describe colony density and morphometric characters, basal diameter, height width and branching pattern, as described by Tsounis (Tsounis *et al.*, 2006a). Furthermore, the orientation (0°, 45°, 90°, 135°, 180°) of the colonies was recorded following the scheme suggest by Rossi (Rossi *et al.*, 2008) (Fig. 1). This method allowed us to obtain an extensive set of data in a non-destructive way. Although it provided only limited precision, this method was found to be suitable for the scope of this study. The number of colonies with a diameter of more than 7 mm (Tsounis *et al.*, 2006a) was also determined, as well as the number of colonies taller or shorter than 10 cm (Tsounis *et al.*, 2006b).

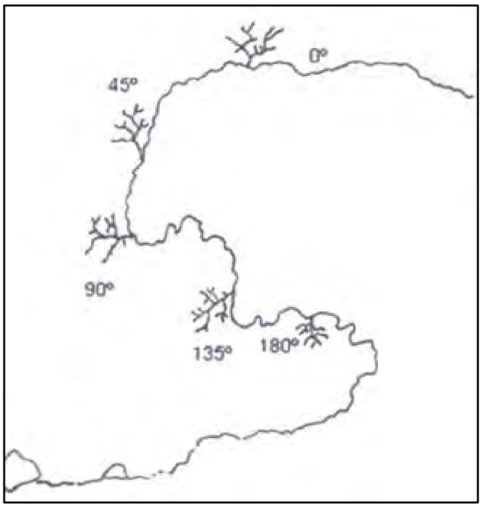


Fig. 1: Colony orientation (modified from Rossi *et al.*, 2008)

RESULTS

The presence of red coral was recorded in 12 transects, located in three different areas (Fig. 2), two in the Tyrrhenian Sea and one in the Ionian Sea. These areas were characterized by different environmental conditions and associated fauna.

- Area A**:** within Lamezia Gulf, was characterized by banks or boulders of 1 to 5 m height separated by soft substrata, water depth between 70 and 130 m. During winter, terrigenous input from rivers was present in the area. Hard substrata was colonized by encrusting red algae, bryozoans and sponges. Depending on depth, different gorgonians took up the three dimensional space: *Paramuricea clavata* (until 80 m), *Acanthogorgia cf. hirsuta, Eunicella sp.* and *Callogorgia verticillata.* Here the red coral colonies often were sparse and we observed that ~ 16 %

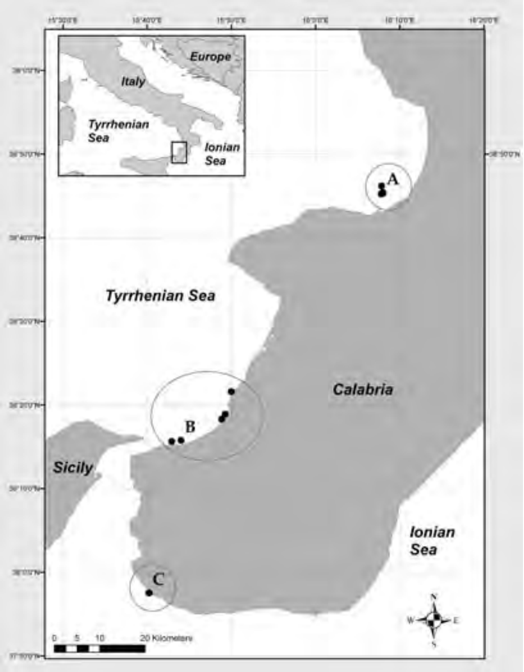


Fig. 2: Study area

(generally larger size) were dead.

- Area B: Coastal area from Palmi to Scilla, where vertical cliffs from the surface down to the sea-floor were influenced by the strong currents of the Messina Strait. Here the assemblages were constitutes by sponges, echinoderms (*Hophidiaster hophidianus, Hacelia attenuata)*, sea-urchins of genus Cidaridae and gorgonians (*Eunicella cavolinii* and *P. clavata*). Only 1.5 % of the colonies were dead.
- Area C: Capo dell’Armi, along the Calabrian coast of the Messina Strait. This area was characterized by just a little slope with south exposition that reached the soft bottom at 105 m depth. Here coralligenous biocenoses were formed by facies of *C. rubrum*. The number of colonies was very elevated, but they were restricted and brittle.

Table 1 summarized the data collected and the differences among sites.

Tab. 1: Data collected

Area	Number of transetcs	Total lengh of transects (km)	N° of photos analysed	Photos 100 m^{-1} mean ± SD	Density (col m^{-2}) mean ± SD
A	5	2.7	14	5.9 ± 2.5	6.42 ± 4.6
B	5	2.9	32	13.6 ± 16	18.04 ± 23.6
C	2	0.4	17	60 ± 69	96.57 ± 7.5

Areas with similar sampling effort (2.7-2.9 km) were compared using an F test. The difference between means of number of photos (related to coral patch frequencies) was significative (F=40.7; p<0.01).

The density of colonies was estimated for each area (Tab.1, Fig. 3). Minimum and maximum density values for all surveyed areas (1 to 101.8 colonies m^{-2}) underlined high density variability between areas.

Table 2 reported the values of the morphometric parameters. Differences among measure (diameter, height and width of colonies) for each area (A, B, C) were graphically described in Fig. 4 (Box PLOT).

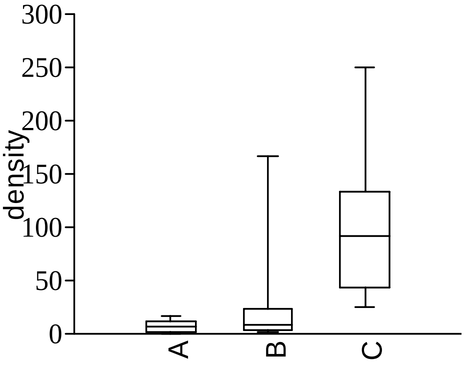


Fig. 3:Mean density (colonies m-2)

Tab. 2: mean (σ± SD), maximum and minimum values of diameter, height, width and number of branches of colonies

	n		height	width	diameter	branch
A	20	σ ± SD	9.14 ± 6.6	7.25 ± 5.3	0.64 ± 0.3	2.44 ± 1.3
		min	0.7	0.45	0.22	0
		max	21.8	17.5	1.38	6
B	162	σ ± SD	5.52 ± 4.2	6.21 ± 3.5	0.65 ± 0.4	1.86 ± 1.2
		min	0.3	0.9	0.18	0
		max	27	23.4	2.88	6
C	14	σ ± SD	3.27 ± 1.9	4.73 ± 1.7	0.44 ± 0.1	2.14 ± 1.1
		min	0.4	2.6	0.28	0
		max	6.3	7.5	0.65	4

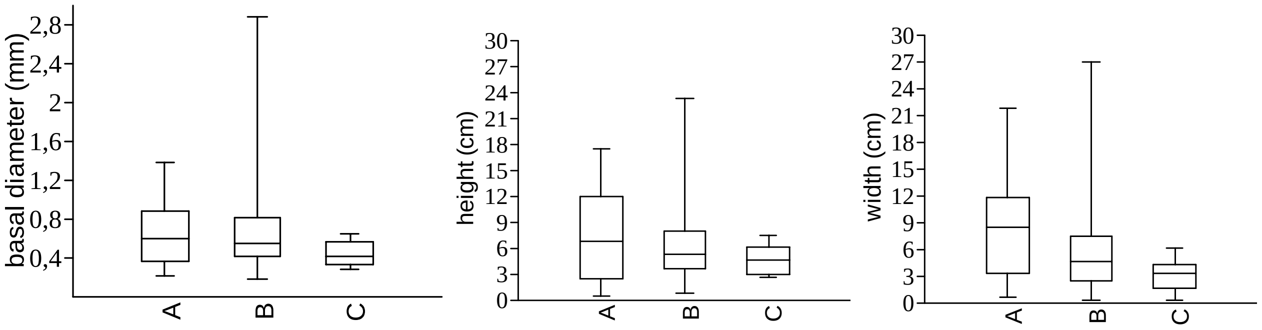
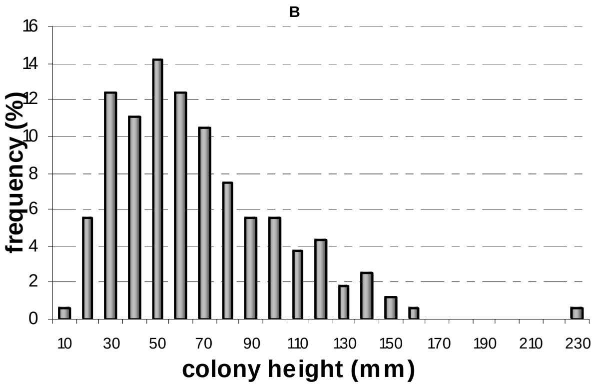


Fig. 4: Box PLOT for each area (A, B, C) of basal diameter, height and width of colonies

Highest number of measured colonies in B, respect to the other areas, allowed us to calculate the frequency distributions of the height and basal diameter of the colonies in this site. Both distributions showed a positively skewed curve (Fig. 5a, b), with average values of 6.22 ± 3.5 SD cm of height (2.79 mode, 5.34 median) and respectively 6.5 ± 3.8 SD mm (4.4 mode, 5.5 median) of basal diameter.



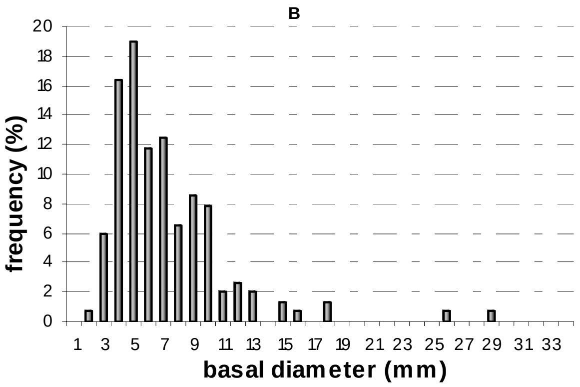


Fig. 5a: Frequency distribution of height of colonies   **Fig. 5b: Frequency distribution of basal diameter**

Colony frequencies were divided in 2 size classes for both height and basal diameter (Figs. 6-7).

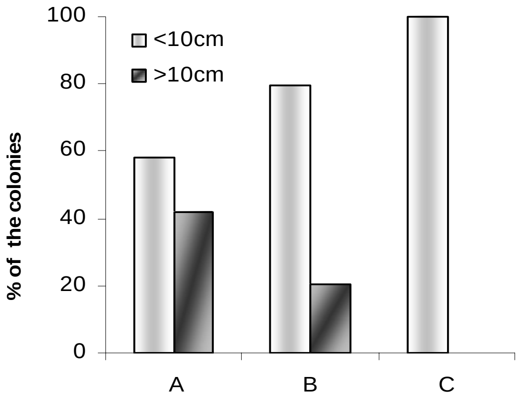


Fig. 6: Percentage of colonies bigger and smaller than 10 cm height

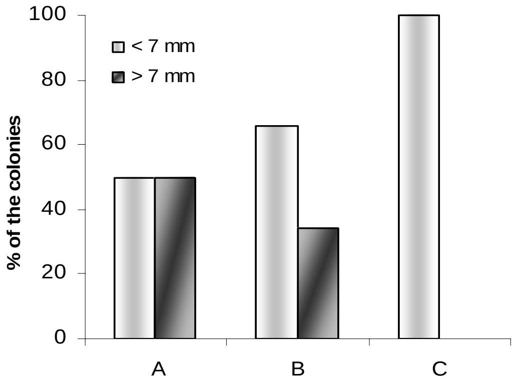


Fig. 7: Percentage of colonies bigger and smaller than 7 mm diameter

The number of colonies with a height more than 10 cm was determined, as well as the number of colonies with diameter greater or smaller than 7 mm. In all areas (A, B, C) more than 50% of the colonies measured were smaller than 10 cm in height (Fig. 6). Our results indicated that the proportion of colonies larger than 10 cm were slightly higher in A than in B.

In area A the colonies higher than 10 cm were more than 40 % respect to area C where their were absence. We can observe a similar trend for the colonies with a smaller or larger than 7 mm basal diameter, the legal harvesting size (fig 7).

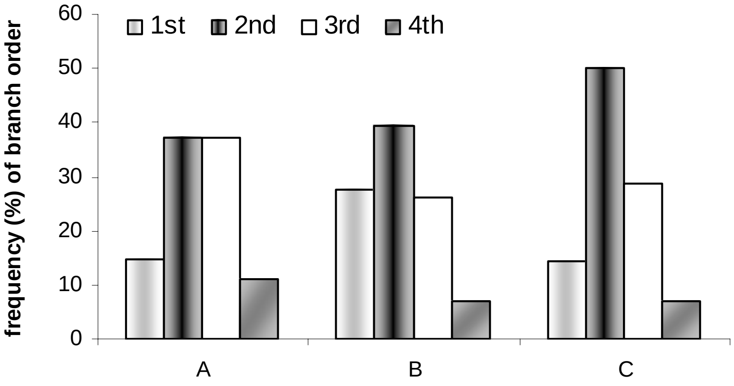


Fig. 8: Frequency distribution of number of branches for each area

Two branches colonies were the commonest typology of red coral we encountered (Fig. 8). For each area we recorded the orientation of the colonies respect to the inclination of the substratum. In area A most part of the colonies were perpendicular to the hard bottom or 45°/90° respect to the vertical cliffs. In the other sites more than 80% of colonies were hanging upside-down in the crevices or with a clear orientation tzowards the inside part of the crevice (Fig. 9).

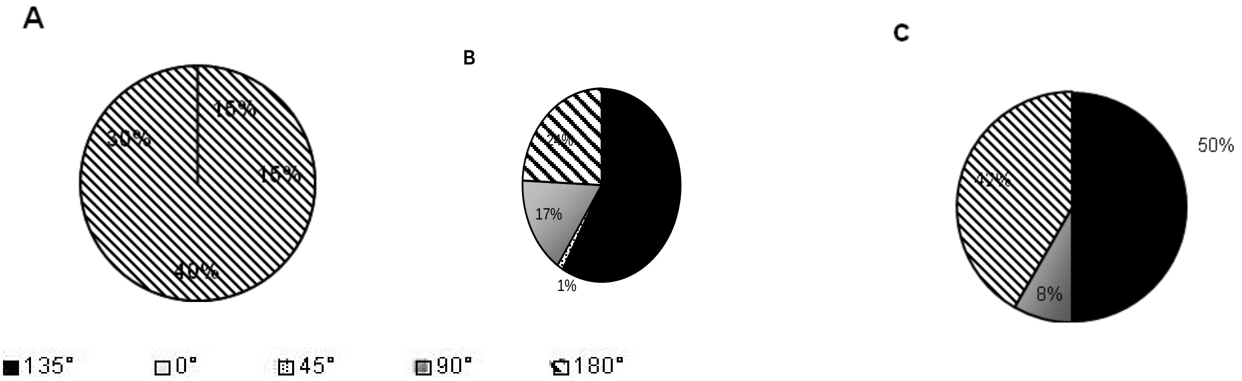


Fig. 9: percentage of colonies for each orientation (0°, 45°, 90°, 135°, 180°) for all areas (A, B, C)

DISCUSSION AND CONCLUSIONS

Enormous difference between study areas given by dissimilar environmental conditions (rate of sedimentation, light attenuation, currents) and type of substrata (boulders, slopes or cliffs) remarkably influence benthonic assemblages.

Greater density of colonies is in area C. Here the greatly sloping cliff and the strong currents, that keep high sedimentation rates, allow a more homogeneous pattern of the red coral growing. In this area, characterized by very rag bioconcretion rock, the colonies found never exceeded 10 cm in height. In area A, where red coral grows on boulders, surrounded by mud, we find lowest patches frequency and density. Nevertheless, the colonies are larger in size if compared to the other two areas. Morphometric measures and branching order confirm this trend, highlighting an inverse relationship with density. B area, characterized by vertical cliff, shows a strong variability in the colony distribution. From one transect to another, patch distribution varies from very lower values to points with elevated concentration. Density reflects the same trend. The number of small size (< 10 cm height and < 7 mm basal diameter) colonies is extremely high. Even if bigger colonies (never exceeded 20 cm height) are present, our results indicate a higher level of harvesting in this area, being already well known as situ of professional harvest.

Red coral, being a sciaphilic species, prefers dimly lit crevices and cave entrances. Light intensity limits not only density but also orientations of colonies. In the area A, where water turbidity influences the amount of light intensity, colonies grow in less sheltered conditions with more upright orientation (0°-90°). The extremely clear water of the other two surveyed areas (B and C), determinates, on the contrary, a different colony orientation (135°-180°).

The data collected in the three areas, even if the areas aren't comparable, highlight the presence of red coral from 70 m depth and a decreasing trend of patch frequency and average density with depth, which is in accordance with data available in literature. For all areas there is an inverse relation between density and size of colonies.

Overall, in the surveyed areas density values aren't high respect to other areas of the Mediterranean. Moreover, dominance of smaller size red coral colonies is probably due to over- exploitation of this species.

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BIOLOGICAL INTERACTIONS AFFECTING THE GROWTH RATES OF RED CORAL (*CORALLIUM RUBRUM*) COLONIES

ABSTRACT

*The red coral (*Corallium rubrum*: Cnidaria, Anthozoa) is a significant Mediterranean resource with wide historical, economic and cultural involvements. Several countries in the Mediterranean Sea have adopted different kinds of strategies for its conservation. On the other hand, the main data necessary for a rational management of a biological resource is the time necessary for the recruits to reach an exploitable size. Data about the growth rate of just settled or juvenile colonies living in shallow waters (< 50 m) are abundant and values of 1 mm year^{-1} for the base diameter and 1 cm year^{-1} for the height of the colony are generally accepted. Nevertheless it is demonstrated that 4-5 years after the settling, the growth virtually stops or becomes negligible: colonies monitored for more than 20 years along the French coast reached an height of about 4 cm and a basal diameter of 0.5 cm. Historical and recent data about the size and density of the shallow water population of Portofino Promontory (Ligurian Sea) are available, indicating important fluctuations of these parameters on banks not subjected to anthropogenic impact. Firstly, the colony size is inversely related to their density, suggesting an intraspecific competition linked to the space availability and trophic inputs. Moreover, it is surprising that in the last ten years the Portofino populations have shown an unusually fast growth rate, reaching the maximal colony size never recorded in the previous 43 years (15 cm in height and 20 DW g). This unusual fast growth rate was recorded after the mass mortality episodes of 1999 and 2003, involving not only red coral but also several other benthic species and provoking a significant change in the structure of the coralligenous assemblage. All these evidences suggest that the growth of the Mediterranean red coral is strongly affected by intra- and interspecific interactions linked not only to local variables by also to stochastic events.*

KEY WORDS: red coral, growth, biological interactions, Mediterranean Sea

INTRODUCTION

The red coral (*Corallium rubrum*: Cnidaria, Anthozoa) is an important Mediterranean resource with huge historical, economic and cultural involvements (Cicogna & Cattaneo-Vietti, 1993; Cicogna *et al*., 1999). It is widely distributed throughout the Mediterranean: occurring both in commercially exploitable concentrations, as off Spain, Algeria and Sardinia, as well as at lower densities from the Aegean and southern and eastern Mediterranean to the Sea of Alboran. Some populations are recorded in the Capo Verde Archipelago (Zibrowius *et al*., 1984).

Preoccupation has been expressed by fishermen and industry with the declining returns to an ever more sophisticated harvesting gears capable of operating at more than one hundred metres depth, which have progressively substituted the primitive dragging equipments. Scuba harvesting tends to be in a "pulse" mode, in which local patches are cleaned out selectively, leaving only inaccessible or non commercial individuals, before another patch is located and harvested in turn (Caddy, 1993). Consequently, several countries in the Mediterranean Sea have adopted different kinds of strategies for the red coral conservation, particularly the closure of coral fishery in overexploited areas.

Red coral population density and colony size vary from place to place, also according to depth and exploitation (Tsounis *et al.* 2006; Rossi *et al*., 2008). Schematically, we can distinguish two different spatial situations: (i) coastal populations, occurring up to 50 m depth, characterised by high density (up to 1,000 colony/m^2) and small colony size (until 5 cm height), most of colonies produce tens of planulae per year; (ii) deeper populations, extending up to 200 m depth and more, characterised by low density and high colony size. These colonies may produce until 2,000 planulae per year (Santangelo *et al.,* 2003). Of these two kinds of situations, the second one only is really important from an economic viewpoint while the first one, merely of naturalistic value, constitute a stock of breeders for the species.

After settlement, the growth rate of shallow water colonies is about 1 mm year^{-1} for the base diameter, and 10 mm year^{-1} for the height (Cattaneo-Vietti & Bavestrello, 1994) but after 4-5 years, the growth virtually stops or becomes negligible. In fact, long-term studies (22 years) indicate an average growth rates extremely low: 0.24 ± 0.05 mm year^{-1} for the basal diameter and 1.78 ± 0.7 mm year^{-1} for colony height (Garrabou & Harmelin, 2002). Similar data were indirectly obtained by examining the growth rings of shallow water colonies: specimens with basal diameter of about 7 mm were at least 30-40 years old with a growth rate of the basal diameter of 0.35±0.15 mm year^{-1} (Marschal *et al*., 2004). Bramanti *et al*. (2005) measured the growth rate of colonies settled on long-term artificial substrates: after four years the colonies exhibited an average annual growth of the stem diameter of 0.62 ± 0.19 mm year^{-1}. Similar data were also obtained by Torrents *et al*. (2008). Practically no informations are available for deeper populations, but if these trends are applied to all cases, we may estimate age of several decades for colonies of 10-20 mm of basal diameter and 20-30 cm of height.

Although very few data are available, coral growth rate is probably affected by physical and chemical variables (light, currents, input of organic matter, Ca^{++} availability) and biological ones (food availability, competition). Finally anthropogenic impact can be very important. An underestimated phenomenon is the impact on coral populations of fishing lines that broke the branches of the colonies.

Also the thermal anomalies can affect the size and shape of the coral colonies. During these episodes autotomy of the branch tips (Russo *et al*., 1999) was noticed on several colonies. The reproductive implications of this phenomenon still need to be clarified.

In this paper, we discuss present and historical data on size and density of the red coral populations of the Portofino Promontory (Ligurian Sea). Larval biology together with intra- and interspecific competitions, are invoked to hypothesise a general framework for the biology of the Mediterranean red coral.

RESULTS

1. Size/density relationship along a depth transect

We have conduced a series of measures on the density and size of the red coral colonies along a depth transect on the rocky cliff of Portofino Promontory (Ligurian Sea). This study was conduced during July 2008, by using non-destructive photographic methods. Data were recorded in three stations, at 30, 50 and 70 m depth by scuba diving.

The observations indicate that the two variables are inversely related, as shown in Fig. 1. Density is very high at 30 m depth (about 300 colonies m^{-2}), but the average height of the colonies is low (about 5 cm). At this depth the colonies mainly growth hanged to the roof of the crevices of the coralligenous conglomerate. The biocoenosis includes several sponge species insinuating, encrusting and massive or erected. The stony coral *Leptopsammia pruvoti* is often present. Among bryozoans *Smittina*, *Rynchozoon,* and *Reteporella* are among the commonest genera.

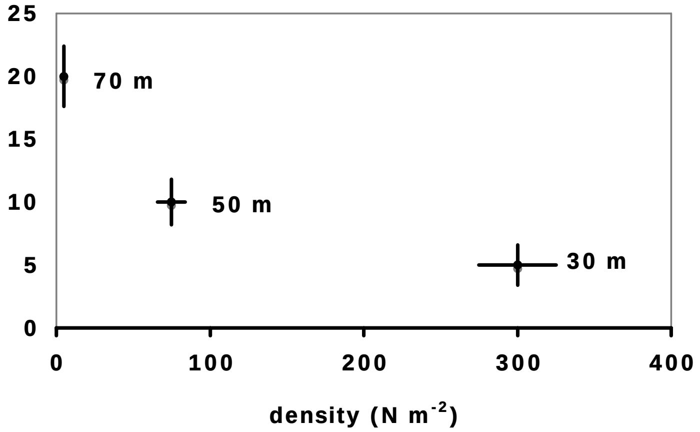

Fig. 1: Density/size relationships along a depth transect on the Portofino Promontory

At 50 m depth the size of the colonies drastically increases but, contemporaneously, the density is reduced. Here red coral settle perpendicularly to the cliff together with several sponges and bryozoans. *L. pruvoti* is very abundant.

At 70 m depth, the colonies are of commercial size: 1-2 cm in the basal diameter and about 15 cm in height, but their densities drop down to only 2 colonies m^{-2}. Recruits and juvenile colonies are very rare or completely lacking. At this depth the colonies live on sparse rocks arising from the detritic bottom. The sedimentation is very high and a sheet of thin sediment covers the rocks. *Leptopsammia* and bryozoans are rare while only erected sponges are common. *Haliclona mucosa* that in shallow waters produces thin crusts inside crevices, here has a thick ear-like shape.

2. Growth rate variation

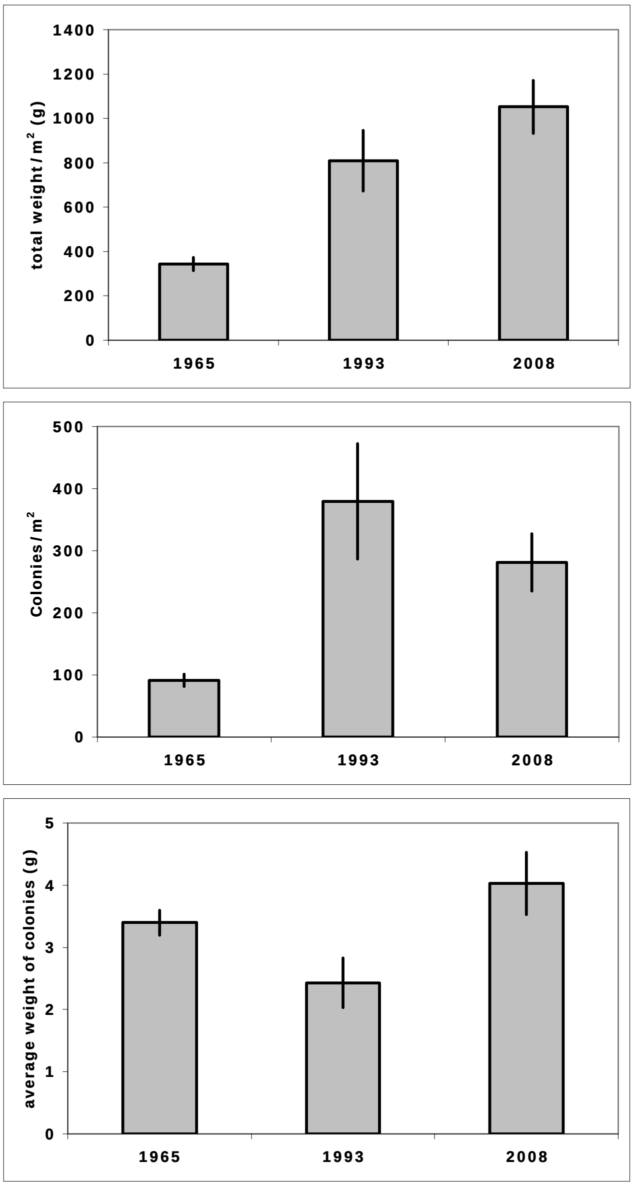

Fig. 2: Historical and present data of biomass (A); density (B) and average colony weight (C) of the coral population of the Portofino Promontory

During the last 43 years, three series of measures of density and weight of the red coral colonies were conduced along the southern cliffs of the Portofino Promontory on populations living at 30-40 m depth (Fig.2).

First information are due to Marchetti (1965) who recorded a DW biomass m^{-2} lower than 400 g. This datum was determined by a low number of colonies (< 100) with an average weight of about 3.5 g. About 30 years after, Cattaneo-Vietti *et al.* (1993) came back in the Marchetti stations, recording an increasing in biomass, reaching about 800 DW g m^{-2}. The colony density was increased of more than three times, but the average weight of a single colony decreased until 2.5 g.

During 1999 and 2003 and, with less intensity in 2005 and 2006, the populations of red coral of the Ligurian Sea were strongly affected by episodes of mass mortality, sometimes killing more than 90% of the colonies. Together with red coral also several sea fans, sponges and bryozoans (almost 23 species in 1999 and 14 species in 2003) were affected drastically, changing the structure of the whole biocoenosis (Cerrano *et al.*, 2000; 2008; Perez *et al.*, 2000; Garrabou *et al.*, 2001).

Recent surveys, conduced in the summer 2008, on the same stations, showed a further increasing of the biomass, until 1000 DW g m^{-2}.

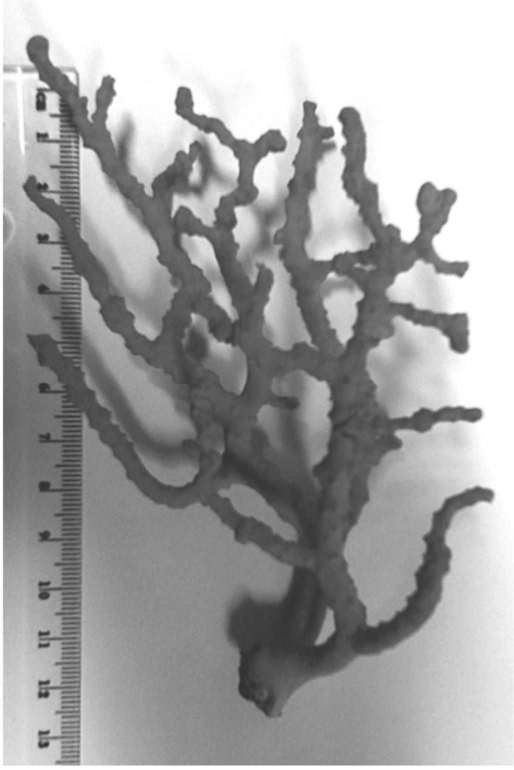

Fig. 3 – A large colony of 30 g collected on the Portofino cliff.

This value is due to an increasing of the average size of the colonies that sometimes reach 15 cm in height and 20 g in DW (Fig. 3). Contemporaneously, the density of population again decreases.

DISCUSSION

Among benthic cnidarians, the Mediterranean red coral shows a peculiar life strategy, not completely clarified: its population density is inversely related to colonies size, along both spatial and temporal trends. These structural characteristics, observed studying the red coral populations living along the Portofino cliffs (Ligurian Sea), agree with ROV studies conducted on the Spanish coasts (Rossi *et al.*, 2008).

In shallow populations, density and size of the Mediterranean red coral can be affected by harvesting: recently Tsounis *et al.* (2006) have demonstrated that the fishing in Costa Brava has deeply influenced the population structures, transforming them from a “forest-like” structure to a “grass plain-like” one. This has been evidenced comparing harvested populations with “natural” ones, living in the Medas Islands MPA.

The harvesting not only affects the size structure of a shallow population for the obvious reason that fishermen collect preferably colonies of large size, but also enhancing the larval settling. In 1990, we have experimentally scraped all the colonies present in a 30 x 30 cm surface inside a dense Portofino Promontory population. All the colonies were counted and measured. Four years after, all the colonies present in the same surface were again collected: their number was decreased (Fig. 4).

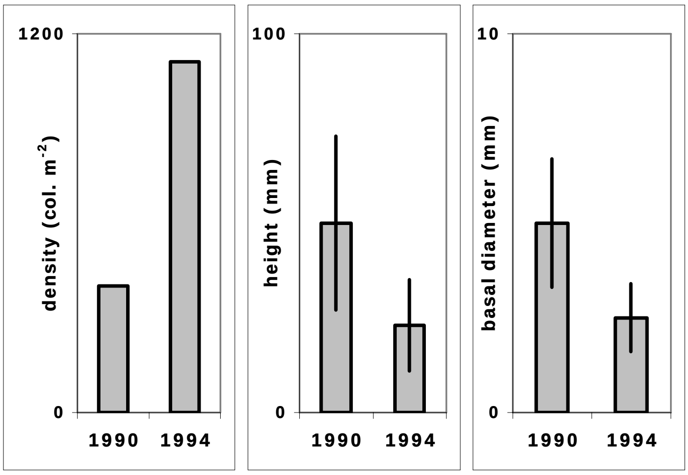

Fig. 4 – Comparison of density and size of the original and the reconstituted population after 4 years

This result suggested a strong intraspecific competition as the available space induced a high larval settling (Cerrano *et al.*, 1999). Under this condition, the coral populations appear like a “copse wood” where, after the cut, the new young trees grow densely and quickly, forming a bushy structure that remain in this situation for a long span of time due to intraspecific competition. Tsounis *et al.* (2006) stated that 14 years of protection at the Medas Island were not sufficient to reach a “forest-like” structure. At the same, the Portofino coral populations were heavily exploited during the ’50-60 years, but in the last 30 years no more fishing activities have been done. During this long span of time, these shallow water populations remained in an immature stage, confirming the idea that the “copse wood effect” could stop for long time the further size increase of the population.

An open question is why the recruitment is so high only in shallow waters while in the deeper ones no juveniles were observed although it is well known that the large deeper colonies are able to release thousands of planulae (Santangelo *et al*., 2003).

It is possible that the high sedimentation recorded 70 m depth, on the rocks emerging from the soft bottom, could prevent the recruits as avoids the settling of other benthic organisms like encrusting sponges and bryozoans. It is possible to hypothesise that the planulae released by deep colonies, in the absence of a suitable substratum, move to shallow habitats. By this way, the superficial populations are continuously supplied by the larvae produced by themselves and by those released by deeper colonies, while in deep waters the larval settling remains rare, linked to the stochastic presence of favourable micro-environmental situations. Following this hypothesis, the high density and small average colony size of the superficial populations could be a natural phenomenon, locally enhanced by harvesting and due to the high recruitment typical of these habitats.

On the other hand, free from competition, the deep colonies are able to grow more quickly. Moreover, living in more constantly colder water, their final size could be higher as recorded for the greatest part of ectothermic organisms (Atkinson & Sibly, 1997).

As indicated by our data, the situation of shallow water population can be changed by stochastic event like the mass mortality episodes occurred in the Ligurian Sea during 1999 (Cerrano *et al.*, 2000) and 2003 and with low intensity in 2005 and 2006 (Cerrano *et al.*, 2008). Since the first mass mortality episode, the Portofino populations have shown an unusually fast growth rate, reaching maximal colony sizes (until 15 cm in height and 1 cm of basal diameter, 20 g DW) values never recorded in the previous 43 years.

The obvious explication of this phenomenon is that for the few, survived colonies, the intraspecific competition decreased and the greater availability of several resources gave them the opportunity of a faster growth rate. It is intriguing that, although the average size of colonies is now the largest of the past 43 years, the density is greater that in 1965. This fact suggests that intraspecific competition is not the only constrain able to affect coral growth: very likely also interspecific competition plays a significant role.

This is particularly evident in the relationships between red coral and the stony coral *Leptopsammia pruvoti*. On the cliff of the Portofino Promontory although the two species are able to coexist, they tend to colonise alternative areas along a same horizontal transect (Cattaneo-Vietti *et al*., 1993).

All these evidences suggest that the growth of the Mediterranean red coral is strongly affected by intra- and interspecific interactions linked not only to local variables by also to stochastic events.

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COMMUNAUTES BENTHIQUES REMARQUABLES DU CORALLIGENE DU PARC NATIONAL D'AL HOCEIMA (MEDITERRANEE - MAROC)

RESUME :

A 150 Km environ à l'Est du détroit de Gibraltar, à l'ouest de la ville d'Al Hoceima Le Parc National d'Al Hoceima est situé sur la façade méditerranéenne du Maroc. La superficie totale de ce Parc côtier est de 48.000 ha dont une partie marine de 19.600 ha. La partie marine du parc est caractérisée une suite de falaises montagneuses entrecoupées par des plages réduites sous forme de criques généralement difficiles d'accès; elle comporte des grottes, plusieurs îlots et rochers.

Les résultats exposés dans ce travail sont collecté dans le cadre du Projet régional pour le développement des aires protégées marines et côtières dans la région méditerranéenne (projet MedMPA[1]) et en vue de fournir l'assistance technique aux autorités compétentes marocaines pour l'élaboration d'un plan de gestion de la partie marine du Parc National d'Al Hoceima.

L'étude des peuplements benthiques du coralligène du Parc National d'Al Hoceima à révéler une grande richesse spécifique ceci est du à la particularité hydrologique et géographique de cette région de la méditerranée occidentale située à l'entrée du Détroit de Gibraltar.

MOTS CLEFS : Coralligène, Communautés benthiques, Al Hoceima, Aires marines protégées, Méditerranée, Maroc.

INTRODUCTION

Les côtes du Maroc et leur plateau continental, bordés au Nord par la mer Méditerranée et à l'Ouest par l'Océan Atlantique, sont baignés par deux masses d'eaux marines aux caractéristiques différentes (Bayed, 1991). La présence du détroit de Gibraltar (Fig.1), véritable carrefour, où des échanges bien définis se réalisent entre les masses d'eaux océaniques et méditerranéennes, renforce cette dualité (Bayed, 1991).

Le Parc d'Al-Hoceima est situé sur la façade méditerranéenne du Maroc, à 150 Km environ à l'Est du détroit de Gibraltar, à proximité de la ville d'Al-Hoceima. Ce Parc côtier de 48.000 ha comporte une partie marine de 19.600 ha. C'est un espace montagneux au relief tourmenté avec un rivage composé de falaises et de grottes et plusieurs îlots et rochers.

La façade Méditerranéenne marocaine, façade sud de la mer d'Alboran, souvent exposé au vent Chergui, est caractérisée par des plages réduites sous forme de criques généralement difficiles d'accès. La profondeur moyenne du bassin est égale à 1500 m (Miller, 1983). Cette mer profonde ne compte pas de plateaux continentaux (profondeur de 200 m). Les talus continentaux abrupts commencent à l'aplomb des côtes ou très peu au large.

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[1] Le projet de MedMPA couvre 7 régions méditerranéennes et implique des arrangements de collaboration parmi différents établissements scientifiques méditerranéens et administrations publiques environnementales

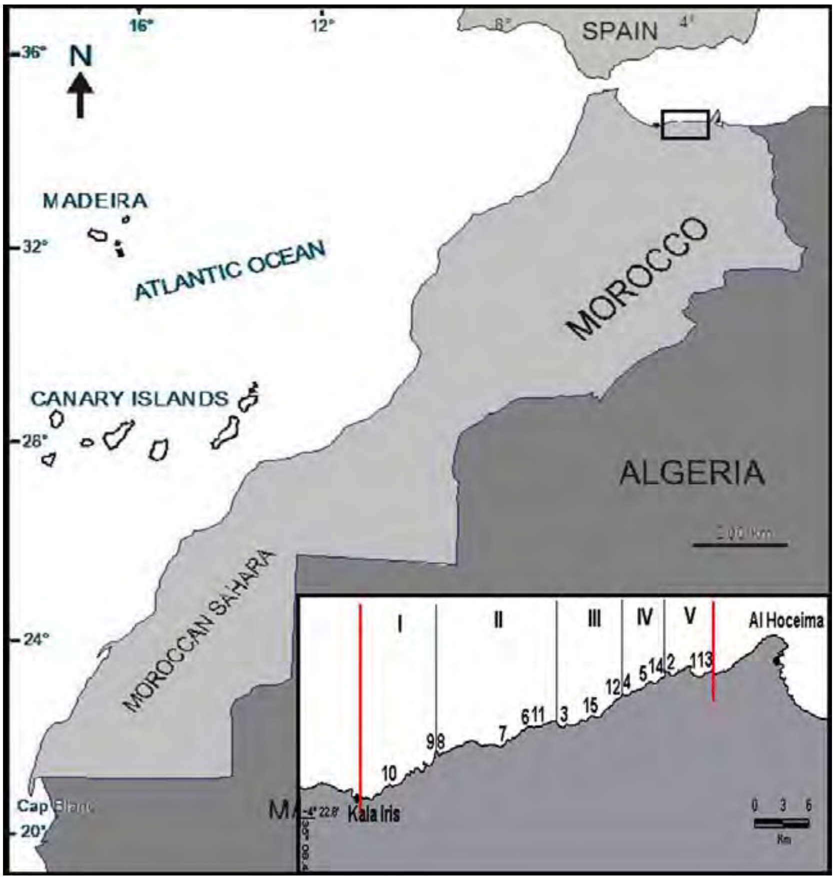

Fig 1: Localisation de la zone d'étude

L'eau atlantique plus légère que l'eau méditerranéenne s'écoule en surface d'ouest en est par le détroit de Gibraltar, large de 13 km et profond de 300 m (Fig. 2, 3 et 4). Le débit annuel de cette masse d'eau est évalué à 53,0 10^{12} m3/an (Béthoux, 1980), soit un débit de 1-2 Sv (remarque : 1 Sv = 106 m3/s). Sa salinité est estimée à 36,15-36,18 psu ou mesurée, sur une année, d'environ 36,6 psu selon les auteurs (Lacombe *et al.,* 1981; Béthoux, 1980; Lacombe & Richez, 1982) tandis que sa température est comprise entre 17°C en mars et 21°C en août (Lacombe & Richez, 1982).

En sens inverse, l'eau méditerranéenne sort du bassin ouest vers l'Atlantique en suivant le fond du détroit. Le débit de cette masse d'eau est du même ordre de grandeur que celui entrant en surface et est estimé à 50,5 10^{12} m3/an par Béthoux (1980). La salinité de cette eau méditerranéenne est évaluée à 37,9 et 38,4 psu (Béthoux, 1980) et mesurée de l'ordre de 38,3 psu (Lacombe *et al.,* 1981), sa température est d'environ 13,3°C (Lacombe & Richez, 1982).

La différence de densité entre le bassin méditerranéen occidental d'une part et les bassins atlantique et méditerranéen oriental d'autre part est responsable des transports moyens au travers des détroits de Gibraltar et de Sicile et contribue au forçage de la circulation cyclonique des masses d'eau superficielle et intermédiaire sur l'ensemble du bassin occidental (Lacombe & Tchernia, 1972; Millot, 1987, 1991).

L'eau atlantique modifiée est l'eau d'origine atlantique qui pénètre en surface dans le bassin méditerranéen par le détroit de Gibraltar. Cette circulation est davantage due à la différence de salinité entre l'eau atlantique et l'eau méditerranéenne (Tintoré *et al.*, 1988 ; Perkins & Pistek, 1990) qu'aux effets du vent. La couche d'eau concernée est de quelques centaines de mètres d'épaisseur et circule principalement dans les zones côtières d'ouest en est tout d'abord pour ensuite remonter vers le nord en un circuit cyclonique dans le bassin occidental (Fig.2). Sur son trajet, cette eau entrante est sujette à évaporation et mélange avec les couches plus profondes, ce qui a pour effet de changer ses caractéristiques, d'où son nom, et en particulier d'entraîner une augmentation régulière de sa salinité donc de sa densité. Dans la zone de Gibraltar, celle-ci est d'environ 36,6 psu et atteint 38,3 psu dans le détroit de Sicile. L'écoulement de l'eau atlantique modifiée d'ouest en est, qui progressivement s'approfondit de 20 à 50 m, a été repéré par un minimum de salinité, signature de son origine atlantique (Lacombe & Richez, 1982).

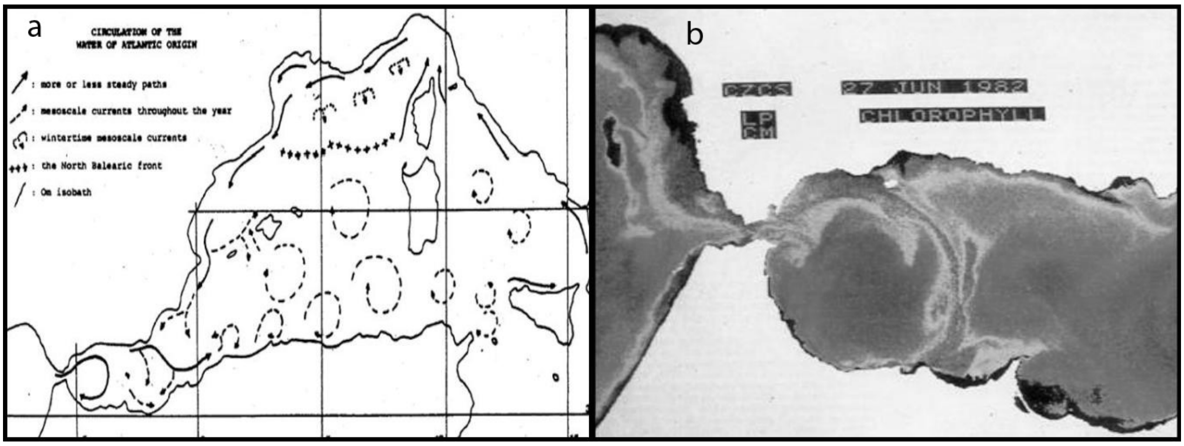

Figure 2. Circulation de l'eau atlantique modifiée
a : Modélisation (Millot, 1987)
b : Circulations des eaux riches en Chlorophylle (Jacques & Tréguer, 1986).

Après avoir franchi le détroit de Gibraltar, l'eau atlantique modifiée forme deux tourbillons anticycloniques dans la mer d'Alboran (Lanoix, 1974; Gascard & Richez, 1985). Le tourbillon occidental existe la plupart du temps tandis que le tourbillon oriental n'est qu'occasionnel (Millot, 1987). Des images satellitales montrent que ces deux grands anticyclones oscillent sur une période de quelques semaines (Heburn & La Violette, 1990).

MATERIEL ET METHODES

L'analyse en plongée de 15 transects effectués (Tab. 1) dans le Parc National d'Al Hoceima nous permet l'étude des peuplements benthiques.

Tab. 1 : Localisation et dates de prospection

N° du Transect	Date	Longitude	Latitude
1	10/09/2002	004°00,969’	35°14,426’
2	10/09/2002	004°02,458’	35°14,147’
3	11/09/2002	004°08,961’	35°12,000’
4	11/09/2002	004°05,426’	35°13,220’
5	12/09/2002	004°03,886’	35°13,673’
6	13/09/2002	004°11,366’	35°11,906’
7	13/09/2002	004°12,836’	35°11,248’
8	15/09/2002	004°17,113’	35°10,848’
9	15/09/2002	004°17,325	35°10,740
10	15/09/2002	004°20,199	35°09,502
11	16/09/2002	004°11.336	35°12.020
12	18/09/2002	004°05.638’	35°13.124’
13	10/09/2002	003°59,828’	35°14,163’
14	10/09/2002	004’°02,458’	35°14,147’
15	11/09/2002	004’°07,342’	35°12,356’

Un ruban gradué est déroulé dans le sens de la pente, L'analyse porte sur une bande large de 2 mètres (1 m de chaque côté du transect environ). La longueur maximale de chaque transect est fonction de la profondeur de chaque station, nous avons fixé une profondeur maximale de 33 mètre pour les zones profondes et une longueur maximale de 100 mètre de ruban pour les stations où la pente est douce. De haut en bas, le transect est découpé en tronçons à peu près homogènes par leur topographie (pente) et par leur peuplement. La longueur et la profondeur maximale de chaque tronçon sont mesurées. Dans chaque tronçon, la liste des espèces macroscopiques (déterminables sur le terrain, avec éventuellement vérification au laboratoire) est établie et le recouvrement des espèces dominantes (recouvrement = % de substrat couvert en projection verticale par l'espèce considérée) est évaluée approximativement *in situ*.

Quelques espèces peu abondantes mises en évidence à l'occasion de la détermination, au laboratoire, d'espèces de grande taille, sont mentionnées mais la liste des espèces présentes dans chaque tronçon ne prétend pas être exhaustive.

Pour chacun des 15 transects une reconstitution graphique, sous la forme d'un profil synthétique de la topographie et du peuplement est donnée. Compte tenu des contraintes graphiques, les données ne sont utilisées que partiellement: toutes les espèces recensées ne peuvent êtres représentées. En outre, il n'est pas toujours possible de donner à chaque espèce une importance proportionnelle au recouvrement évalué sur le terrain. Mais la proportionnalité des dominances a été respectée autant que faire se peut pour donner une image plus proche des peuplements.

RESULTATS ET DISCUSSION

L'étude des peuplements algaux de la zone littorale du Parc National d'Al Hoceima a permis d'identifier un total de 264 taxons répartis entre trois groupes systématiques: 57 Chlorophyceae, 52 Fucophyceae et 155 Rhodophyceae (Benhissoune 2002, Benhissoune *et al*. 2001, 2002$_{\mathbf{a\ et\ b}}$ et 2003). La nomenclature adoptée durant tout ce travail est celle de Silva *et al.* (1996).
Les peuplements coralligènes sont bien structurée et se caractérisent par une grande richesse spécifique ; il faut signaler aussi que les peuplements du PNAH se distinguent par leur proximité de la surface difficile de rencontrer en d'autres lieux de la Méditerranée.

Les forêts de laminaires affleurent de surface sur presque l'ensemble du PNAH avec une riche sous strate de Corallinacées et autres macrophytes benthiques. Ainsi que les denses peuplements de *Parazoanthus axinellae* non loin de la surface font du Parc National d'Al Hoceima un site de grand intérêt écologique et scientifique de la Méditerranée.

A l'issue de notre travail sur le Parc National d'Al Hoceima (PNAH) les résultats obtenus ont d'une grande importance et doivent êtres mises en avant pour sensibiliser les décideurs de l'urgence de mettre en place un plan de gestion d'une manière légale et effectives dans le PNAH.

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Actes du 1^{er} Symposium sur le Coralligène et autres Bio-Concrétions calcaires de Méditerranée
(Tabarka, 15-16 Janvier 2009)

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INTEGRATION OF DIFFERENT TECHNOLOGIES INTO A GEOGRAPHIC INFORMATION SYSTEM (GIS) TO STUDY CORALLIGENOUS BIOCENOSIS IN CALABRIAN COASTAL WATERS (SOUTH ITALY)

ABSTRACT:

A marine biodiversity monitoring project was conducted by ICRAM in the coastal waters of Calabria (South Italy) on board of ICRAM's research vessel R/V Astrea, by means of a Remotely Operated Vehicle (ROV). The aim of the project was to study the hard bottom macrozoobenthos in the 30- 250 m depth range. The ROV was equipped with an underwater acoustic tracking position system, a digital camera (Nikon D80, 10 megapixel) with underwater strobe (Nikon SB 400), two laser pointers spaced 10 cm apart (used as linear scale) and a three-jaw grabber to take species samples. Multibeam data were collected, before ROV dives to identify and map potentially interesting sites. These data were also used to create two-dimensional digital maps and were integrated with the acoustic tracking data in a Geographic Information System (GIS) in order to have the ROV position georeferenced in real time on a PC screen during the dives. The analysis of the videos collected by the ROV was done in post-process by means of the software ADELIE, developed by Ifremer, and video-clips of the identified species were inserted in the right position (latitude, longitude) on the multibeam three-dimensional maps, previously created by means of a GIS software. Photos of the identified species were also placed on the 3D maps in the right position (latitude, longitude), linking every picture click-time with the time of the acoustic tracking position system. These methodologies allowed us to find and study the coralligenous habitat at depths not reachable in safety by scuba divers equipped with compressed air, trimix or rebreather, and for a very long time.

Furthermore, the integration of these tools in order to create georeferenced 3D seascape maps allows a simple representation and interpretation of the real situation respect to traditional 2D maps, also thanks to the possibility of creating animations. This tool is also particularly useful to study spatial distribution of coralligenous biocenosis presence along sub-horizontal or inclined substrata.

KEY-WORDS: coralligenous, ROV, GIS.

INTRODUCTION

The scientific exploration of the seas started more than 200 years ago, but it is only 60 years that the use of autonomous respiration equipment allowed researchers to dive, to observe and collect marine species in their natural environment. Unfortunately this exploration was limited to first 50 meters of water were the scientific diving is considered to be "safe". Only in recent years, the use of more evolute underwater equipment as rebreaters or trimix allow divers to reach the depth of 100 meters, and in some cases 150 meters (Pyle, 2000). Apart the necessary skills required for the divers, the extreme costs of this equipment and the limited time at bottom, The safety of these techniques is still matter of discussion.

Starting in the '60s, sprung by military necessity, the creation and the evolution of remotely operated vehicles (ROV) began to support the scientific exploration of the seas with equipment that can be easily accustomed to accomplish different tasks, such as collecting high resolution videos and pictures or samples. ROV video transects have become an unvaluable tool to survey benthic communities (Ninio *et al.*, 2003). Over the past few decades, revolutionary changes have taken place in our ability to map and visualize the ocean floor. At the core of these new technologies is the development of multibeam sonar systems that use beam-forming techniques to insonify large swaths of the seafloor while producing high resolution (both lateral and vertical) bathymetry and seafloor

imagery (backscatter). Multibeam bathymetric surveys can provide 100% area coverage at sub-meter resolution, and depending on the particular system used, is capable of high resolution mapping of both shallow (1m) and deep (1000m+) environments (Hughes-Clarke *et al.*, 1996, Mayer *et al.*, 1997). Multibeam data are used to create 3D surface models of the seafloor, to facilitate interpretation of complex data sets, which can be analyzed with a variety of GIS techniques. Multibeam bathymetry, when analyzed with GIS landscape analysis tools, can create effective models capable of predicting “preferred” habitat based on species-specific parameters. For these reasons, multibeam bathymetry is a versatile and effective method of benthic habitat classification. Furthermore, understanding the link between organisms and their habitat can help reveal ecosystem dynamics affecting both large- and small-scale patterns of species distribution and abundance.
In this paper, we describe how all these technologies were employed to study deep coralligenous biocenosis in coastal area of south Tyrrhenian and Ionian Sea, discovering several rare habitat and species some of which, never observed in their natural environment.

MATERIALS AND METHODS

This work was conduct as part of the marine biodiversity monitoring project Mo.Bio.Mar.Cal, conducted by ICRAM in the coastal waters of Calabria (South Italy) (Fig. 1). The research was conducted on board research vessel R/V Astrea. The aim of this project was to study the hard bottom macrozoobenthos in the 30- 250 m depth range. Multibeam echosounder Reson SeaBat 8125 was used to collect detailed batimetric data up to 120 meters depth. This echosounder uses 240 dynamically focused 0.5° beams and measures a 120º swath across the seafloor, detecting the bottom, and delivering the measured ranges at a depth resolution of 6 mm. The backscatter intensity image is displayed in real time on the sonar display. DGPS Sea Star with differential corrections (with submetric accuracy) provides the right position of the ship. A sound velocity profiler recorded the speed of sound through the water column to account for salinity and temperature changes. An IXSEA Octans fibre optic gyro and motion sensor provided the correction for gyro, pitch and roll data. The multibeam data, acquired with the software PDS 2000, were processed and imported into ArcGIS 9.1, as 1 meter x, y, z (latitude, longitude, depth) point data. An observer class ROV “Pollux” (Fig. 2) (Global Electric Italiana s.r.l.) able to dive up to 400 meters, was used to explore rocky bottom assemblages. The ROV was equipped with a high definition digital camera

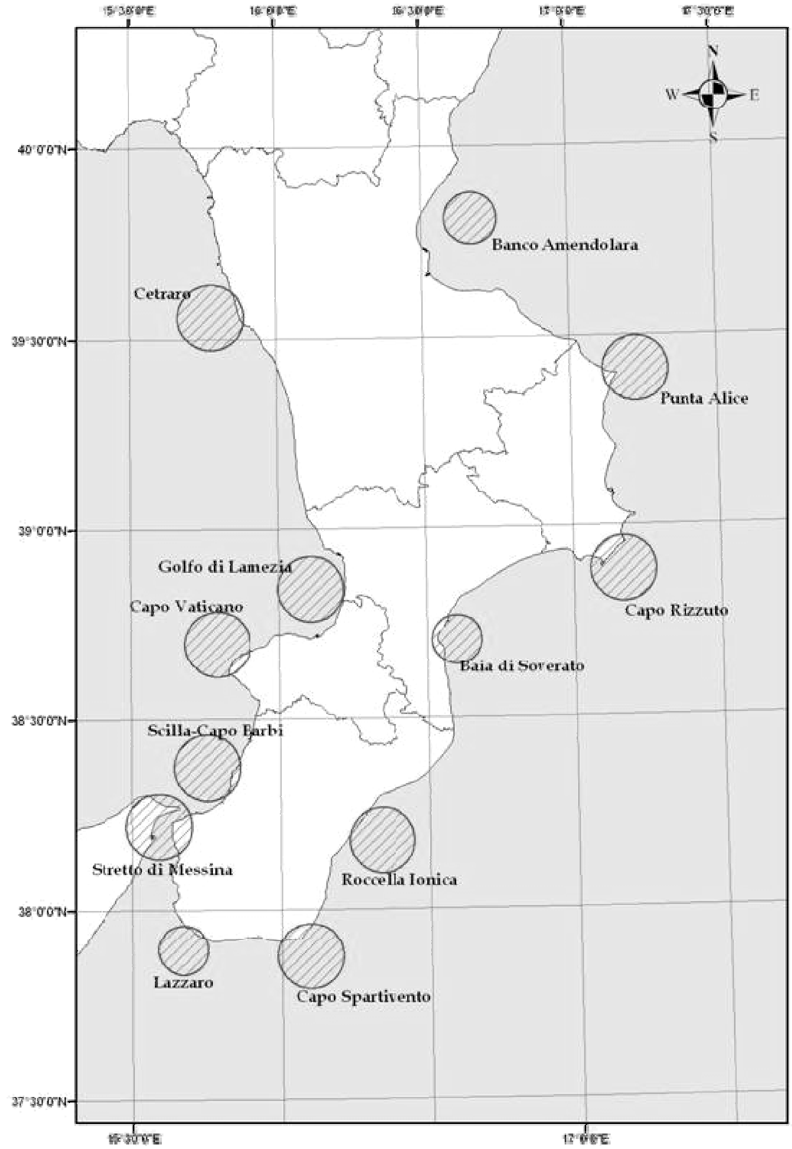

Fig. 1: Study area, circles represent the positions of 12 sites investigated

(Nikon D80, 10 megapixel) a with a high definition digital camcorder (Sony HDR-HC7) that were enclosed in two dedicated housings. The camocorder was used only in the most interesting sites and set to record continuously for the whole dive. A small strobe (Nikon SB 400 TTL), placed in a separate housing, was used as light source for the Nikon camera. Two parallel lasers pointers (λ= 635 nm, power: 10mW) were installed in the camera housing, pointing to the centred of photo. The two beams were spaced 10 cm apart, and where used to determine the relative size of the specimens being photographed. A three-jaw grabber (www.seabotix.com) was used to collect selected specimens. Tracklink 1500 MA, ultra short baseline acoustic tracking system (www.link-quest.com), with a positioning accuracy of 1 degree, was interfaced with gyro and motion sensor and used to calculate, by the proprietary software Tracklink, the position of the ROV (latitude, longitude and depth). ROV position data were sent by means of a serial port to a dedicated personal computer, running GIS software allowing us to visualize and record the ROV position in real time on the georeferenced bathymetric chart during sampling. ROV video analysis was done by means of the underwater vehicle data post-processing software ADELIE, developed by Ifremer. ADELIE is equipped with several post-processing tools able to correlate the recorded video with the ROV recorded track, generating a sequence of frames each of which is associated to the geographic position. These frames were imported into the multibeam three-dimensional maps, previously created by means of the 3D Analyst extension using the kriging statistical tool. High definition photographs were also placed on the 3D maps in the exact position in which they were taken linking every picture click-time with the time of the acoustic tracking position system. The high-resolution multibeam data were analyzed in GIS to extract data about slope, rugosity, and relative topographic position to assess and quantify species distribution and habitat preference.

Fig. 2: ROV "Pollux" equipped with camera and strobe housing, grabber and acoustic trasponder

RESULTS

During 2007 and 2008, 12 sites along calabrian coast (Fig. 1) were investigated with 86 ROV dives. Of these dives, 23 were performed in a 15 square kilometres area that was previously mapped with multibeam echosounder. These data were used to create three-dimensional digital maps and were projected and integrated with the acoustic tracking data in a GIS in order to have the ROV position georeferenced in real time on a PC screen during sampling (Fig. 3).

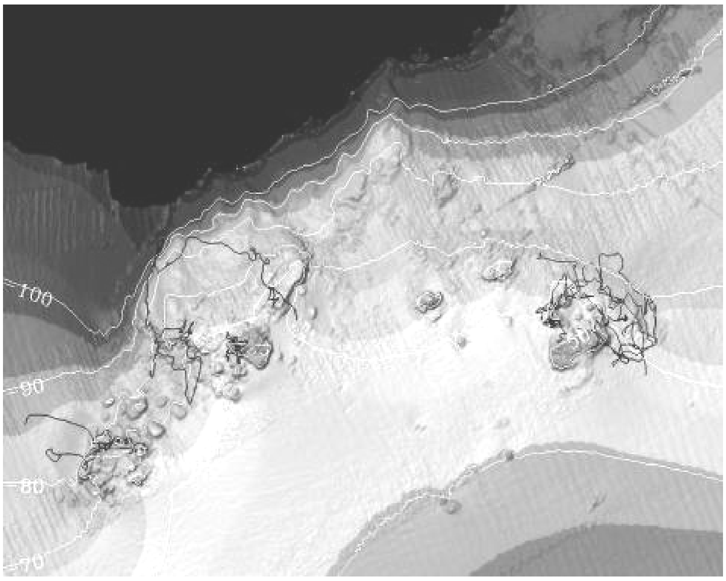

Fig. 3: Multibeam chart and Rov route

More than 3500 georeferenced HD pictures and 10 hours of HD video were collected. This work allowed us to identify and explore several rocky assemblages not present on the official charts and to obtain detailed 3D images of several of them (Fig. 4). ROV surveys revealed the presence of several coralligenous biocenosis with very interesting and rare species. Some of them have never or rarely been observed in their natural environment: *Antipathes dichotoma, Acanthogorgia cf. hirsuta, Errina aspera, Callogorgia verticillata, Antipathella subpinnata, Gerardia savaglia* and *Callanthias ruber*. All these species were filmed, photographed and, when possible, a fragment was collected. With the use of the acoustic positioning system we were able to know constantly the exact position (lat, long and depth) of the ROV and these data were used to calculate the number and the density of encountered species. The high definition movies and photos collected, were useful for species identification and allowed us to observe, for the first time, the morphology and the behavior of several species never seen until now in their natural environment. The presence of two laser pointers was essential to measure with dedicated software morphometric characters and the density of individuals encountered (for an example see the papers by Salvati *et al.* and Angiolillo *et al.* presented at this Symposium). Multibeam echosounder data were also used to create three-dimensional georeferenced distribution maps of protected species, in relation of depth, orientation and slope of the substrata (for an example see the papers by Giusti *et al.* and Bo *et al.* presented at this Symposium).

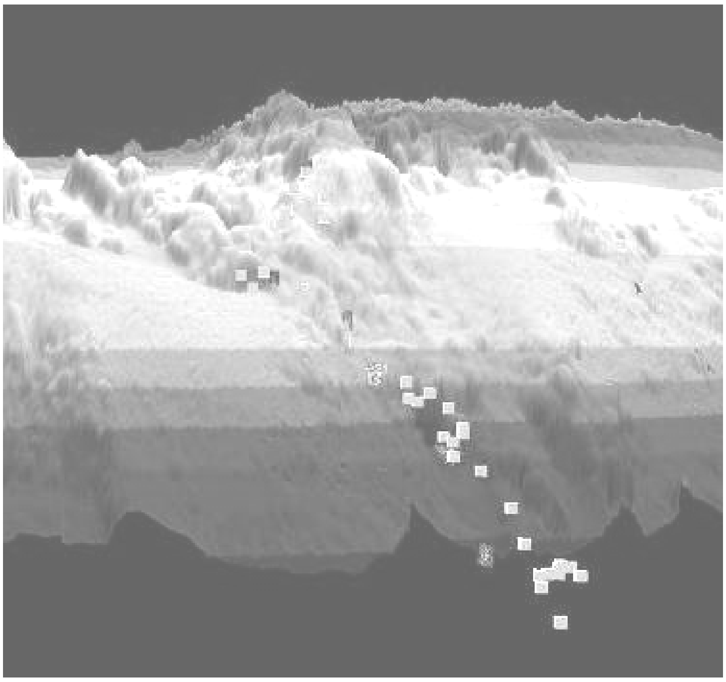

Fig. 4: 3D Map (vertical exaggeration 2X) with pictures

DISCUSSION AND/OR CONCLUSIONS

The use of a small observer class ROV equipped with an acoustic positioning system and interfaced with the GIS, provided us the opportunity to navigate safety with extreme precision, also in difficult environments like vertical cliff and deep rocky assemblages, even from a small and economic research vessel or fishing boat. The use of ROV and high-resolution multibeam sonar maps, allowed us to discover and evaluate the distribution and abundance of marine, uncommon, rare and protected species, present in the twilight zone. This is a high biodiversity environment rich of species that are presents both in deep and in shallowl waters, like several gorgonians, black corals and sponges. The information collected can be crucial to help in making decisions concerning potential locations of marine protected areas (Anonimous, 2002) for remote and sensible habitat characterized by extremely rare and protected species like the false black coral *Antipathes dichotoma.* Regarding this species, in all the Mediterranean Sea we know only few specimens. Detailed habitat mapping provides a large amount of information on the benthic assemblage of an area in a relatively short amount of time, and further processing of data with GIS can produce accurate estimates of actual areas categorized by various physical parameters. This information, coupled with field surveys to obtain information on animal and habitat associations, can allow for detailed and accurate estimates of abundance of marine organisms. Three-dimensional visualization facilitates new and encouraging avenues to process, explore, and present complex processes in marine science (Wolanski *et al*. 2000) and, in particular, benthic habitats. While spatial databases and spatial analysis have made major advances in recent years, the integration of 3D visuals has not. Viewing benthic data in an interactive 3D environment can provide the additional display and analysis environment needed to view relationships not recognized in 2D. Effective 3D visualizations of complex data sets make it easier for scientists in different disciplines to perceive patterns because the spatial relationships are easier to recognize and comprehend. Effective 3D visualization cuts through such problems and facilitates viewing of complex data in a medium that is inherently easier to understand by most audiences.

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TROPHIC STRUCTURE AND FUNCTIONING OF VERMETID REEF COMMUNITY BASED ON CARBON AND NITROGEN STABLE ISOTOPE ANALYSIS

ABSTRACT

Vermetid reefs are highly biodiverse biogenic substrata that have been receiving increasing attention in the last years, as they are an important habitat protected by international conventions. However, very little is known about the food habits of the bioconstructor species and food web structure of the entire community. The main goals of this study were to describe the trophic structure of vermetid reef community and to asses differences in the exploitation of basal sources by reef inhabitants. Therefore, as the vermetid reef is divided in three morphological portions along a transect perpendicular to the coastline (inner edge, cuvette and outer edge) differing both in wave exposure level and populations, tests were carried out to determine whether differences occur between these portions in the role played by organic matter sources. Carbon and nitrogen stable isotope composition of the main components of a vermetid reef from the north-western coast of Sicily (Italy) was analysed in May 2006. The analyses were carried out on the major bioconstructor of the reef, the cenogastropod Dendropoma petraeum, other benthic consumers (e.g. anfipods, polichaets, fishes, sipunculid worms) and the potential organic matter sources (macroalgae, microphytobenthos, suspended particulate organic matter). The species investigated belonged to various trophic guilds, such as filter-feeders, herbivorous and predators/scavengers. The major sources of energy were identified as originating from macroalgae and microphytobenthos, followed by suspended particulate organic matter. Organisms from the reef portions showed differences in the isotopic composition, suggesting a different use of organic matter sources related to wave exposure level. The results of this study helped to increase the little knowledge of vermetid reef ecology and provided new interesting insights into their functioning and weaknesses.

KEY-WORDS: Vermetid reef; food web; stable isotope; Mediterranean.

INTRODUCTION

Intertidal systems are characterized by food webs with high level of connectance and by a strong bentho-pelagic coupling (Carlier *et al.*, 2007). In intertidal flats the organic matter sources available for benthic organisms are diverse because of the various inputs and the large variety of organic matter sources (e.g., seagrasses, macroalgae, microphytobenthos and planktonic derived matter) (Grall *et al.*, 2006). Stable isotope analyses have been proven to be a powerful tool in describing the organic matter flow and resolving trophic relationship in coastal ecosystems (Bode *et al.*, 2006). The technique is based on the observation of a predictable isotopic fractionation from one trophic level to the next. $\delta^{13}C$ and $\delta^{15}N$ composition of consumers reflects that of assimilated food plus, a slight and a more consistent enrichment for $\delta^{13}C$ and $\delta^{15}N$ respectively (Post, 2002). To our knowledge this approach has never been used to describe trophic structure and functioning of vermetid reef intertidal communities, since information about the organic matter sources exploited in this system by the macrofauna is lacking. Vermetid reefs are highly biodiverse biogenic constructions (Safriel & Ben-Eliahu, 1991), structurally comparable to coralline reefs in tropical seas, indeed they play a key role in modifying shape and ecological characteristics of the transitional area between mesolittoral and infralittoral flats, making the structure tridimensional and more complex (Safriel & Ben-Eliahu, 1991; Consoli *et al.*, 2008). In addition, vemetid reefs are protected by international conventions (e.g. Barcelona Convention). In the Mediterranean Sea *Dendropoma petraeum* is the main structural species (Safriel, 1975).

D. petraeum reefs host a great number of algae and interstitial organisms (Huston 1994), amplifying the available space for species belonging to several taxa (e.g. molluscs, polychaets, crustaceans).

Among these, the interstitial Sipinculida worm (*Phascolosoma granulatum*), deserves particular attention. It is an abundant inhabitant tightly connected to the platform, living in the biocostruction pores and in empty shells of *D. petraeum* (Colombo, 2008).

Along a transect perpendicular to the coastline, *D. petraeum* reefs can be divided in three morphological portions, the inner edge, the *cuvette* and the outer edge, which correspond respectively to the terrestrial boundary, the hollows of the central portion and the sea boundary of the bioconstruction platform. These portions differ both in level of exposure to waves and in populations: the *cuvette* is the most conspicuous portion, with the most complex and numerous community, including fishes (Chemello, 1989). An important factor limiting the distribution and the width of the vermetid reef is the superficial hydrodynamism; exposed shores and higher hydrodynamic levels are preferable (Dieli, 2003). In this context, it is feasible to hypothesize that at a small spatial scale, such as the seaward transect from the inner to the outer edge, the different exposure can affect distribution, feeding and growth of *D. petraeum* and the other associated organisms.

So far, the functional ecology of these unique and complex bioconstructions has received very little attention in contrast to other marine rocky reefs. The aims of the present study were to evaluate whether differences in organic matter exploitation occur in specimens living in different portions of the reef (inner edge, *cuvette*, outer edge), related to superficial hydrodynamism, and to describe the food web associated with vermetid reefs, with particular emphasis on the identification of the main exploited organic matter sources.

MATERIAL AND METHODS

The study was conducted along the north-western coast of Sicily (Italy) in the Marine Protected Area (MPA) “Capo Gallo-Isola delle Femmine”. Six stations, separated by a distance of approximately 15 m, were chosen in zone B of the MPA.

Sampling was carried out in May 2006 and consisted in collecting three replicates of the main components of the vermetid reef: *D. petraeum* and *P. granulatum* were collected in the three portions of the reef (inner edge, *cuvette*, outer edge); the most abundant benthic animals living in the *cuvette*: Mollusca Patellidae (*Patella caerulea, Patella rustica, Patella ulyssiponensis,*), Crustacea Amphipoda (*Hyale* sp. and Gammaridae), sessile (Sabellidae, Terebellidae) and mobile (Eunicidae and Nereididae) Anellida Polychaeta, Pisces Blennidae (*Aidablennius sphinx*, *Coryphoblennius galerita, Lipophrys canevae, Parablennius sanguinolentus*). Potential organic matter sources were also sampled both in the *cuvette* [the macroalgae *Laurencia* sp., *Cystoseira* sp., *Ceramium* sp. and epilithon (benthic diatoms and filamentous microalgae)] and in the facing marine area [particulate organic matter (POM)].

Every sample was identified and rinsed with distilled water. All samples were oven dried to constant weight at 60° C and ground into a homogeneous powder by using mortar and pestle or a ball mill.

Isotopic analyses were performed with an isotope ratio mass spectrometer (ThermoElectron Delta Plus XP) connected to an elemental analyser (ThermoElectron Flash EA 1112). Isotopic values were expressed in conventional δ unit notation (as part per mil) in relation to international standards, following the formula: $\delta X = [(R_{sample} / R_{standard}) - 1] \times 10^3$, where X is ^{13}C or ^{15}N and R is the corresponding $^{13}C/^{12}C$ or $^{15}N/^{14}N$ ratio. Analytical precision based on the standard deviation of replicates of internal standards was 0,2 ‰ for both $\delta^{13}C$ and $\delta^{15}N$.

The analysis of variance (ANOVA) was performed to test the hypothesis that *D. petraeum* and *P. granulatum* isotopic composition varied among the three portions of the reef. The GMAV version statistical software was used to perform ANOVA. A mixing model was applied as proposed by Phillips and Gregg (2003) in order to determine the relative contribution of different organic matter sources to organism diet. The OM sources used were POM and benthic sources. Benthic source values were obtained averaging epilithon and reef macroalgae values, except for *D. petraeum* and sessile Polychaeta, for which only epilithon values were considered, as ingestion of macroalgae is highly improbable.

RESULTS

Comparing $\delta^{13}C$ and $\delta^{15}N$ values of *D. petraeum* and *P. granulatum* from the three portions of the reef (Fig. 1) significant differences were found only in the carbon isotopic composition (ANOVA, $P \leq 0.05$ for both species). These two sessile invertebrates showed $\delta^{13}C$ values more depleted in the outer edge, followed by the *cuvette* and the inner edge (Fig. 1) (SNK tests: outer edge < *cuvette* < inner edge).

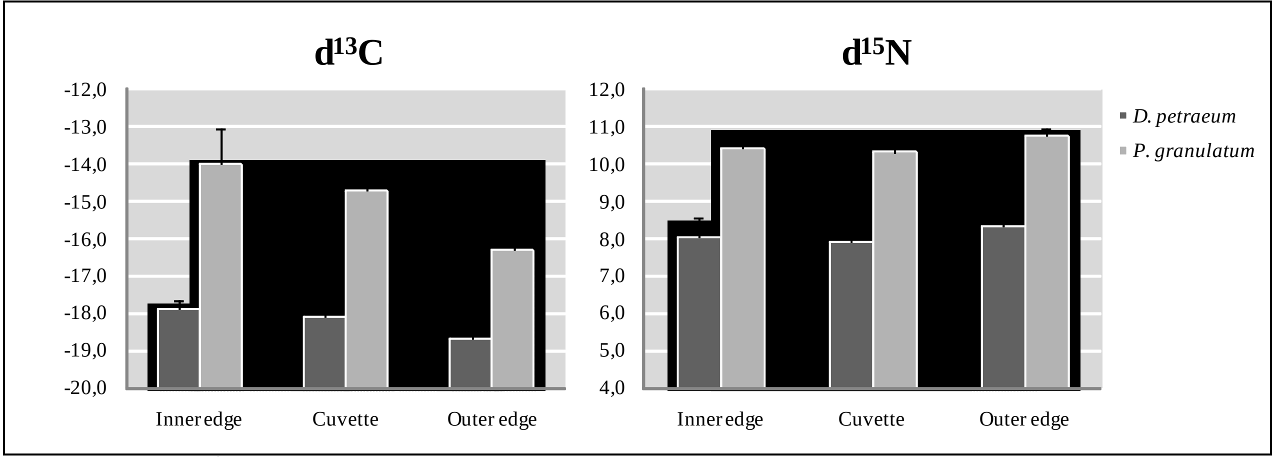

Fig 1: Means of $\delta^{13}C$ and $\delta^{15}N$ (± sd ‰) values for *D. petraeum* and *P. granulatum* of the three portions of the reef.

Since $\delta^{13}C$ values indicate the sources of organic matter exploited, these results confirmed the hypothesis that different levels of exposure affect the availability of the organic matter for consumers. Results of isotopic analyses of the main components of the community were plotted in Fig. 2.

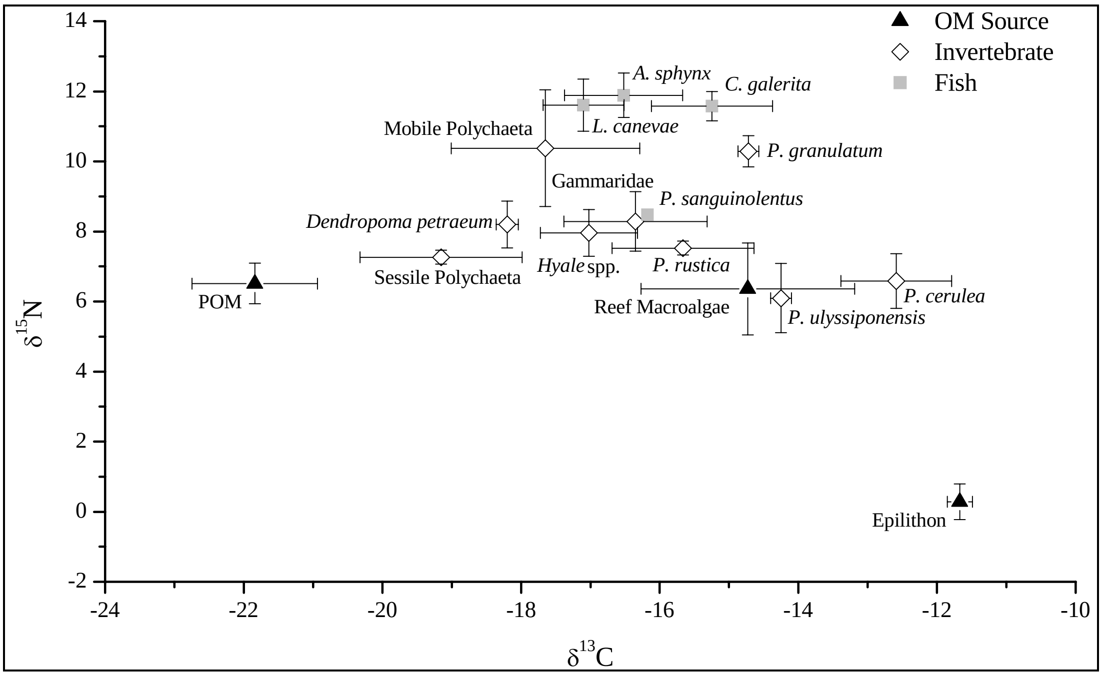

Figure. 2. Means of $\delta^{13}C$ and $\delta^{15}N$ (± sd ‰) values for the food web components sampled.

The $\delta^{13}C$ values of the organic matter sources varied greatly, ranging from −21, 84‰ in POM to −11,67‰ in epilithon. $\delta^{13}C$ showed also variability in the consumers, ranging from −19,15‰ in sessile Polychaeta to −12,58‰ in *P. caerulea*. $\delta^{15}N$ signatures varied consistently from the food sources (epilithon: 0,3 ± 0,7‰) to consumers (*A. sphynx*: 11,9 ± 0,7‰), in accordance with the expected ^{15}N increase through the food web as an enrichment of about 3–3.5‰ is generally found from a trophic level to the upper one (Post, 2002).

Mixing models were applied to estimate the contribution of benthic sources (reef macroalgae and epilithon) and POM to the diet of consumers. Results showed that for 7 out of 12 consumers benthic sources contributed by approximately 50% (Tab. 1). *P. ulyssiponensis* showed the highest relative contribution of benthic sources (100%) (Tab. 1). Sessile and mobile Polychaeta and *D. petraeum* derived a more important organic matter input from POM (Tab. 1).

Tab 1: Percentage (%) contribution of benthic sources and POM to the diet of consumers, determinated by mixing models.

Consumers	Benthic sources	POM
P. ulyssiponensis	100	0
P. rustica	69	31
C. galerita	57	43
P. granulatum	56	44
***Hyale* spp.**	54	46
Gammaridae	53	47
P. sanguinolentus	51	49
L. canevae	46	54
A. sphynx	45	55
Mobile Polychaeta	37	63
D. petraeum	32	68
Sessile Polychaeta	28	72

DISCUSSION AND CONCLUSION

Considering the baseline organic matter sources, in this work the POM isotopic composition (δ^{13}C: -21,8‰ ± 0,9; δ^{15}N: 6,5‰ ± 0,6) exhibited values that are distinctive of planktonic components, as measured in other areas of the Tyrrhenian Sea: phytoplankton typically range between -23 and -20‰ for carbon and 5/6‰ for nitrogen (Vizzini *et al.*, 2002). Epilithon isotopic values (δ^{13}C: -11,7‰ ± 0,2; δ^{15}N: 0,3‰ ± 0,5) did not match diatom values found in other studies (δ^{13}C:-15/-14‰, δ^{15}N: 5/7‰; Bode *et al.,* 2006; Vizzini & Mazzola, 2006), although being constituted mostly by benthic diatoms. Probably, filamentous algae present in the samples played a significant role in determining the isotopic signature of the overall epilithic community. Reef macroalgae showed a higher proportion of heavy isotopes than planktonic organic matter, which is in line with previous findings (Michener & Schell, 1994), and their isotopic composition is in the same range found for other Mediterranean macroalgae (Bode *et al*., 2006).

δ^{13}C values in primary producers (such as phytoplankton or phytobenthos) are affected by the source of carbon and fractionation processes, and in turn affect the isotopic signatures of their consumers (Riera *et al*., 1999), allowing distinctions to be made between pelagic and benthic (Grall *et al*., 2006) contribution to the diet of organisms that live at intertidal level.

The hypotesis that different exposure can affect feeding of *D. petraeum* and *P. granulatum* was confirmed by the results obtained from the comparison among the portions of the reef. We found differences in the carbon isotopic composition of the two consumers investigated. The isotopic variability suggests the use of organic matter sources of different origin: the more exposed organisms are more affected by the contribution of the planktonic component (POM), depleted in ^{13}C compared to the benthic algae, while in the most sheltered portion the influence of benthic organic matter is also observed. The different hydrodynamic conditions and exposure to the tides and waves influence feeding rates and behaviours: the *cuvette* results less subject to hydrodynamic forcing, in comparison to the inner edge and, above all, to the outer edge. The organisms living in the *cuvette* are subject to more stable conditions and more prolonged submersion. In this portion a filter feeder, such as *D. petraeum,* besides the planktonic particulate matter, that typically constitutes the principal source of organic matter for suspension feeders, also exploited benthic components (i.e. epilithon). *P. granulatum*, which is described as a scavenger detritivorous (Murina *et al*., 1999), could be considerate a benthic source relying organism: but in this work it was highlighted how in outer portion of the reef, it showed a relevant influence of planktonic origin organic matter.

Considering the whole community of the *cuvette,* the conventional values of isotopic fractionation (≈1 ‰ for δ^{13}C; ≈3,5 ‰ for δ^{15}N, Post, 2002) was used to describe the trophic relationships within the food web. The species investigated belonged to various trophic guilds. *D. petraeum* and sessile Polychaeta are suspension feeders that base their diet on particulate matter (Pierri *et al*., 2006; Barash & Zenziper, 1985). Mixing model results highlighted that the contribution of benthic sources was 28% for Polychaeta and 32% for *D. petraeum*: this benthic input was from epilithic microalgae that became available to the filter feeders through resuspension processes. In addition it is well known that *D. petraeum* can use a grazing-like behaviour that mainly provides an anti-fouling tool, but at the same time supplies additional food (Calvo *et al*., 1998) limited to the epilithic component; the direct exploitation of macroalgae seems to be highly improbable.

Amphipoda (Gammaridae and *Hyale* sp.) generally show a variable diet, being described as grazers and/or deposit-feeders (Ruffo, 1998); many species (e.g. *Hyale* sp.) exploit preferentially epiphytes on the macroalgal surface (Ruffo, 1998). In this study the isotopic signatures of Amphipoda is consistent with the assimilation of both benthic sources and POM, as derived from the mixing model outcomes that showed an almost equal partition of contribution (about 50%) (Tab.1).

Patellidae are known in literature reference as grazers that basically forage on microalgae (Espinosa *et al*., 2006). In this study these organisms showed the highest percentage contribution of benthic derived matter (Tab. 1). The three species sampled demonstrated a marked variation in carbon isotopic signature, showing that congeners species are able to differentiate their trophic niche. In particular *P. caerulea* showed the most enriched carbon isotopic values among consumers, and exhibited isotopic values that did not match any of the food sources, suggesting the exploitation of additional algae not sampled in this study.

For mobile Polychaeta and *P. granulatum* literature describes a mixed diet of animal and vegetal detritus (Murina *et al*., 1999; Giangrande *et al*., 2000): indeed they showed an isotopic composition compatible with a omnivorous diet. In this work they were represented in a very small range δ^{15}N values, suggesting that they belong to the same trophic level, but mixing model results showed that Polychaeta probably feed more on prey that foraged on planktonic organic matter (63% from POM organic matter) than *P. granulatum* (44% from POM organic matter).

Intertidal fish assemblages are structured manly trough feeding differentiation (Munõz & Ojeda1, 1997); indeed Blennidae sampled in this study could be differentiated in two trophic groups: *A. sphinx*, *C. galerita, L. canevae* that showed an isotopic signature consistent with an essentially carnivorous diet, and *P. sanguinolentus* that demonstrated the same trophic level of herbivorous invertebrates (e.g. Amphipoda). Mixing model results for *P. sanguinolentus* displayed an equal relative contribution for both sources considered. *C. galerita* probably prey more on invertebrates that rely on benthic origin matter, as highlighted by mixing model, compared to *A. sphinx* and *L. canevae.*

Therefore, these alignments of consumer isotope signatures indicate that in intertidal habitat they obtain their food from a mixture of benthic sources and phytoplankton. Stable isotope studies on coastal benthic consumers have revealed the importance of locally produced food sources for the benthic consumers (Deegan & Garritt 1997, Riera et al. 1999), but the great relevance that planktonic matter can have on intertidal consumers is also known (Menge & Branch 2001). The *cuvette* portion of vermetid reefs seems to function in a similar way as transitional coastal basins, where both autochthonous (reef primary producers) and allochthonous (open-sea primary producers) organic matter plays an important trophic role, although clear differences were revealed in the various species depending on their feeding strategy and current and wave exposition level.

Other studies have highlighted the relevance of microphytobenthos in soft bottom flats (Rzeznik-Orignac *et al*., 2008), however in rocky shores microphytobenthos would be relatively less important for consumers than other primary producers (Bode *et al*., 2006). In this work we found how the epilithic community is an important source for several primary consumers, belonging to scavengers and suspension and deposit feeders. This study widened the knowledge on the food web of the vermetid reef, and suggested the importance of protecting compartments from which the organic matter source exploited derives. Future studies will be necessary to gain a better understanding of the trophic structure and processes of vermetid reefs and to comprehend the functioning and vulnerability of these complex systems worthy of protection.

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ENVIRONMENTAL AND CONSERVATION RELEVANCE OF THE PUNTA MANARA CORALLIGENOUS BEDS (EASTERN LIGURIAN SEA)

ABSTRACT

The seafloors in front of the Punta Manara (eastern Ligurian Sea) are characterised by a wide extension of rocky bottoms hosting many different flourishing facies of the Mediterranean coralligenous assemblage. The relevance of this area was pointed out firstly in the fifties, with the description of the rich presence of some species of Gorgonians and the first record of the zoanthinarian Gerardia savaglia for the Italian seas.

The aim of this contribution is to synthesise the available data on this site, showing the results of the most recent multi-beam and side scan sonar campaigns, coupled to scuba diving and ROV (Remote Operating Vehicle) original observations. The most updated information on the extension of the whole complex of rocky reefs and the list of the main relevant facies of the coralligenous is given in relation to their distribution and range of depth.

This data together with the information on the main threats affecting this habitat lets to recommend some management measures for this area that is included in a Site of Community Importance (SCI - EC Directive 92/43).

KEY-WORDS: Coastal management, Coralligenous assemblages, nature conservation

INTRODUCTION

The coralligenous marine habitat is a unique calcareous formation of biogenic origin of the Mediterranean Sea, creating by the addition of encrusting algae growing in a particular range of dim light and particular environmental conditions (Ballesteros, 2006). The conservational relevance of this assemblage, due to its structure and to its richness in species (Giaccone, 2007), coupled with its vulnerability to human activities, motivated the decision of adopting a specific action plan for its protection by the Contracting Parties of the Barcelona Convention (UNEP/MAP, 2007).

The protection of biodiversity at the European Community level finds its primary application through the implementation of the EC Directives 79/409 and 92/43, respectively known as the "Birds" and "Habitats" Directives. These two complementary Directives foresee the creation of a network of protected sites called NATURA2000, whose objective is the conservation of European threatened species and habitats. In this framework each Country creates a homogenous system of Sites of Community Importance (SCIs) also in its marine environment. In Italy the Regional Authorities are directly involved in the definition of the sites constituting the Italian NATURA2000 network.

The Tigullio Gulf is considered a site of high natural interest and the biological richness of its marine benthic assemblages depends on the action of different ecological factors and on its strategic position in the Ligurian Sea and in the Western Mediterranean (Morri *et al.*, 1986).

The particular ecological relevance of this marine area was outlined at the end of the fifties by Rossi (1958) with the publication of the first record for the Italian seas of the "false black coral" *Gerardia savaglia*, as an element of a rich coralligenous habitat characterised by the presence of large sea-fans. At the end of the nineties the implementation of the EU Directives allowed to propose one SCI located near Punta Manara, mainly officially devoted to protect *Posidonia oceanica* meadows (# IT 1333371- Fondali di Punta Manara). The boudaries of this SCI were successively officially modified in 2005 with a Regional Act on the basis of new information (Diviacco & Coppo, 2006; Rovere *et al.*, 2006), mainly to include the coralligenous habitat. Actually the Punta Manara SCI covers 86.94 ha, including bottoms up to 80 m of depth.

The need of information to draw up the SIC management plan motivated the running of specific field studies to collect data on marine geomorphology and to estimate the distribution of this habitat in the area. The results of the field campaign, implemented on GIS, were used to create a detailed bathymetry and map. This cartographic layer was the reference for the analysis of the data sets on the presence and the bathymetric distribution of main benthic species recorded by means of specific research activities carried out using a Remote Operating Vehicle (ROV) and scuba dives.

MATERIALS AND METHODS

A detailed morphological survey has been carried out by means of Multibeam Echo Sounder Simrad EM3002 (300 KHz), applying also the Side Scan Sonar option, and this data was geo-referred by a dGPS and by a movement compensation system. The placement of a tide gauge respect to the tide levels allows to adjust bathymetrical data.

The set of corrected data was utilized to define a “x, y, z” grid, with x-y mesh of 1 m. The software GIS Vertical Mapper (Mapinfo professional) was applied to this grid to create a digital model of the seafloor.

The data on the main benthic species characterising the coralligenous in the study area *per* depth and location was collected from 12 to 45 m depth by means of 16 scientific scuba dives, and from 36 to 85 m depth by means of 18 Remote Operating Vehicle (ROV) transects. Presence and distribution of all the species were recorded by pictures and video supports.

RESULTS

The analysis of the data collected by the Multibeam Echo Sounder survey allowed obtaining a preliminary map of the area. The application of the GIS Vertical Mapper software produced a model of the sea-floor, giving a global view of the rocky bank system (Fig. 1).

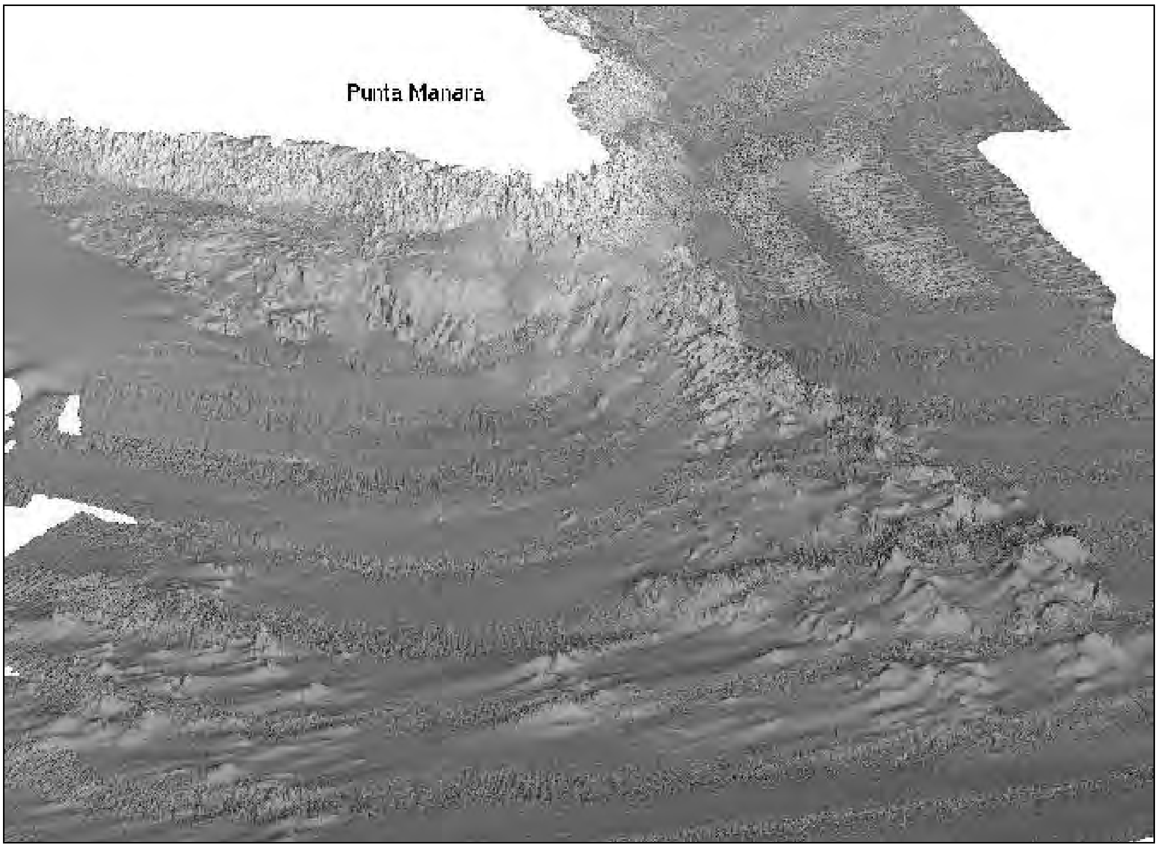

Fig. 1: Digital model showing the distribution of the rocky shoals in front of Punta Manara.

This 3D figure is particularly useful to appreciate both the spatial distribution of the rocky bottom, and its morphology, characterised by two main crests, North-South oriented, and by a third, more western and fragmented.

The transposition of all the information collected on the benthic assemblages by scuba diving and ROV, on the model of the seafloor allowed to create a 2D bionomic map of the rocky banks, placed in front of Punta Manara (Fig. 2). The rocky bottom in the studied area hosts the biocoenosis of the photophilic algae until 12 m depth approximately (Fig. 2). This assemblage is followed by a belt of sciaphilic algae, settled on sparse rocky blocks. The coralligenous starts, after a short stretch of soft bottom, on the rocky shoals located at 24 m depth (top of the blocks about -20m).

On the whole the coralligenous characterizes the studied rocky bank in front of Punta Manara in the range of depth comprised from -24 m to - 85 m, covering an area of about 35 ha.

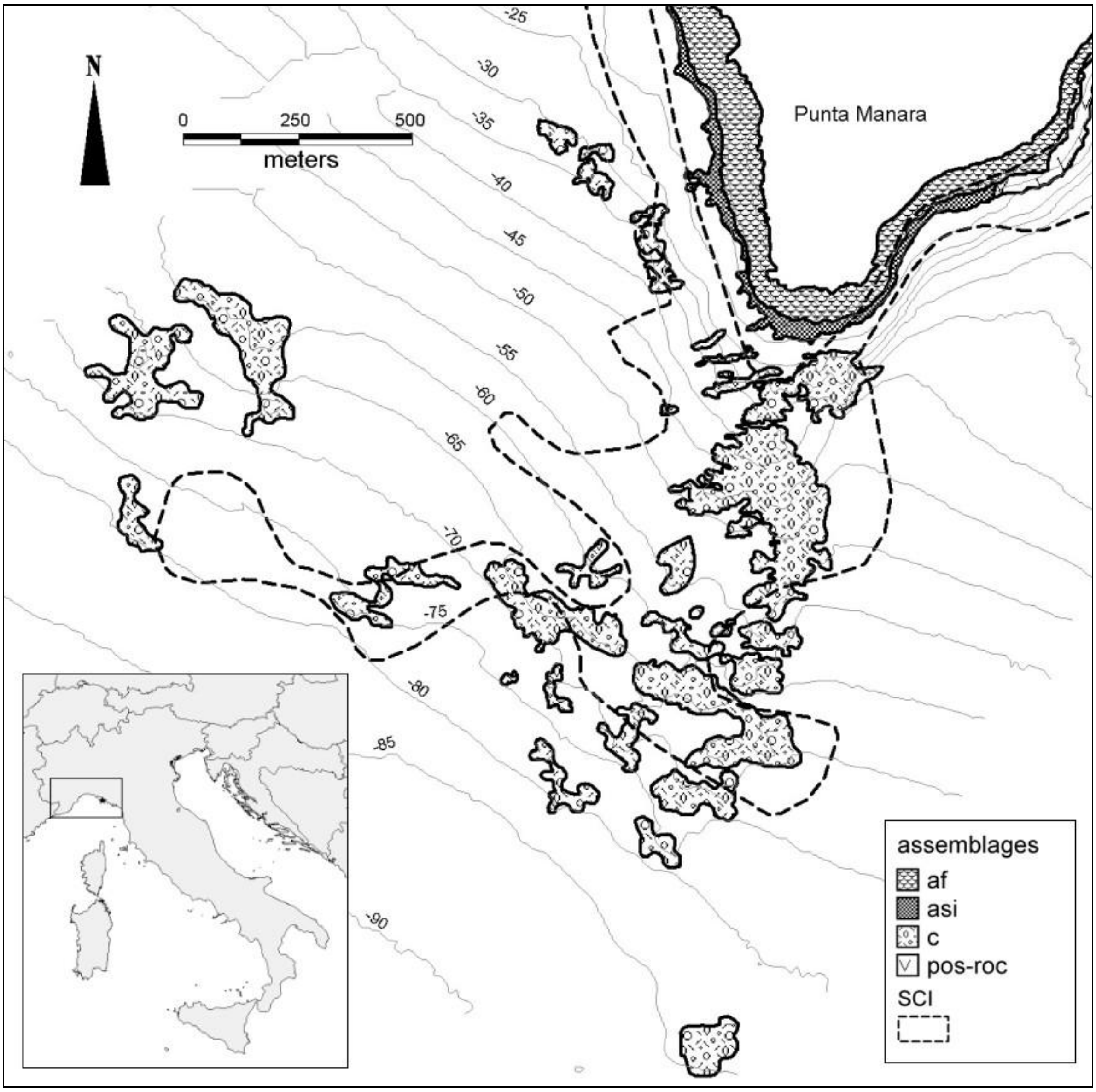

Fig. 2: Distribution of the coralligenous on the rocky banks in front of Punta Manara and extension of SCI (Site of Community Importance - EC Directive 92/43) (af = photophilous algae; asi = infralittoral sciaphilic algae; c = coralligenous; pos-roc = *Posidonia oceanica* on rocky bottom).

Taking into account the dominance of particular key-species, considered because architecturally important or economically valuable (Ballesteros, 2006), in the studied area were identified 3 main typologies of coralligenous:

- dominated by Coralline algae (mainly *Lithophyllum* sp.p.) – this typology characterises the depth range 24-30 m; no particular species were recorded associated to the coralline algae, because the most abundant (*E. sepositus, E. singularis, P. fascialis, Petrosia* sp., *S. cunctatrix*), were recorded in a wide range of depth in the area (Tab.1);

Tab. 1: List of the main species recorded on the rocky bank during scuba and ROV surveys and depth range of finding.

	SPECIES	*DEPTH RANGE*
Algae	*Cystoseira* sp.	27-61
	Dictyota dichotoma	29-36
	Lithophyllum stictaeforme	59
	Flabellia petiolata	24-50
	Peyssonnellia squamaria	25-41
	Psedolithophyllum expansum	20-41
Porifera	*Axinella damicornis*	35-78
	Axinella polypoides	27-82
	Axinella verrucosa	20-75
	Calyx nicaeensis	29-75
	Hemimycale columella	29-78
	Ircinia fasciculata	29-69
	Ircinia foetida	71-79
	Ircinia sp.	58-75
	Petrosia ficiformis	72
	Spirastrella cunctatrix	20-58
	Verongia aerophoba	27
Cnidaria	*Anemonia sulcata*	29
	Cerianthus membranaceus	24-35
	Cladocora coespitosa	29-36
	Eunicella singularis	24-85
	Eunicella verrucosa	40-83
	Gerardia savaglia	53-83
	Leptogorgia sarmentosa	24-82
	Paramuricea clavata	27-85
	Parazoanthus axinellae	20-45
Echiurida	*Bonellia viridis*	27-80
Mollusca	*Hypselodoris picta*	59
	Peltodoris atromaculata	29-36
Annelida	*Bispira volutacornis*	20-27
	Filograna implexa	26-85
	Protula tubularia	20-27
	Sabella spallanzanii	20-25
Tentaculata - Bryozoa	*Myriapora truncata*	20-70
	Pentapora fascialis	24-53
	Porella cervicornis	78-79
	Reteporella sp.	20-79
	Bonellia viridis	56-85
Echinodermata	*Echinaster sepositus*	24-36
	Holoturia sp.	78
Tunicata	*Halocynthia papillosa*	20-41

- dominated by *Axinella damicornis* epibionted by *Parazoanthus axinellae* - this typology characterises only specific stretches of rocky bottom, located on the most north-eastern part of the bank, within -35 and -37m; the species associated to this assemblage (*L. stictaeforme*, *F. petiolata*, *E. sepositus*, *E. singularis*, *P. fascialis*, *Petrosia* sp., *S. cunctatrix*) were recorded in the area in a wide range of depth and exposition (Tab.1); specimens of *A. damicornis* epibionted by *P. axinellae* were recorded in the depth range from -24 to -72m;
- dominated by *P. clavata* (-29-85 m) – this last typology, characterised by the red sea fan, shows in the studied area three main situations:
    - huge dominance of large *P. clavata*;
    - dominance of *P. clavata* with and high presence of *A. polypoides* (mainly in the depth range 69-70m);
    - dominance of *P. clavata* with and high frequency of the “false black-coral” *G. savaglia*, species that becomes very common in the depth range 79-83 m.

The shallower colony of *G. savaglia* was recorded at -53. This species became very common on hard bottom between -79 and -83 m.

Scuba and ROV observations allowed evidencing a huge human impact on the studied area. The main treats registered were related to a phenomenon of degradation by fishing activities. It was possible to identify two different typology of problems: one due to the lost of dozens of hand-lines and many nets; the second one due to the intentional overboard of broken tools or corroded trawl warps on a stretch of seafloor where trawling is naturally “impossible”, due to the presence of rocky bank.

DISCUSSION AND CONCLUSIONS

The collected data allowed to define with precision the spatial and bathymetric distribution of coralligenous beds in front of Punta Manara, the eastern limit of the Tigullio Gulf, and to characterize their main conspicuous benthic species. Focusing on the bathymetric range of distribution of the coralligenous, the upper and the lower limits recorded in the studied area are in accordance with the values summarised by Ballesteros (2006) for some sites of the Western Mediterranean. Nevertheless the extension of 60 m of the depth range of presence (from 20 to 85m depth) is particularly wide. This peculiarity could be explained both considering the water transparency in the area (the minimal depth for the presence of the coralligenous frameworks depends on the amount of irradiance reaching the sea floor), and probably other aspects as nutrients and water movement.

The new, more precise, data shows the need of a partial revision of the official boundaries of the SCI # IT 1333371- Fondali di Punta Manara, because partially unsuitable to include all the extension of the rocky banks. The area represents one site of high relevance for the richness of its benthic assemblages and its extension. This is confirmed by the large presence of the assemblage dominated by *P. clavata* and also by specific typologies of coralligenous, characterised by the dominance of *A. damicornis* epibionted by *P. axinellae* and by the high frequency of the “false black-coral” *G. savaglia*, that becomes common between 79 and 83 m depth. This last species holds a particular historical relevance, because Punta Manara was the site were the species was recorded for the first time in Italy (Rossi, 1958).

Considering the main coralligenous *facies* indentified as relevant in the Mediterranean Action Plan (UNEP/MAP, 2007), on the basis of gorgonian species, in the studied area the absence of the assemblage characterised by *Eunicella cavolinii* must be highlighted. The yellow sea-fan, very common in the waters of the Portofino promontory (Morri *et al*., 1986), the western limit of the Tigullio Gulf, is absolutely absent in the studied area (that represents the eastern limit of the same Gulf). The absence of this species assimilates the studied area to Punta Mesco (Tunesi *et al*., 1991), an other eastern relevant environmental site of the Ligurian Sea. The new collected data points out a clear distributive trend of *E.cavolinii facies* from East to West along the Ligurian coast: the western part of the Tigullio Gulf constitutes the area of its appearance.

Recorded data, showing the environmental relevance of the site, point out the need of new campaigns to characterize in detail the algal species composition and to draw up a more complete species list.

The studied area shows a degradation mainly due to fishing (direct and indirect), while the impact of the diving activity seems to be, in general, negligible. Particular attention should be paid to evaluate if the actual range of distribution of *G. savaglia* is due only to its ecological requirement and not to a specific action of collection by divers, one of the main causes of its rareness in the past in Mediterranean (Boudouresque *et al*., 1991). In fact at present this species is very common only on the hard bottoms between -79 and -83 m, depths unattainable for sports scuba divers.

The boundaries of Punta Manara site (# IT 1333371- Fondali di Punta Manara) were modified on the basis of the more recent interpretation of the NATURA 2000, including in the category "1170 – Reefs", the coralligenous concretions (EC, 2007). The creation of a SCI to protect the studied area constitutes an important conservative choice, considering that both Portofino Promontory and Punta Mesco seafloors are included in two national Italian marine protected areas. Although the guide-lines for the management of "NATURA2000 habitats - 1120 *Posidonia beds" were recently published (Díaz-Almela & Duarte, 2008), at EU level complete indications for the management of the Mediterranean marine SCIs are lacking (Tunesi *et al*., in press).

Collected data stresses the need of regulation and control perfectly in line with the indications contained in the Mediterranean Action Plan (UNEP/MAP, 2007). In particular, the studied area requires a strong control of the waste discharge ban, and the regulation of fishing activities (sport and artisanal).

The main environmental problems seem to be due primarily to the wrong behaviour of the locals. This situation could be overcame developing specific awakening campaigns and informing the inhabitants on the environmental relevance of the site. This approach, coupled with an operation to remove all the wastes actually present on this rocky bank, could be the first main required activities at the start up of the management of the new protected area.

The Punta Manara SCI could be an excellent "pilot area" where, improving some management options identified in the framework of the Mediterranean Action Plan (UNEP/MAP, 2007), it will be possible to identify solutions useful to support the definition of guidelines for the management of Mediterranean SCI conceived to protect the NATURA2000 "1170 – Reefs".

The Coralligenous assemblages constitute one of the most important 'hot spots' of species diversity in the Mediterranean (Boudouresque, 2004). All the Countries should do their best to improve the available knowledge and to apply specific conservation measures following the solutions agreed within the Mediterranean Action Plan.

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MORTALITY AND RESILIENCE: A TEN-YEAR MONITORING OF GORGONIAN POPULATION TRENDS IN THE EASTERN LIGURIAN SEA (NW MEDITERRANEAN)

ABSTRACT

Several episodes of mass mortality, affecting local populations of gorgonians and other sessile invertebrates, coinciding with anomalous water warming, have been recorded during the last decade in the north-western Mediterranean. The population of the gorgonian Paramuricea clavata *living on a vertical cliff in the Gulf of La Spezia (Eastern Ligurian Sea) was affected in late summer 1999 and 2003 by two mortality events. The structure of this population was studied over a period of eleven years (1998-2008). Population size structure changed significantly after the two mortality events and the colony modal class shifted from 16-25 cm to 6-15 cm in height. During the post mortality period, the density of dead colonies, covered by heavy carbonate epibionts, decreased, while that of healthy colonies increased significantly, showing two opposite trends. A significant increase of recruits, found in 2008, together with the decrease in the extent of injuries of colonies, due to their ability to regenerate loss tissues, indicate a high resilience of the population and a high recovery capability of the species.*

KEY-WORDS: *Paramuricea clavata*, Mass mortality, Population dynamics, Global Climate Change, Ligurian Sea

INTRODUCTION

Repeated mass mortality events are becoming a main concern for conservation of biodiversity at the whole community level (Loya *et al*., 2001, Hughes & Jackson, 1985). The Western Mediterranean shallower coralligenous assemblages (up to about 30-35 meters depth) have been recently affected by mass mortality events which involved several ecosystem engineer species (Cerrano *et al.*, 2000; Perez *et al*., 2000; Bramanti *et al*., 2005; Linares *et al*., 2005; Ribes & Coma, 2005). The population of the gorgonian *Paramuricea clavata* (Risso, 1826), dwelling in the Gulf of La Spezia (NW Mediterranean, Italy), supplies a paradigmatic example of the response of a population living near the edge of the summer thermocline (16-25 m depth, a bathymetric range shallower than usual) to the 1999 and 2003 mortalities associated to anomalous temperature increases. Furthermore, this species is described as slow growing (0.8 cm yr^{-1}) and slow recruiting (Mistri & Ceccherelli, 1994; Coma *et al*. 1998), and low resilience to mortality increase can be forecasted for its populations.

It has been recognized that effects of mass mortalities may persist for a long time after the event (Hoegh-Guldberg, 1999) so that large temporal-scale monitoring is increasingly believed to be required to detect changes in population features. The population of *P. clavata* in the Gulf of La Spezia (Eastern Ligurian Sea) has been studied over eleven years (1998-2008) to detect any variation of spatial and temporal patterns. This paper aims to examine changes in its size structure, in injury extent of damaged colonies to analyze population resilience and regeneration ability of damaged colonies. To this target, the findings of the post-mortality' period (2004-2008) are here compared with those of the *pre-events* period (1998).

MATERIALS AND METHODS

The study was carried out on the group of islets (44°01'N, 09°50'E) in the western part of the Gulf of La Spezia (Eastern Ligurian Sea, Italy). That area is characterized by high turbidity and very low transparency; in this area a well structured coralligenous community with a *facies* of *P. clavata* dwells on a rocky, vertical cliff between 16 and 25 meters depth. During late summer 1999 and 2003, when mass mortality occurred, temperature peaked to 23 and 24°C at 20 m depth and above 22.5°C at 25 m depth, respectively. In two locations at some hundred meters one from the other, six plots $1m^2$ each were randomly selected at the depth of 21 ± 2 m. Within each plot, colony height (measured with a ruler as the distance from the colony base to the tip of the longest branch), extent of damage (proportion of colony surface with no living tissue or overgrown by epibionts) and epibiosis (different organisms covering gorgonian's axes) were recorded. Three categories of colonies were identified: undamaged, partially damaged and died.

In order to test if the extent of injury of partially damaged colonies significantly differed in the post-mortality' period (2004-2008), one-way ANOVA was used. Differences among years were checked by SNK test. For demographic analysis, undamaged and partially damaged colonies were grouped into six size classes: < 5, 6-15, 16-25, 26-35, 36-45, > 46 cm; recruitment was assessed as the number of < 5 cm high colonies found in each survey. The size structure and the modal class of the living population recorded in 2004 (after the two mortalities) and in 2008 were computed and compared with those recorded before mortalities (1998). In order to test if colony density significantly differed among pre and post-mortality' period (1998-2004-2008), one-way ANOVA was used. Differences among years were checked by SNK test.

The ability of damaged colonies to recover was monitored between 2004 and 2008 using photography on tagged colonies. Computerized images were then analyzed and the percentage of regenerated tissue was computed on the total length of each colony.

RESULTS

After 1999 and 2003 mass mortality events, population density of *P. clavata* collapsed from 36.3 ± 8.7 col m^{-2} in 1998 to 8.2 ± 3.6 col m^{-2} in 2004 (Tab. 1). After 4 years, in 2008 an about 2-fold higher density was recorded (17.3 ± 7.7 col m^{-2}) (one-way ANOVA, F = 25.23, $P < 0.0001$) (1998 *vs* 2004: SNK, $P < 0.0001$) (2004 *vs* 2008: SNK, $P < 0.05$).

In 1998, six size classes (from < 5 to > 46 cm height) were found. The population was well structured and the 16-25 cm size class was the modal one, with an average density of 11.7 living colonies (Fig. 1). In 2004 even if the number of colonies for each size-class greatly reduced, the modal class did not change (Fig. 1). Only a small number of colonies of the larger classes (36-45 and > 45 cm) survived and recruits were scarce (1 ± 0.7 col m^{-2}). In 2008, the population structure changed and the modal class shifted toward smaller colonies (6-15 cm height), with an average density of 7.5 ± 0.3 col m^{-2} (Fig. 1). A sharp increase in the number of recruits (6 ± 3.2 col m^{-2}) was recorded, accounting for 23.9 % of total living colonies, whereas the larger size classes were still scarcely represented.

Table 1: Colony density (± SD) in 1998, 2004 and 2008. Data averaged from the two locations.

Year	colony· m^{-2}	SD
1998	36.3	8.7
2004	8.2	3.6
2008	17.3	7.7

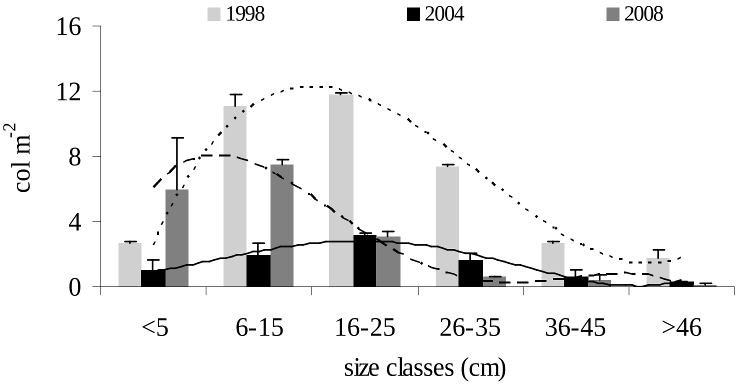

Fig. 1: Size structure of living colonies in 1998, 2004 and 2008. Data averaged from the two locations (± SE).

In 2004 after the two mortalities, the percentage of died colonies within the population was 69.9 ± 14.4 % (Fig. 2). From 2004 and 2008 undamaged colonies increased from 2.3 ± 1.2 to 68.9 ± 4.7 % respectively. On the contrary, died colonies fallen to 5.4 ± 1.3 % in 2008. Even if no significant changes in the percentage of partially damaged colonies (ranging between 24.7 and 28.8 %) occurred, the total extension of the injured surface showed a significant increase (one-way ANOVA, F=46.57, $P < 0.0001$) (Tab. 2). Although the average extent of injury did not significantly vary from 2004 and 2006, in 2004 it was more than 5-fold that in 2008 (57.2 ± 7.8 *vs* 10.7 ± 5.4 % of colony surface) (SNK, $P < 0.001$) (Tab. 2).

Table 2: Injured surface (%) of partially damaged colonies (± SD).

Year	injured surface (%)	SD
2004	57.2	7.8
2005	63.6	13.8
2006	58.5	19.9
2007	25.1	11.9
2008	10.7	5.4

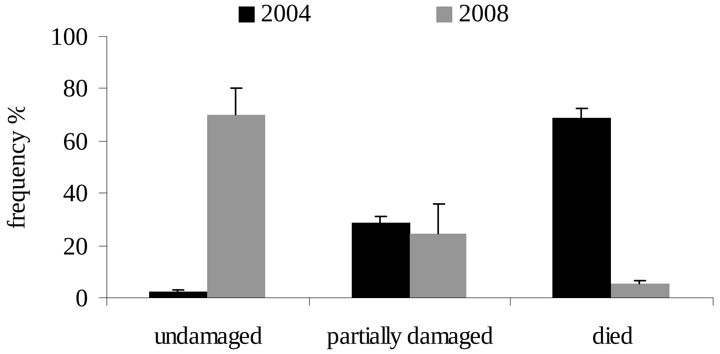

Fig. 2: Frequencies (%) of undamaged, partially damaged, died colonies in 2004 and 2008 averaged for the two locations (± SE.).

In 2004, total mortality affected all size classes even if recruits resulted less damaged than larger colonies (Fig. 3a). While in 2004 only in the lower size classes (< 25 cm height) a little proportion of undamaged colonies could be found (3 % of total density) (Fig. 3a), in 2008 almost all colonies belonging to < 5 and 6-15 cm size classes were undamaged (59.9 % of total density; Fig. 3b).

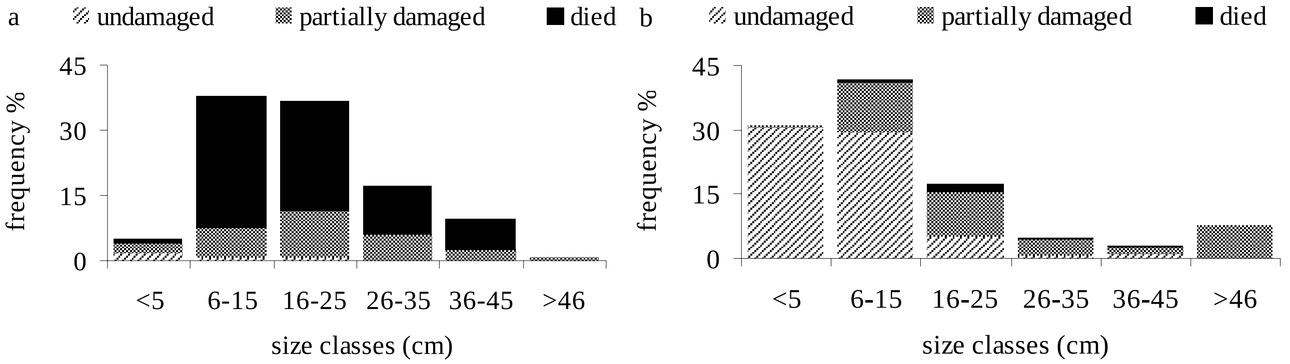

Fig. 3: Frequencies (%) of undamaged, partially damaged, died colonies in the six size classes in 2004 (a) and 2008 (b).

Annual photographic monitoring performed from 2004 to 2008 showed that partially damaged colonies exhibited an unexpected capacity to regenerate lost tissue. In the post-mortality period, 68.3 % of all damaged colony recovered between 60 and 100% of the injured surface.

In 2004, partially damaged and died colonies were colonized by many sessile organisms, mainly bryozoans, hydroids, algae and porifera (Fig. 4). Damaged colonies, which branches were heavily overgrown, frequently broke or detached and fell down from the vertical cliff.

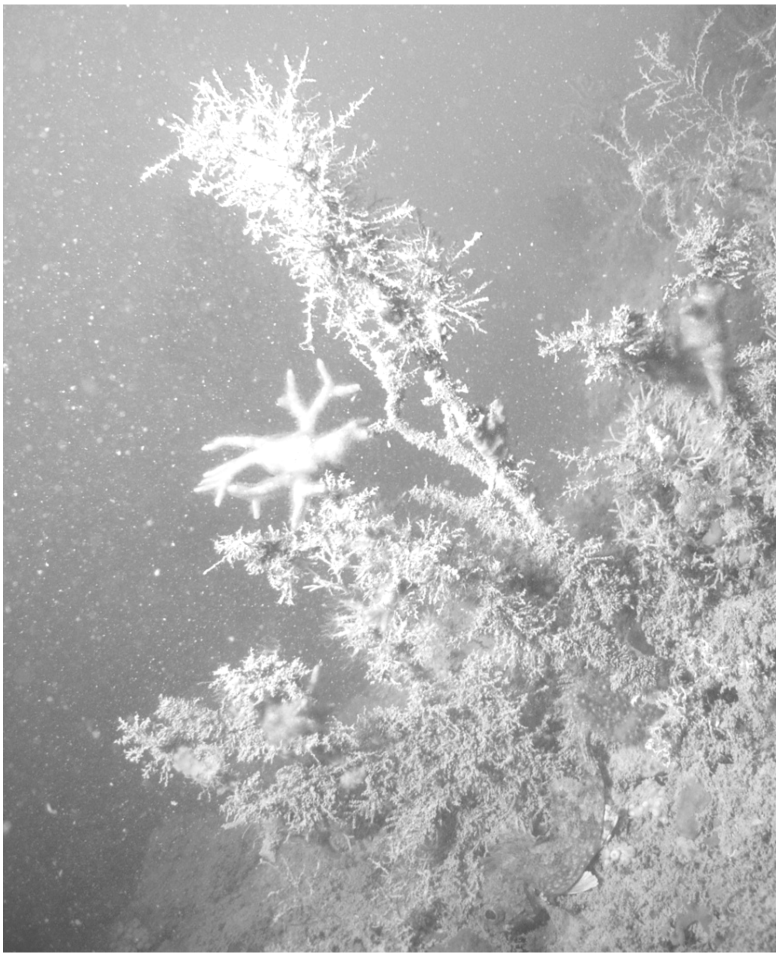

Fig. 4: Branches of died colonies of *Paramuricea clavata* heavily overgrown by epibionts (mainly bryozoans and hydroids).

DISCUSSION

The mass mortality events which occurred in the summer 1999 and 2003 in the Ligurian Sea and in the neighbouring NW Mediterranean (Cerrano *et al.*, 2000; Bramanti *et al.*, 2005; Linares *et al.*, 2005; Ribes & Coma, 2005; Santangelo *et al.*, 2007; Cupido *et al.*, 2008) strongly affected the population of *Paramuricea clavata* in the Gulf of La Spezia. The large impact suffered by this species, both in term of population size structure changes and colony density decrease, is among the most impressive reported in literature for the NW Mediterranean as consequence of that events (Cupido *et al.*, 2008; Linares *et al.*, 2005). Cupido *et al.*, (2008) hypothesised that the shallow bathymetric range (near the edge of the summer thermocline, quite unusual for this species) could be the main reason of the heavy mortality suffered by the population. Given the structural and biomass contribution of *Paramuricea clavata* (an engineer species) to one of the most diverse coralligenous communities (Ballesteros, 2006), the survival of the whole community may be closely linked to that of this gorgonian.

The most relevant change in the 1998-2008 period was the sharp decrease of colony density (69.9 %) shortly after the mortalities, followed by a significant increase (52.6 %) in the following four years. A great contribution to the higher number of colonies found in 2008 was due to recruits (about 24 % of total living colonies), even if low recruitment rates in the post-mortality period have been considered common in gorgonians (Coma *et al.*, 2006). The increase of recruits throughout the four years could thus be considered an important clue for population recovery, especially if compared with the increase of 3 % only reported by Linares *et al*. (2007).

Larger colonies of *P. clavata* were more frequently affected than small ones, (Cerrano *et al*., 2005), causing a sharp reduction of the larger size classes (>36 cm high). Furthermore, the few large colonies, survived shortly after the mortalities, were threatened by long-lasting epibiosis by encrusting species, and presumably by parasites and borers, that could make them more susceptible to breakage. As a matter of fact, portions of dead colonies heavily overgrown were found at the base of the cliff. Breakage of dead colonies, described as a common outcome for heavily overgrown branches of cnidarians (Karlson, 1986), could reduce the number of died and thus increase the percentage of undamaged colonies in 2008. The finding of a constant percentage of colonies with partial mortality after mortality events is consistent with previous results (Coma *et al*., 2004; Linares *et al*., 2005; Cupido *et al*., 2008). Contrary to the low regeneration ability previously described for *P. clavata* (Bavestrello *et al*., 1998), we observed a significant decrease in the extent of injury over time after mortality. The ability to regenerate lost tissue after stress events is common to most of the marine clonal organisms (Wahle, 1983; Sanchez & Lasker, 2004). A completely recover as that recorded for some colonies represents a suitable strategy for facing mortality events, such as those occurred in 1999 and 2003.

The high colony recovery and recruitment rates found in the *P. clavata* population studied suggest a good resilience, also if the geographical isolation, together with an increased frequency of mortality events, could challenge its persistence. The occurrence of two events of mass mortalities in the NW Mediterranean at only four years one from the other indicates that these episodes may occur with an high frequency and suggests that further occurrences can be expected in the coming years, due to global warming. Although the mid-scale impact of mass mortality events on gorgonian populations has been increasingly studied (Coma *et al.*, 2006; Linares *et al.* 2005; Cupido *et al.*, 2008), for the longer-term impact evaluation of an increased frequency of mortality events, population modelling studies will provide suitable tools (Santangelo *et al.*, 2007; Linares *et al.*, 2007). As environmental processes act on multiple, interacting scales, there is now evidence that long-term monitoring and demographic studies are necessary for detecting changes in populations of engineer species (Walther *et al.*, 2002), to understand and “forecast” the effects of climate change on communities and ecosystems.

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OVERVIEW ON THE HOMOSCLEROMORPHA SPONGES DIVERSITY IN THE MEDITERRANEAN

ABSTRACT

Sponges are often dominant in marine benthic communities, especially on Mediterranean hard substrates. The Homoscleromorpha group is a poorly known sponge clade, represented by a single family, the Plakinidae, with an unresolved phylogenetic position at the basis of the Metazoan tree. For some of the representatives of this group, the absence of skeleton, main morphological character for sponge taxonomy, explains also the very complicated history of species statut. At present time, 77 species are listed in the World Data Base, with 22 valid species in the Mediterranean and several representatives remaining to be described. All the genera of the family are represented in the Mediterranean: one species from genus Corticium, one species of Pseudocorticium, one species of Placinolopha, one Plakortis, ten species of Plakina and 8 Oscarella species. Most of these sponges only grow sparsely in the Mediterranean with distributions often limited to dark submarine caves. The exceptions are Corticium candelabrum *and several species of the genus Oscarella, who seem to grow only on coralligenous substratum. In some places, Oscarella sp. can be predominant and constitute specific facies. Therefore, they appear as strong competitors for space, overgrowing massive sponges, sea fans and bryozoans. This is especially the case of a new species which seems to be highly dynamic. This strong out-competing ability may be particularly due to an efficient secondary metabolism and the biochemical defense it confers. This hypothesis is also supported by the absence of well-known predator or epibiotic organisms.*

KEY-WORDS: Homoscleromorpha, Oscarella, Mediterranean, distribution, ecology

INTRODUCTION

Sponges represent one of the most ubiquitous and abundant group of metazoans within worldwide hard substrate benthic communities. In the Mediterranean coralligenous community, sponges dominate both in term of biomass and biodiversity on cliffs and overhangs (Sara & Vacelet, 1973; Kefalas *et al.*, 2003; Balata *et al.*, 2005) where in some places, they can cover up to 100% of the substratum surface.

Sponges are also well known to provide goods and services to human societies. The coralligenous community can shelter several species of commercial bath sponges (*Spongia officinalis*, *Spongia agaricina* and *Hippospongia communis*), but also species which provide bioactive compounds (the so-called secondary metabolites), with potential cytotoxins, antibiotics, anti-inflammatory and even anti-fouling agents (for a review see Kornprobst 2005). Among these compounds, there is a number of potential candidates for further development in the biomedical and environmental fields.

Among about 660 Mediterranean species (Pansini & Longo 2003), our attention is given to a small sponge group -Homoscleromorpha- which represents only 3 % of the Mediterranean sponge diversity. Over the last years this sponge group has been subject of a special attention because of its peculiar position at the basis of the Metazoa phylogenetic tree (Ereskovsky *et al.*, 2009). Indeed, Homoscleromorph sponges have long been considered as a part of Demospongiae (sub-class Homoscleromorpha, order Homosclerophorida). Their position has been recently challenged by Borchiellini *et al.* (2004). This sponge group appears now as distinct from the other high level sponge clades, namely Demospongiae, Calcispongiae and Hexactinellida. Homoscleromorph sponges display many morphological, cytological, biochemical and embryological features that distinguish them from other sponges and are more evocative of the Eumetazoa (Borchiellini *et al.*, 2004; Ereskovsky *et al.*, 2009). For example, they are the only sponges that possess a basement membrane made of collagen IV (Boute *et al.*, 1996), this character being presently considered as a synapomorphy of Eumetazoans. We have recently discussed the interest of the Homoscleromorpha reproduction traits for research in Evolutionary Developmental Biology (Ereskovsky *et al.*, 2009). For instance, their cinctoblastula larva has recently been hypothesized as similar to a step in the early evolution of Metazoa (Nielsen, 2008). Finally, Homoscleromorph sponges appear as a promising sponge group in marine natural product research, with several species offering a high secondary metabolite diversity with potential value for the biomedical field (Kornprobst, 2005; Ivanisevic *et al.*, 2008).

Although some information on taxonomy, cytology and reproduction of Homoscleromorphs are available (see for instance Muricy *et al.*, 1996, 1998; Ereskovsky *et al.*, 2009), little is known about their ecology and distribution in the Mediterranean. We are presently conducting several programmes which aims at improving our knowledge on Mediterranean Homoscleromorpha diversity, chemical diversity and phenology in relation to changes in environmental conditions. In this paper, we give a review of Homoscleromorphs distribution in the Mediterranean Sea.

MATERIALS AND METHODS

Data about sponge distribution were obtained from the literature (extensive work by Muricy, PhD thesis) and then through several sampling trips. Homoscleromorph sponges were studied through several national and international programmes (INTAS, PHENOMED, ECIMAR, RFBR) which made us investigate the Mediterranean Sea from Gibraltar Strait to Lebanon. The specimens were collected by SCUBA diving from 1999 to 2008. Most of the time, an *in situ* picture was associated to the sample.

In Homoscleromorpha sponges, the main taxonomic characters are siliceous spicules (*e.g.* diods, triods, calthropes) and in the absence of skeleton, a cytological characters such as mesohyl cell types (vacuolar cells, cells with inclusions) and endosymbiotic bacteria (Muricy & Diaz 2002).

For the study of spicules, the sponge tissue is digested in nitric acid. The dissociated spicules are separated by filtration on a 0.2 μm cyclopore membrane for observation under scanning electron microscope (SEM) or mounted on glass slides for light microscopy. For cytology in light microscopy and transmission electron microscopy (TEM), specimens are fixed in glutaraldehyde 2.5% in a mixture of 0.4 M cacodylate buffer and seawater (4:5 v/v). They are then postfixed for 2 h in 2% osmium tetroxide in seawater, dehydrated through an alcohol series, and embedded in araldite.

RESULTS

Homoscleromorpha consists presently of one family – Plakinidae - with 7 genera and 77 species, including 22 Mediterranean species (Tab. 1). This represents about 29 % of the Homoscleromorphs biodiversity reported so far in the World Porifera Database.

The species *Oscarella lobularis*, *Plakina monolopha* and *P. trilopha* are reported to be cosmopolitan, but most records from outside the Mediterranean were probably misidentified (Boury-Esnauly *et al.*, 1992; Muricy *et al.*, 1998). Homoscleromorph sponges are generally located in shallow waters from 4 to 35 m, but some species, such as *O. tuberculata*, *P. monolopha*, *P. trilopha* and *Plakortis simplex* have been already found at more than 100 meters depth. All species are dwellers of sciaphilic hard substratum communities often in semi dark or dark conditions. *Corticium candelabrum* and several species of the genus Oscarella homoscleromorphs seem to be only growing on coralligenous substratum. In some places, Oscarella sp. can be predominant and constitute particular facies. They seem to be strong competitors for space, overgrowing massive sponges, sea fans and erect bryozoans. This high out competing ability may be particularly due to their efficient secondary metabolism and the biochemical defenses it confers. This hypothesis is also supported by the absence of well-known predator or epibiotic organisms.

Tab. 1: Checklist of Mediterranean species of Homoscleromorpha

Corticium candelabrum Schmidt, 1862
Oscarella imperialis Muricy, Boury-Esnault, Bézac & Vacelet, 1996
Oscarella lobularis (Schmidt, 1862)
Oscarella microlobata Muricy, Boury-Esnault, Bézac & Vacelet, 1996
Oscarella tuberculata (Schmidt, 1868)
Oscarella viridis Muricy, Boury-Esnault, Bézac & Vacelet, 1996
Placinolopha moncharmonti (Sarà, 1960)
Plakina bowerbanki (Sarà, 1960)
Plakina crypta Muricy, Boury-Esnault, Bézac & Vacelet, 1998
Plakina dilopha Schulze, 1880
Plakina endoumensis Muricy, Boury-Esnault, Bézac & Vacelet, 1998
Plakina jani Muricy, Boury-Esnault, Bézac & Vacelet, 1998
Plakina monolopha Schulze, 1880
Plakina reducta (Pulitzer-Finali, 1983)
Plakina tetralophoides Muricy, Boury-Esnault, Bézac & Vacelet, 1998
Plakina topsenti (Pouliquen, 1972)
Plakina trilopha Schulze, 1880
Plakina weinbergi Muricy, Boury-Esnault, Bézac & Vacelet, 1998
Plakinastrella copiosa Schulze, 1880
Plakinastrella mixta Maldonado, 1992
Plakortis simplex Schulze, 1880
Pseudocorticium jarrei Boury-Esnault, Muricy, Gallissian & Vacelet, 1995

Among the 22 Mediterranean species the most widely distributed are *Corticium candelabrum, O. lobularis, O. tuberculata, P. monolopha, P. trilopha* and *P. simplex* (Tab. 2). These species inhabit predominantly coralligenous substrates at the depth from 10 to more than 100 m, but also in caves. The highest number of reports belong to the Northern coastal regions of Mediterranean.

Corticium candelabrum (Fig. 1) is a tiny thinly encrusting to cushion-shaped sponge, sometimes lobate, with a colour from light brown to brown and sometimes reddish. Its consistency is firm to cartilaginous, and its skeleton is dominated by clathrops of several types. This species is quite common in shallow coralligenous community.

Oscarella lobularis (Fig. 1) was long considered as the only species of the genus *Oscarella*, with different chromotypes and consistencies. This sponge is thinly encrusting to lobate, from white to deep purple and sometimes blue. This sponge is devoid of skeleton and its consistency is rather soft. This species is one of the most common and abundant Homoscleromorpha in the Mediterranean, conditioning specific facies in some places. It is distributed from shallow waters down to 300 m, in the coralligenous community and at the entrance of caves. This species is regularly found growing on the sea-fan *Paramuricea clavata*.

Oscarella tuberculata (Fig. 1) is one of the “sister species” of *O. lobularis*, which is also common in shallow coralligenous community. This sponge is also thinly encrusting to lobate, but its color is highly variable (yellow, green, blue and sometimes pink). Its consistency is more cartilaginous than *O. lobularis*, it harbors a particular type of vacuolar cell which also allow distinguishing both “sister” species.

We recently found a new *Oscarella* species (Fig. 1, sp. 1) which has quite the same consistency of *O. lobularis*, but microlobate, with a color from white to orange. This species is able to out-compete many other invertebrates dwelling in the coralligenous (gorgonians, bryozoans and other sponges), probably due to a very efficient secondary metabolism.

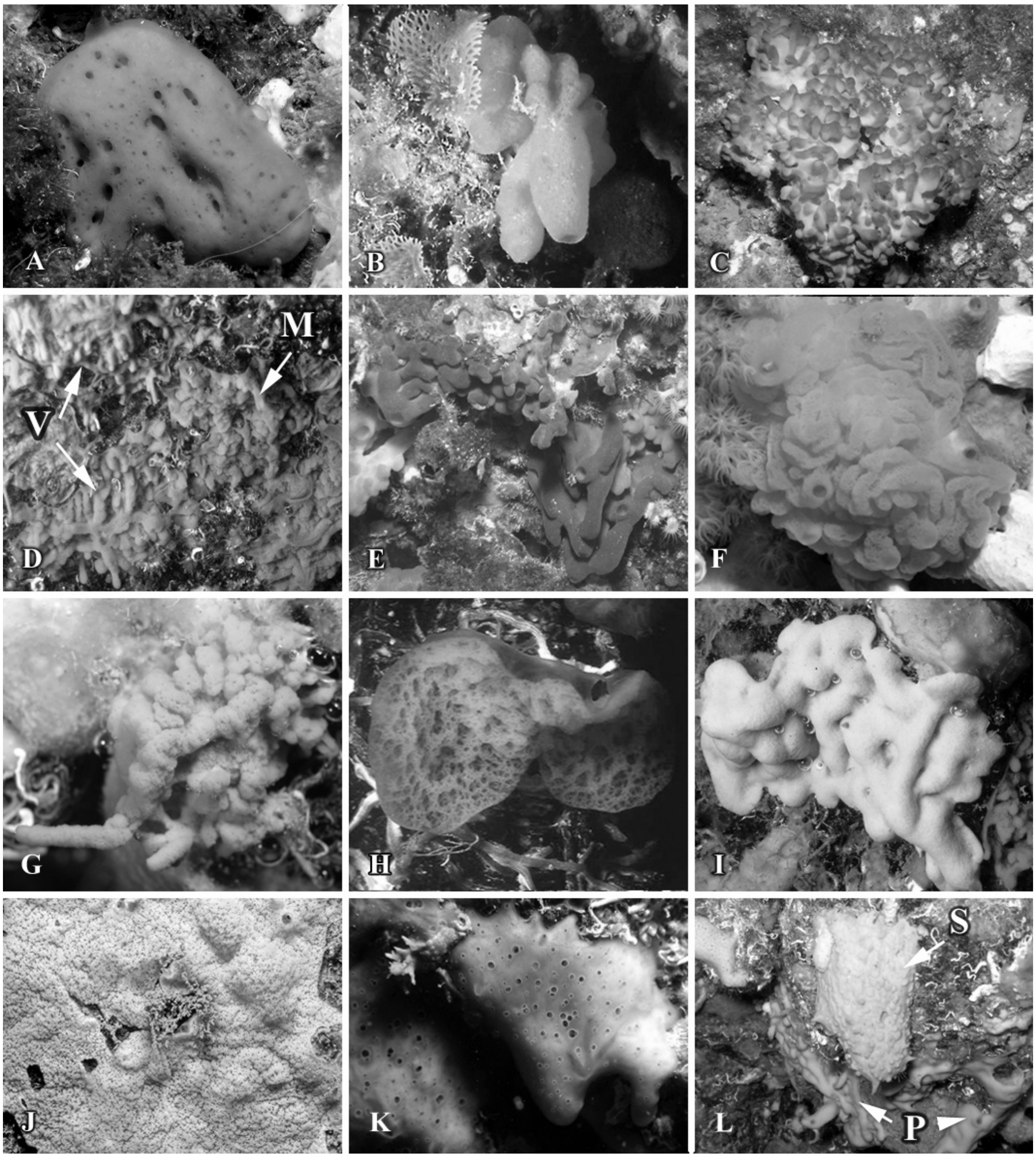

Fig. 1: Some Mediterranean Homoscleromorpha species. A – *Corticium candelabrum* ; B - *Oscarella imperialis*; C - *Oscarella lobularis*; D - *Oscarella microlobata* (M) and *Oscarella viridis* (V); E - *Oscarella tuberculata*; F – *Oscarella* sp. 1; G - *Oscarella* sp. 2; H - *Plakina crypta*; I - *Plakina trilopha*; J - *Plakina monolopha*; K - *Plakina weinbergi*; L - *Plakortis simplex* (S) and *Plakina jani* (P).

Species dwelling in submarine cave remain poorly known. 82% of Mediterranean Homoscleromorph species can be cave dwellers and 41% are only found in semi dark and dark caves (Table 2). Several new homoscleromorph species were recently described in some Mediterranean caves: *O. microlobata, O. viridis, P. crypta, P. endoumensis, P. jani, P. topsenti, P. trilopha, P. weinbergi* and *Pseudocorticium jarrei* (Tab 2). Some of these species were only registered in one or two Mediterranean locations. Moreover, within these sites, we have also found out some potential new species which will be described soon.

Among the Mediterranean species, one remains rather puzzling: *Placinolopha moncharmonti*, which has been found only once – near Naples (Italy) at the depth 90 m.

Tab 2: Distribution of Homoscleromorpha sponges in the Mediterranean Sea

Species	Regions and sectors of Mediterranean	Habitat	Depth (m)	References
Corticium candelabrum	WR*, septentrional sector; ASR* middle, lower sectors; ER*: septentrional, central, meridional (Aegean, Levantine Seas) sectors	Coralligenous/cave	1 - 60	Pulitzer-Finali, 1983; Uriz, Bibiloni, 1984; Voultsiadou, 2005;
Oscarella imperialis	WR, septentrional sector	Coralligenous	15 - 25	Muricy et al. 1996
O. lobularis	WR, septentrional; ASR, high sector	Coralligenous	5 - 35	Boury-Esnault *et al.* 1992
O. microlobata	WR, septentrional sector; ER: meridional (Liban, Levantine Seas) sector	Cave	15 (6-34)	Muricy *et al.* 1996; Voultsiadou, 2005
O. tuberculata	WR, septentrional, central (Spain, Italy, Corse) sectors; Gibraltar; ASR high (Limski Kanal), middle sector; ER: central, meridional (Aegean, Levantine Seas) sectors	Coralligenous/cave	1 – 40 - 350	Pulitzer-Finali, 1983; Carballo, 1994; Uriz, Bibiloni, 1984; Boury-Esnault *et al.* 1992; Voultsiadou, 2005
O. viridis	WR, septentrional sector	Cave	15	Muricy *et al.* 1996
Oscarella sp. nov.	WE, septentrional, central (Corse) sectors, ASR middle sector	Coralligenous/cave	8 - 30	Unpubl.
Placinolopha moncharmonti	WR, central sector (Italy - Naples)	Coralligenous	90	Sara, 1960
Plakina bowerbanki	WE, central (Italy) sector; ASR middle, lower sectors (Trimiti isl),	Deep sea	1 - 15	Sara, 1961a; Pulitzer-Finali, 1983
P. crypta	WR, septentrional sector (3PP Cave - La Ciotat, France)	Cave	22	Muricy *et al.* 1998
P. dilopha	WE, septentrional, central (Italy) sectors; ASR high sector; ER: septentrional, central sectors	Cave	4	Voultsiadou, 2005
P. endoumensis	WR, septentrional sector	Cave	3 - 5	Muricy *et al.* 1998
P. jani	WR, septentrional sector	Cave	15-20	Muricy *et al.* 1998
P. monolopha	WR, septentrional, central sectors (Spain, Italy); Gibraltar; ASR, high, middle sectors; ER: septentrional, sector	Coralligenous/cave	2 – 40 (1 – 370)	Sara, 1961a; Pulitzer-Finali, 1983; Carballo, 1994; Uriz, Bibiloni, 1984; Voultsiadou, 2005
P. reducta	ASR: middle sector; ER: meridional (Liban, Levantine Sea) sector	Cave	5 – 30	Pulitzer-Finali, 1983; Voultsiadou, 2005
P. topsenti	WR, septentrional, central sectors	Coralligenous/cave	12	Pouliquen, 1972; Pulitzer-Finali, 1983
P. trilopha	WR, septentrional, central (Italy, Spain) sectors; ASR: middle, (i. Tremiti, Bari), lower sectors. ER: septentrional, sector	Cave	1 – 40 (570)	Sara, 1961a,b; 1962; Pulitzer-Finali, 1983; Uriz, Bibiloni, 1984; Muricy *et al.* 1998; Voultsiadou, 2005
P. weinbergi	ER, central (Crete), meridional (Liban, Levantine Sea) sectors	Cave	9 - 20	Muricy *et al.* 1998; Vacelet unpubl.
Plakinastrella copiosa	WR, septentrional, central sectors; ER: septentrional, sector;	Coralligenous/cave	10 - 20	Uriz, Bibiloni, 1984; Voultsiadou, 2005
P. mixta	WR, central sector (Spain – Alboran; Italy - Naples)	Deep sea	70 - 120	Maldonado, 1992
Plakortis simplex	WR, septentrional, central sectors (France, Spain, Italy - Naples); ASR: middle, lower sectors (i. Tremiti, Bari); ER: central (Crete), septentrional (Aegean Sea), meridional (Liban, Levantine Sea) sectors;	Coralligenous/cave	1 - 110	Sara, 1961a, b; 1962; Pulitzer-Finali, 1983; Uriz, Bibiloni, 1984; Voultsiadou, 2005;
Pseudocorticium jarrei	WR, septentrional sector; ER: meridional (Liban) sector	Cave	14-16	Boury-Esnault *et al.* 1995; Vacelet unpubl.

* Subdivision of Mediterranean on biogeographical region accepted in this work according Fredj (1972). WR - western region, ER – estern region, ASR – Adriatic Sea region.

CONCLUSION

Complementary tools are necessary for the investigation of Homoscleromorpha sponge diversity in the Mediterranean. For example, a chemical fingerprint approach giving an indication of the sponge metabolome is now applied to most Mediterranean Homoscleromorpha species (Ivanisevic *et al.*, 2008) in order to contribute to a phylogenetic analysis using a combination of morphological, cytological, chemical and molecular characters. Homoscleromorph sponges display many features that distinguish them from other sponges and are more evocative of the Eumetazoa. That made this group very important for evolutionary development studies. That is the reason why we have also just proposed *O. lobularis* as a new sponge model for this research field (Ereskovsky *et al.*, 2009).

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Actes du 1er Symposium sur le Coralligène et autres Bio-Concrétions calcaires de Méditerranée
(Tabarka, 15-16 Janvier 2009)

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THREE- DIMENSIONAL DISTRIBUTION OF *GERARDIA SAVAGLIA* IN RELATION TO DEPTH, ORIENTATION AND SLOPE OF THE SUBSTRATA IN THE SOUTH TYRRHENIAN SEA

ABSTRACT

The false black coral Gerardia savaglia *(Cnidaria, Zoanthidea) is a colonial hexacoral unable of creating branch-like colonies on its own. It invades gorgonian colonies and, partly or entirely, covers them over. This species is an important component of the twilight zone, usually presents at depth below 60 m.*

G. savaglia *is considered a rare species and it is inserted in the Annex II ASPIM (Convention of Barcelona) and in the Appendix II of the Convention of Bern.*

During a research campaign held by ICRAM in the South Tyrrhenian Sea, a population of this species was discovered. The specimens were filmed and photographed by means of a Remotely Operated Vehicle (ROV), equipped with an underwater acoustic tracking position system, a digital camera (Nikon D80, 10 megapixel) with an underwater strobe (Nikon SB 400) and with two laser pointers 10 cm apart. High resolution multibeam data of the area were collected in order to create three-dimensional georeferenced distribution maps of G. savaglia in relation to depth, orientation and slope of the substrata. An area of 0.12 Km^2 was covered and 3 ROV transects were executed between 20 and 90 m depth. G. savaglia *was found only at depth range between 26 and 42 m. The population is composed by 28 colonies, subdivided in two different groups at a distance of 120 m. Colonies are mixed with a population of* Paramuricea clavata. *Calibrated distance between the two laser pointers was used to measure the colonies. Sizes of the measured specimens are between 22 and 87 cm in height, with a maximal base diameter of 8 cm. They were found on substrata with a North-East or North-West orientation that had slopes between 20°and 60° degrees. Few ecological studies on* G. savaglia *have been conducted until now, particularly due to the difficulty of working at the depth where it usually lives. Our results throw light upon the ecology of this species, pointing out the need for further studies.*

KEY-WORDS: *Gerardia savaglia,* ROV, three-dimensional distribution.

INTRODUCTION

Compared to surface corals, little is known about the biology and ecology of most deep-sea corals, in part due to the difficulties with sampling and observation.

Increased interest in the ecology and biology of deep-sea corals and the habitat that they provide for other organisms has occurred in response to an increasing awareness of the threat of physical destruction caused by pelagic and benthic fisheries. Many deep-sea corals provide habitat important to adult or juvenile recruitment of commercially important fish (Witherell and Coon, 2000; Witherell *et al.,* 2000).

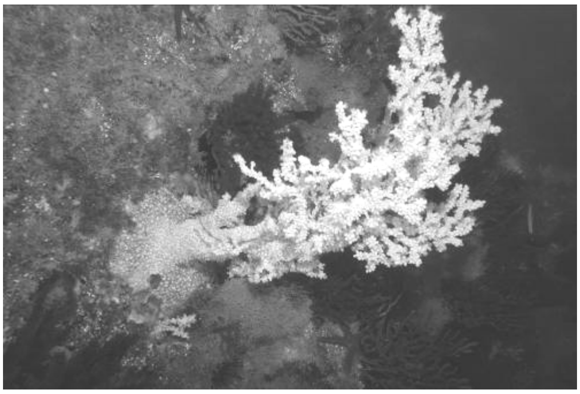

Fig. 1: The false black coral, *Gerardia savaglia.*

The organism studied here, the false black coral *Gerardia savaglia* (Cnidaria, Zoanthidea) (Fig. 1, 2), is a colonial hexacoral and an important component of the lower portion of the Mediterranean Sea coralligenous assemblage (twilight zone), usually presents at depth greater than 60 m. It is unable of creating branch-like colonies on its own and it is the only zoantharia that can produce a skeleton. It invades gorgonian colonies and, partly or entirely, covers them over. The colony initially encrusts a stem of a gorgonian, and then forms a hard organic skeleton that grows to great size (Druffel *et al*., 1995).

Like gorgonians (sea fans, sea whips, etc.) and antipatharians (black corals), *Gerardia* sp. has an organic internal skeleton (endoskeleton) made of hard, dense layered proteinaceous material that more closely resembles a modern plastic than a natural tissue. This skeletal form is unique among skeletal accreting animals (Druffel *et al*., 1995). *Gerardia* sp. grows in a dendritic tree-like fashion to several meters in height with trunks typically 3 to 15 cm in diameter (Roark *et al.*, 2006).

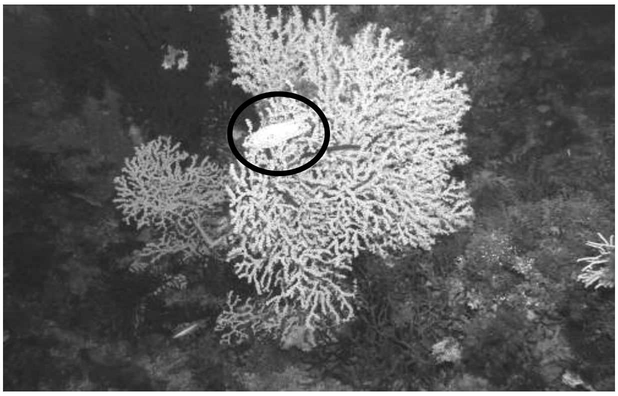

Fig. 2: *G. savaglia* encrusted a Gorgonia with a Small-spotted cat shark egg on it.

A specimen collected from the Mediterranean Sea was reported to have been 2 m high, with a main trunk diameter of 14 cm (Bell, 1891).

G. savaglia might possibly be the longest living coral in the Mediterranean Sea. In the Pacific, colonies of the genus Gerardia might reach 2700 years of age (Roark *et al*., 2006). In the Mediterranean, it is believed that some *G. savaglia* formations might be more than one thousand years old.

G. savaglia is considered a rare species and it is therefore included in the Annex II ASPIM (Convention of Barcelona) and in the Appendix II of the Convention of Bern. Finally, CITES should include *G. savaglia* in Appendix I for maximum protection.

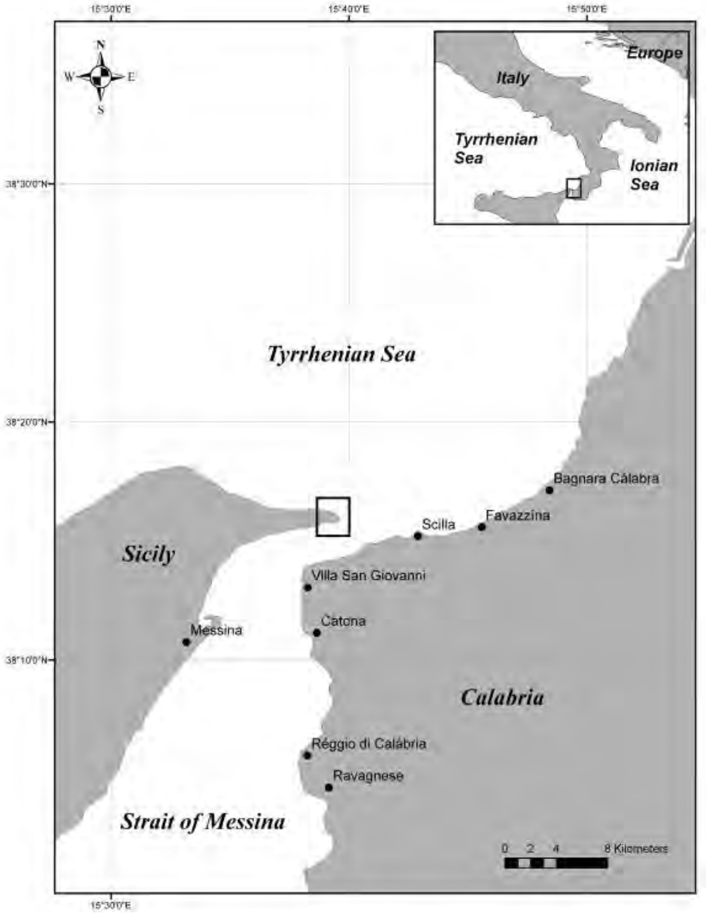

Fig. 3 : Study area

MATERIALS AND METHODS

In July 2008 a research campaign was carried out by ISPRA (ex ICRAM) in the South Tyrrhenian Sea (Fig.3) on board of the R/V Astrea.

During this survey, a population of *G. savaglia* was discovered. The specimens were filmed and photographed by means of a Remotely Operated Vehicle (ROV).

The ROV used in this study was equipped with a video camera and with an underwater acoustic tracking position system connected in real time with a Geographic Information System (GIS), in order to always have the precise position of the vehicle in relation to the research vessel. It was also equipped with an high definition digital camera (Nikon D80, 10 megapixel), with an underwater strobe (Nikon SB 400) and with two laser pointers 10 cm apart, used as reference scale to assist the observers in estimating the dimensions of what was photographed.

Calibrated distance between the two laser pointers was used in the photo analysis to measure the morphology of the colonies (height and base diameter).

In order to survey the area, the ROV navigated with an average speed of 1- 1,5 knots at about 0,5 m above the substrate.

Furthermore, high resolution multibeam data of the area were collected to create three-dimensional georeferenced distribution maps of *G. savaglia*. Multibeam data were converted to a raster surface and used to create three- dimensional georeferenced distribution maps of *G. savaglia* in relation to depth (Fig. 5), orientation (Fig. 6) and slope (Fig. 7) of the substrata. In the raster output surface, orientation identifies the steepest down slope direction from each cell to its neighbors. It is measured clockwise in degrees from 0° (due north) to 360° (again due north, coming full circle). The value of each cell indicates the direction of the cell's slope face. Flat areas having no down slope direction are given a value of -1. Slope is the maximum rate of change between each cell and its neighbors. Every cell in the output raster has a slope value. The lower the slope value, the flatter the substrata; the higher the slope value, the steeper the substrata. The output slope raster was calculated in degrees, from 0° (flat) to 90° (vertical).

RESULTS

During the survey, an area of 0.12 km^2 was covered and 3 ROV transects were executed between the depth of 20 and 90 m. Video analysis pointed out that *G. savaglia* was present only in one of the three dives. The population is composed by 28 colonies, subdivided in two different groups at a distance of 120 m one from the other (Fig. 4).

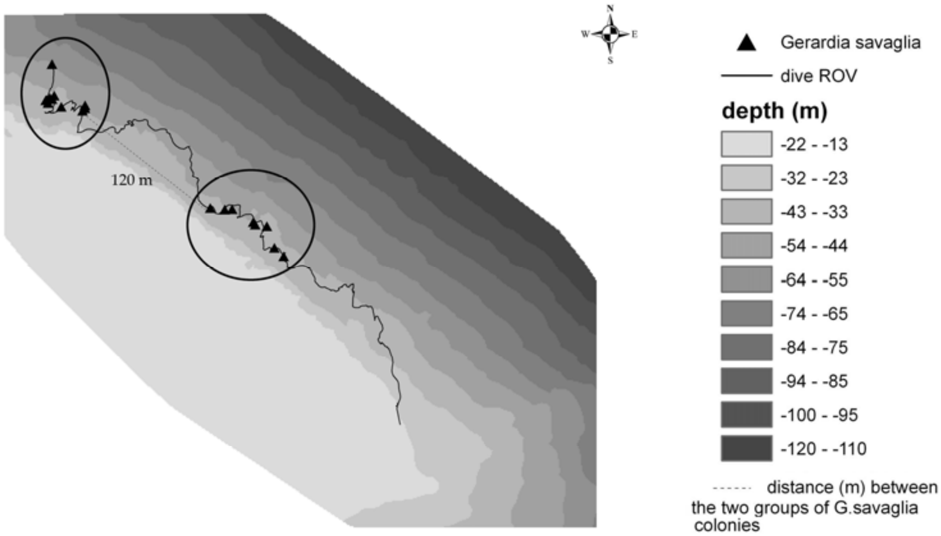

Fig. 4: Distribution of *G. savaglia* along ROV transects.

Colonies are mixed with a population of the endemic Mediterranean Sea red gorgonian, *Paramuricea clavata*.

The sizes of the measured specimens (n= 8) are between 21.6 and 87.4 cm (49.2 ± 22.5 SD; 0.46 CV) in height, with a base diameter between 1.5 and 7.7 cm (5.2 ± 2.3 SD; 0.45 CV).

G. savaglia was present at depths between 23 and 42 m (35 ± 5.01 SD; 0.95 SE; 0.14 CV) (Fig. 5).

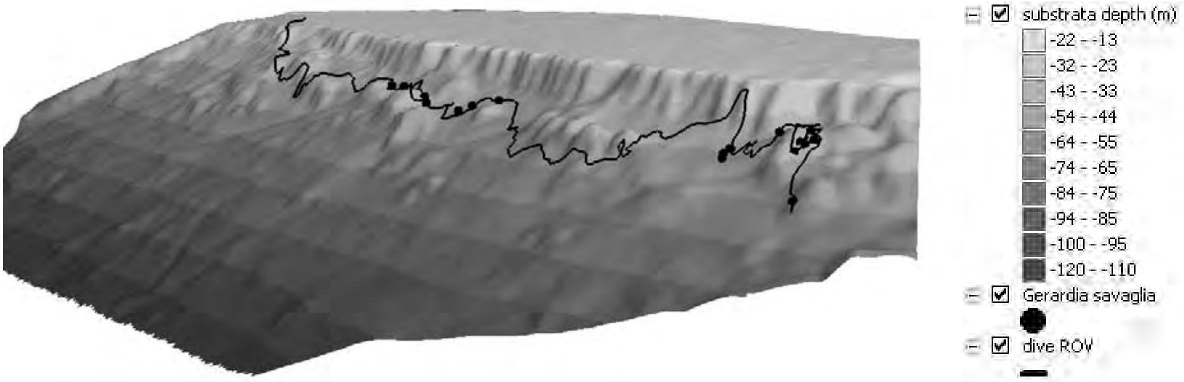

Fig. 5: 3D distribution of *G. savaglia* in relation to substrata depth.

Specimens were found on substrata with a North-East and North-West orientation. In particular, 15 colonies were found on substrata with an orientation between 6° and 42°, 4 colonies between 47° and 100° and 9 colonies between 307° and 343°. No colonies were found in the range 100°- 307° (Fig. 6).

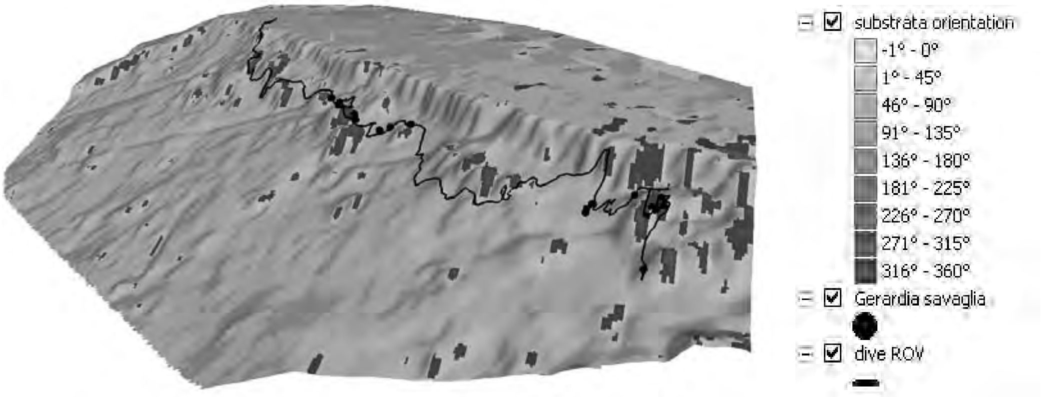

Fig. 6: 3D distribution of *G. savaglia* in relation to substrata orientation.

Slope values were between 12° and 55° (Fig. 7).

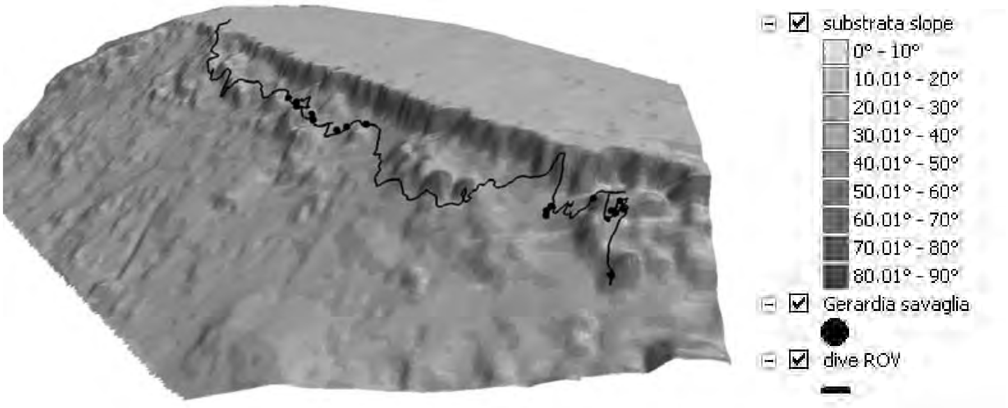

Fig. 7: 3D distribution of *G. savaglia* in relation to substrata slope.

The distance of the colonies from the coast was between 167 and 210 m.

CONCLUSIONS

G. savaglia is an important component of the Mediterranean Sea twilight environment. Despite this, few ecological studies on this species have been conducted until now, particularly due to the difficulty of working at the depth range where it usually lives.

In our study, we recorded the presence of an unusually shallow population of *G. savaglia*. This fact is probably due to both the north orientation of the substrata, which creates a shady habitat, and to the influence of the current of Messina Strait that carries cold water, rich of nutrients.

Due to its unusual shallow distribution this population could be damaged by fishing operations and illegal takes. For this reason we recommend to develop specific protection measures in the area.

Furthermore, this study highlighted the importance of improving the utilization of 3D georeferenced maps, as a tool to visualize benthic species distribution. Viewing benthic data in a 3D environment facilitates the recognition and patterns comprehension of spatial relationships.

ACKNOWLEDGMENTS

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CALCHERB, AN INFORMATION SYSTEM ON CALCAREOUS RED ALGAE OF THE CORALLIGENOUS

ABSTRACT

Frequent cases of polymorphism (intra-species variability) and morphologic convergence (inter-species variability) make the taxonomy of the Corallinales (Rhodophyta) a complex field. Furthermore, the distribution of some species in the Mediterranean area is poorly known. Calcherb is an information system which makes the information stored in the "Nova Collectio Corallinales – TSB" searchable in the Web. The "Nova Collectio Corallinales" is a collection of red coralline algae from the Mediterranean, which includes a relevant amount of interesting specimens. Calcherb was developed as an important support to taxonomic researches, providing easy access to the data of the Collection, and it is articulated in three different archives: DATSBA (Data Archive TSB Algarium), IA (Images Archive) and RDB (References Data Base). Calcherb is also an important part of the wide net of information systems and databases of the Museal System of the University of Trieste (smaTs).

KEY-WORDS: biodiversity informatics, collection, Corallinales, database, iconography

INTRODUCTION

The red calcareous algae (Corallinales) play a key role in submarine ecosystems, and are an important component of the Coralligenous in the Mediterranean (Feldman, 1937; Pérès & Picard, 1951; 1964; Giaccone, 1968; Boudouresque, 1970; Ballesteros, 2006). Environmental factors such as light, temperature, salinity, hydrodinamism and nutrients influence not only the presence and abundance of these algae, but also their fertility. For this reason, some Corallinales can be used as bioindicators (Adey & MacIntyre, 1973; Bosence, 1976; Masaki *et al.*, 1981; Lovric & Sekulic, 1991; Laborel *et al.*, 1993; Di Geronimo & Giaccone, 1994).

Coralline algae are the main Coralligenous builders (Laborel, 1961; Laubier, 1966; Sartoretto, 1996; Ballesteros, 2006). The most active builders among the Corallinales are several species belonging to the *Lithophyllum*, *Lithothamnion*, *Mesophyllum* and *Neogoniolithon* genera (Feldmann, 1937; Boudouresque & Verlaque, 1978; Giaccone *et al.*, 1994; Sartoretto, 1996; Ballesteros, 2006). *Mesophyllum alternans* (Foslie) Cabioch & Mendoza is the main builder in shallow waters (Cabioch & Mendoza, 1998; Ballesteros, 2006), while species such as *Lithophyllum stictaeforme* (Areschoug) Hauck, *Lithophyllum cabiochae* (Boudouresque & Verlaque) Athanasiadis and *Neogoniolithon mamillosum* (Hauck) Setchell & Mason are the most important builders in deeper waters (Feldmann, 1937; Boudouresque, 1973; Athanasiadis, 1999; Ballesteros, 2006).

To our knowledge, complete distributional and ecological information about the Corallinales is still lacking, especially as far as the Eastern-Mediterranean area is concerned. The collection "Nova Collectio Corallinales – TSB", hosted at the University of Trieste, contains several samples for almost all the Corallinales known for the Mediterranean area. It represents an important resource for ecological and taxonomical studies of this complex group, in which polymorphism (intra-species variability) and morphologic convergence (inter-species variability) are very common. The information stored in the collection has been published on-line as a complex information system, CALCHERB (http://dbiodbs.units.it/web/alghe/calc01) which contains constantly updated information about all the samples present in the collection, as well as a rich iconographic archive, containing both images of specimens and pictures taken *in situ*. CALCHERB was planned and developed as a useful support to taxonomic and ecologic studies, as well as a simple resource to access collection data, which could be important to environmental management institutions.

MATERIAL AND METHODS

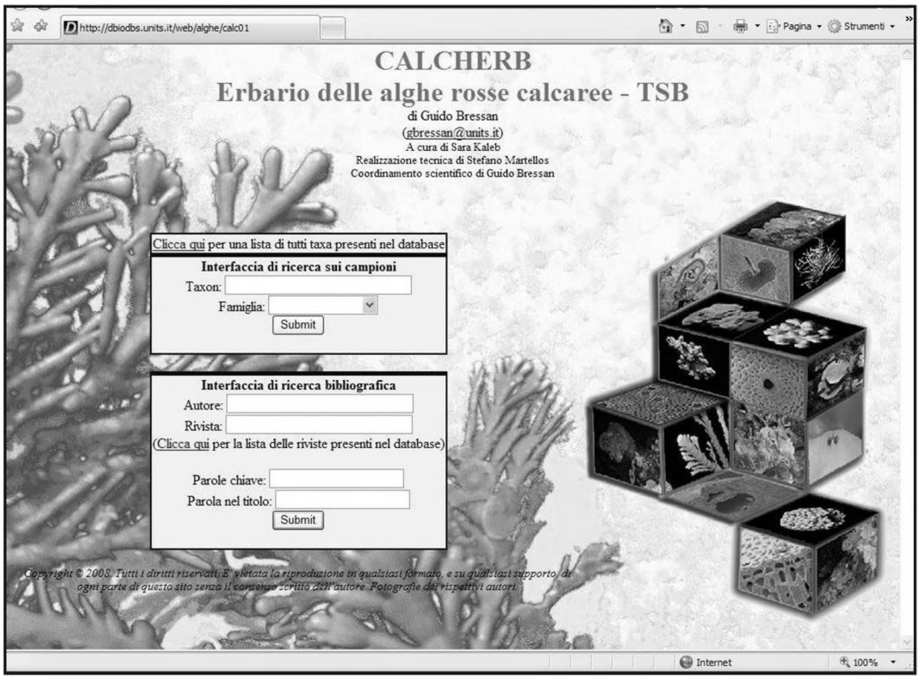
CALCHERB was developed on an Oracle 10g database, and its software is written in PL/SQL language. Data are stored in three main archives:

1. Images Archive (IA), containing pictures of specimens and of the most relevant diagnostic characters. Macroscopic pictures of the specimens have been taken using a digital camera (Nicon CoolPix 4500l) mounted on a stereo-microscope. Ultrastructural pictures have been taken using a Scanning Electron Microscope (Leica MZ6). Pictures of virtual slices have been obtained thanks to the X-ray facilities (SYRMEP line and TOMOLAB)[2]. *In situ* pictures have been taken by scuba divers using digital cameras (HP R817, Pentax K200). All pictures have been stored in jpeg format, and uploaded using a *cgi* script written in Perl language.
2. Data Archive "TSB Algarium" (DATSBA), containing specimens data: identification codes, locality, depth and date of sampling, legit, determinavit, and notes.
3. References Archive (RDB), containing the references used for the identification of the specimens.

Query interfaces can be used with any common Web Browser, and are written in HTML 4.0 according the last W3C recommendations (http://www.w3.org/).

RESULTS

CALCHERB is accessible at the link: http://dbiodbs.units.it/web/alghe/calc01.
Its home page contains two query interfaces: the specimens query interface and the references query interface (Fig. 1).



CALCHERB
Erbario delle alghe rosse calcaree - TSB
di Guido Bressan
(gbressan@units.it)
A cura di Sara Kaleb
Realizzazione tecnica di Stefano Martellos
Coordinamento scientifico di Guido Bressan

Clicca qui per una lista di tutti taxa presenti nel database

(Clicca qui per la lista delle riviste presenti nel database)

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Fig. 1: Home page of CALCHERB, containing both specimens and references query interfaces.

The specimens interface can be queried using any textual string. The search engine is not key sensitive, and it returns all the specimens of a species matching the query, with the related references taken from the references archive (Fig. 2). If pictures are available, the search engine displays also a link to the iconographic archive.
The system can also be queried by selecting a family in a dropdown menu, and eventually combining it with a query string. The output returns all the species matching the query. By selecting one of the species, the system returns a page with all the related specimens, similar to fig. 2.

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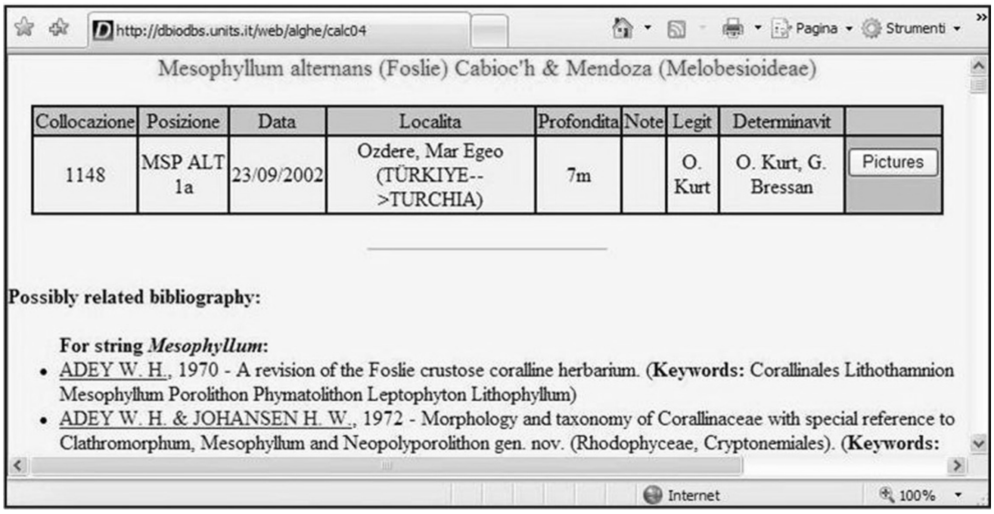
[2] Elettra – Synchrotron Light Laboratory (http://www.elettra.it).



Mesophyllum alternans (Foslie) Cabioc'h & Mendoza (Melobesioideae)

Collocazione	Posizione	Data	Localita	Profondita	Note	Legit	Determinavit	
1148	MSP ALT 1a	23/09/2002	Ozdere, Mar Egeo (TÜRKIYE-->TURCHIA)	7m		O. Kurt	O. Kurt, G. Bressan	Pictures

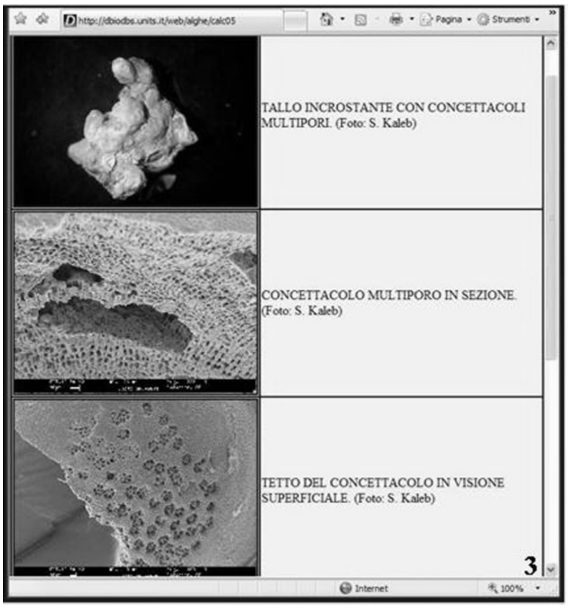
Possibly related bibliography:

For string *Mesophyllum*:

- ADEY W. H., 1970 - A revision of the Foslie crustose coralline herbarium. (**Keywords:** Corallinales Lithothamnion Mesophyllum Porolithon Phymatolithon Leptophyton Lithophyllum)
- ADEY W. H. & JOHANSEN H. W., 1972 - Morphology and taxonomy of Corallinaceae with special reference to Clathromorphum, Mesophyllum and Neopolyporolithon gen. nov. (Rhodophyceae, Cryptonemiales). (**Keywords:**

Fig. 2: Result of a specimens query: the page lists all the specimens matching the query, followed by references.

By clicking on the link to the Images Archive, the system returns a page showing all the pictures of a specimen, both ultrastructural and macroscopic (Fig. 3, 4), with a short note (in Italian only, under translation in English), and taken *in situ* (Fig. 5, 6), provided with metadata about author, locality, date and dept (in meters). The images can be enlarged, so that the relevant diagnostic characters can be better understood (Fig. 4, 6). The Images Archive currently contains almost a thousand pictures, and is currently under further development.



TALLO INCROSTANTE CON CONCETTACOLI MULTIPORI. (Foto: S. Kaleb)

CONCETTACOLO MULTIPORO IN SEZIONE. (Foto: S. Kaleb)

TETTO DEL CONCETTACOLO IN VISIONE SUPERFICIALE. (Foto: S. Kaleb)

Fig. 3: Macroscopic and ultrastructural pictures of aspecimen of *Mesophyllum macedonis* Athanasiadis

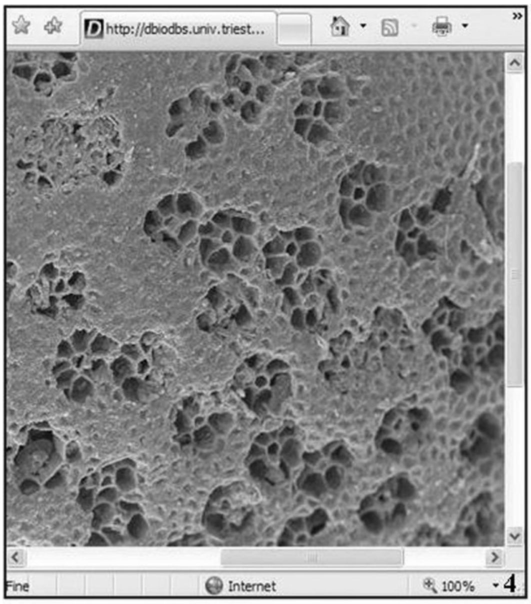


Fig. 4: Enlarged picture - roof of conceptacle with “rosettes” of *M. macedonis*.

VIS (CROATIA). 05/08/2008. -16m.
(Foto: S. Kaleb)

VIS (CROATIA). 02/08/2008. -30m.
(Foto: S. Kaleb)

Fig. 5: Coralligenous of Vis island (South Adriatic) with *Lithophyllum stictaeforme* (Areschoug) Hauck.

Fig. 6: Enlarged picture - *L. stictaeforme* and *Myriapora truncata* (Bryozoa).

The References Archive (RDB) can be queried by: 1) author, 2) journal, 3) keywords, or by using a combination of the three. The output lists all the references matching the query (Fig. 7), sorted by author. For each reference author(s), title, journal, year, keywords and a code are reported. The latter refers to the position of an article in the archive hosted at the Dept. of Life Sciences of the University of Trieste. Names of species in the keywords field can be displayed as hypertextual links (Fig. 7), which allow users to be redirected to a specific taxon page. The RDB contains more than 500 references, and it is constantly updated.

Risultato della ricerca

Coll.	Anno	Autore	Titolo	Riferimento	Parole chiave
8Z.008	1970	ADEY W. H.	A revision of the Foslie crustose coralline herbarium.	Det Kongelige Norske Videnskabers Selskabs Skrifter :1-46	Corallinales Lithothamnion Mesophyllum Porolithon Phymatolithon

Fig. 7: Result of a query in the references archive, with hypertextual links to taxon pages.

DISCUSSION

The Coralligenous assemblage is an important Mediterranean underwater seascape, which management and protection require constantly updated ecological and distributional information on the involved taxa. One of the most important components of the Coralligenous is the red coralline algae (Corallinales), which ecology and distribution in the Mediterranean are exhaustively known only for some areas. Several data are still lacking, especially as far as the Eastern Mediterranean is concerned (Ballesteros, 2006).

Before the wide diffusion of internet, scientific data were available almost exclusively on specialistic journals, and were poorly accessible and understandable outside the scientific community. Still today, as far as this group of algae is concerned, few are the databases freely accessible, and almost no iconography is available on-line. To our knowledge, such resources are completely lacking as far as the Mediterranean area is specifically concerned.

Access to information, which is a basic task in biodiversity informatics, is fundamental for environmental management and protection. CALCHERB is an information system organising data from an important collection of Corallinales, and making them easily accessible. Being published on-line, CALCHERB can be constantly updated by a continuous flow of new data. This is an important advantage, if compared with "classic", paper-printed information resources.

Inside CALCHERB, great relevance is given to iconography, which is a useful support to identification and taxonomic studies. Furthermore, pictures taken *in situ*, with their metadata, represent a sort of a documented "*visual census*", becoming an important source of information for further ecological studies.

CALCHERB can also be a useful tool for transferring scientific knowledge to a larger public, and for making people aware of the importance and ecologic role of the Coralligenous, and of the increasing impact of human activities on this seascape.

CALCHERB is part of the net of information systems and databases of the Museal System of the University of Trieste (smaTs, http://dbiodbs.univ.trieste.it/smats/home.html), and is currently beginning to cooperate with some other national and international projects in the field of biodiversity informatics.

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CONTRIBUTION TO THE CONSERVATION OF CORALLIGENOUS COMMUNITIES THROUGH STUDIES ON POPULATION ECOLOGY OF MEDITERRANEAN GORGONIANS

ABSTRACT

Coralligenous communities are presently under the combined pressure of several human-induced impacts; nevertheless, the effects of these disturbances as well as the capacity to recover from them are poorly understood. Facing the complexity to study these effects on the whole array of species dwelling in this high diverse habitat, it is crucial selecting species enough representative of the whole dynamics of these assemblages. Our research focuses on the population dynamics of long-lived gorgonians to assess the impacts and recovery of coralligenous communities. We present the methods, descriptors and models that we have been using to study gorgonian populations over large spatial (from Spanish and to French littoral including Balearic and Corsica Islands) and temporal scales (from three to almost ten years of monitoring). The data obtained can be considered a precious contribution to understand the population dynamics of these species as well as to evaluate their resistance to the threats that are currently affecting many Mediterranean gorgonian populations.

KEY-WORDS: Gorgonians, Population dynamics, Demographic models, human-induced disturbances

INTRODUCTION

There is an urgent need to understand the resilience of coralligenous communities face increasing human-induced impacts. Due to the complexity to evaluate these impacts at a community level in this high diverse habitat, it is crucial selecting representative species of the whole dynamics of these assemblages. Our research focused on three long-lived gorgonians: *Paramuricea clavata*, *Eunicella singularis* and *Corallium rubrum* (Cnidaria). These species play an important ecological role structuring the habitat and, they have been adversely impacted by a wide variety of local and regional disturbances (Harmelin & Marinopoulus, 1994; Cerrano *et al.*, 2000; Perez *et al.*, 2000; Garrabou *et al.*, 2001, Garrabou & Harmelin, 2002; Coma *et al.*, 2004, Garrabou *et al.* in press).
Focusing in species-level studies allows obtaining a solid knowledge of species' life history traits and population dynamics which is key for quantitative assessment of the impact and consequences of strong disturbances affecting the populations. These data allow also to develop sound demographic models such as Population viability analysis (PVA). PVAs are one of the most powerful tools in conservation biology to explore the potential effects of disturbances. PVAs are developed on the logics of matrix models (Caswell, 2001). Matrix models are mostly used to calculate population growth rate (λ), the stable stage distribution, and the sensitivities and elasticities of population growth to changes in life history parameters of threatened species (Morris & Doak, 2002). For long-lived species, only long-term monitoring of permanent plots can provide the necessary data to develop reliable PVAs models.

In this study, we present two methodological approaches that can be applied to study the response of Mediterranean gorgonians to disturbances such as mass mortality events, diver effects, overfishing, and invasive algae species. Firstly, we propose extensive surveys using random sampling within populations to provide quick static assessments of the health status of gorgonian populations over large spatial scales. Secondly, we propose intensive surveys based on long term monitoring of permanent plots which allow to obtain precise data on the impact and recovery as well as to develop modelling approaches. We contend that the application of these approaches at Mediterranean scale could greatly contribute to understand the resilience of coralligenous communities facing the current environmental change.

MATERIAL AND METHODS

Extensive surveys

Red and white gorgonian populations were sampled along the NW Mediterranean coasts (Spain and France coasts including balearic and Corsica islands) using random quadrats to obtain reference data on density, size and extent of injuries of the populations (Linares *et al.*, 2008). The comprehensive data set allowed searching for new descriptors, faster and easier to measure in the field, which could speed up the assessment of population conservation status.

Intensive surveys on permanent plots

Accurate demographic estimates over time are obtained through the monitoring of each colony present within permanent plots annually. Demographic data of *P. clavata* and *E. singularis* populations are obtained by direct measurements in the field. In contrast due the fragility of *C. rubrum* colonies, the monitoring of red coral populations is performed using photogrammettic methods.

Monitoring of permanent plots for P. clavata *and* E. singularis *populations*

In order to facilitate mapping accuracy, each permanent plot (about 3-4 m^2) was partitioned in small (40x40 cm) quadrats. In the first survey, all gorgonian colonies in each 40x40 cm quadrat were mapped on a polyvinyl sheet by scuba divers. On subsequent years, maps are used to facilitate the re-identification of each colony. For each gorgonian, colony height, extent of colony injury and nature of epibionts are recorded. Colony height is measured with a ruler as the distance between the colony base and the end of the farthest tip. The extent of colony injury is estimated as the proportion of each colony's total surface that showed denuded axis or overgrowth by other organisms (as in and Harmelin *et al.*, 1999). Colony size is used to estimate biomass (Biomass = 0.002 Height $^{2.61}$); corrections for biomass loss caused by injury are introduced to calculations by subtracting the percentage of biomass equivalent to the percentage of colony surface affected by injury. Recruitment is assessed as the number of new colonies that appeared in the permanent plots after each survey.

Monitoring of permanent plots for C. rubrum

Each permanent plot (about 2m^2) is photographed using 20x20 cm quadrats. Two photographs from each quadrat were obtainedusing two slightly different angles, (approximately 30°) to be able to apply photogrammetric methods. This procedure allows obtaining measures in 3D from photographs (Bianchimani, 2005). From each colony present in the permanent plot the basal diameter, the maximum height, extent of colony injury and the number of branches of each colony were obtained as well as the density of the colonies within each quadrat.

Size-structured matrix models

In order to develop size-structured matrix models, first the individuals have to be classified by age, size or stage. There is no way to determine non-destructively the age of gorgonian colonies, whereas size can often be quickly measured in the field. Moreover, in species displaying indeterminate growth, size is almost always a better classifying variable than age. We analyzed the demography of gorgonians using a set of size-defined stage classes. Defining the width and number of classes is flexible and depends on size-dependent changes in vital rates and time lags. These classes must be

chosen to match with the life history traits of the study species. For example for the red gorgonian, *P. clavata*, we used seven age- and size-defined stage classes.
Across each annual transition period, each gorgonian colony could have one of five fates: 1) survive and grow to the next largest size class, 2) survive and shrink by one size class, 3) survive and shrink by two size classes (only applicable to large classes), 4) survive but remain in the same size class, or 5) die. These vital rates are directly estimated from the data for each annual transition. To best evaluate the effects of different mortality sources on population growth and extinction risk, we construct these models using separately-estimated, size-structured survival, growth, and shrinkage rates (see Linares *et al.*, 2007 for further information on the model development).

Results

To facilitate the results presentation, we focused on the data obtained for the red gorgonian *P. clavata*, but similar results are available for the other two gorgonian species.

Extensive surveys

Surveys with random quadrats allowed obtaining quick and accurate estimates of health status of white and red gorgonian populations. The mean % of injured surface (for the whole population) is probably the best descriptor of the impact caused by the different disturbances; but estimations of this descriptor are hard and time-consuming. Interestingly, data obtained in our extensive surveys allowed to obtain a new descriptor percentage of colonies with more than 10% of injured surface which is well correlated with the mean % of injured surface (Spearman Rank Order correlation, r=0.951, p< 0.05; Fig. 1)

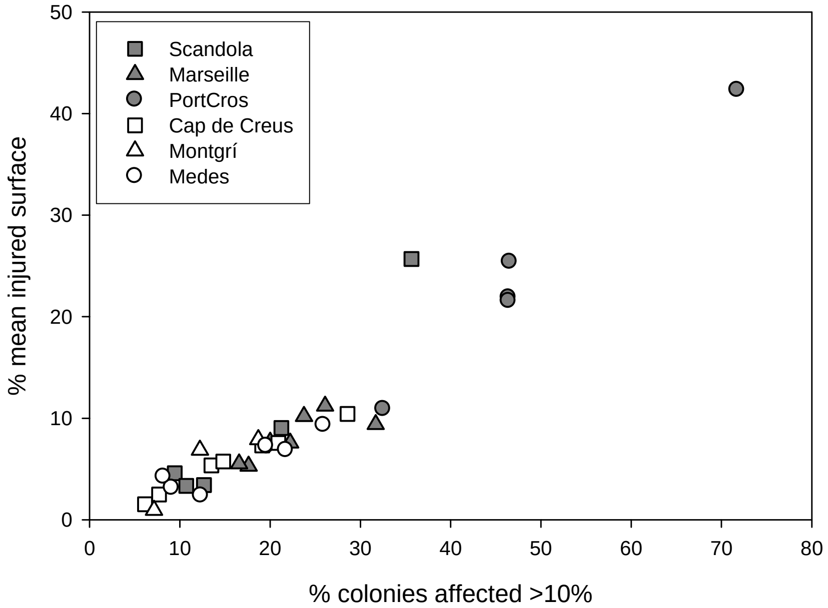

Fig. 1: Relationship between the mean % of injured surface and the % of colonies displaying more than 10 % of injured surface. Each data point represents a population surveyed (in total 34 populations were studied) where more than 50 colonies were measured. Grey symbols represent populations affected by the 1999 or 2003 mass mortality event; white symbols represent populations non-affected by these disturbances.

Since the percentage of colonies with more than 10% of injured surface is a much easier parameter to obtain, this descriptor could be gradually applied to assess the impact of large-scale disturbances, i.e. climate change, at a Mediterranean-wide scale.

Monitoring of gorgonian populations from permanent plots

The Fig. 2 shows the contrasting patterns on the changes of the three main population descriptors (density, % of injured surface and biomass) obtained from the monitoring of the red gorgonian *P.*

clavata populations in the Port-Cros National Park before and up to 9 years after the impact of 1999 mass mortality event (June 1999-vs- November 2008).

Density of colonies decreased steeply after the event (November 2000) and nine years after (2008) they were similar than those obtained in 2000. The extent of injury of the colonies showed a dramatic increase between June 1999 and November 2000 (from 9% to up 50%). However, the overall extent of injury has strikingly decreased during the last years of the study, being similar (about 14%) to those recorded just before the event (Fig. 2b). Regarding the biomass, after the remarkable loss observed just after the event (accounting for around 70%), the mean biomass values have remained constant after nine years of monitoring with any sign of recover (Fig. 2c).

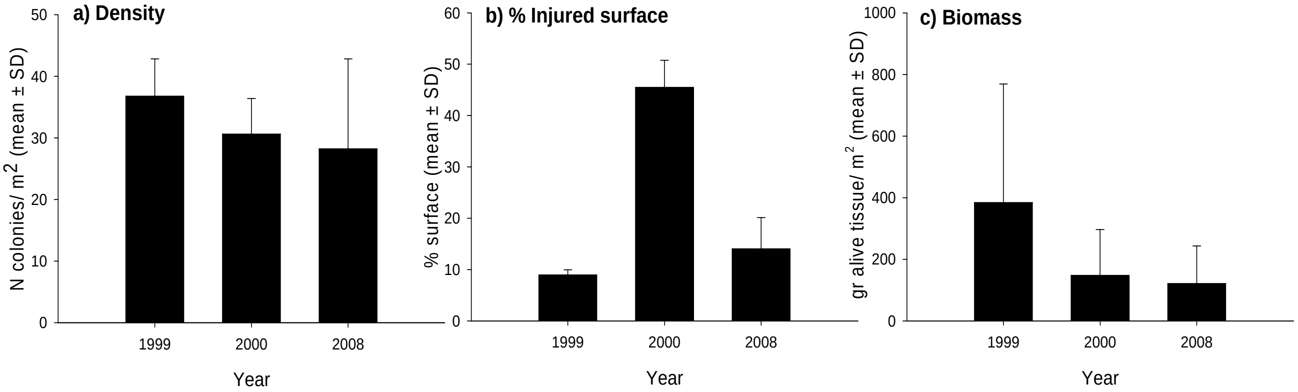

Fig. 2: Temporal changes of the main descriptors used to assess the evolution of *Paramuricea clavata* population affected by the 1999 mass mortality event at Port-Cros National Park (France). Data were obtained just before (June 1999) and after 1 year (2000) and 9 years (2008) of the event. a) Density (N colonies/m^2). b) Partial mortality (% of injured colony surface). c) Total biomass (g alive tissue/m^2). Data (mean ± SD) have been obtained at two localities of Port-Cros (Montrémian and La Gabinière).

After nine years of the impact on red gorgonian populations in Port-Cros, our results showed only a slight recovery of the red gorgonian populations when regarding to the extent of injury (due to the loss of the dead apical parts of the colonies affected). However, the analysis of the evolution of biomass figures demonstrated that the affected populations are still far from their pre-impact state (June 1999), probably due to the loss of large colonies. These results suggest that recovery time will probably be on the order of several decades (in the absence of the impact of other strong disturbances).

Modelling the synergic effects of mass mortality events and divers on red gorgonian *P. clavata* populations

Red gorgonian populations monitored with permanent plots have been submitted to different intensity and/or kind of disturbances: mass mortalities (e.g; Port-Cros) and diving intensity (e.g. Medes Islands and Cap de Creus). Therefore the PVA developed allow to explore the potential effects of different frequencies of mass mortality events and the synergic effects of mass mortality events and diving impact. To analyse the viability of populations under different disturbance scenarios we introduced to the model different data matrices obtained from unaffected years and/or populations. For instance, to explore the potential mass mortality impact in the Medes islands we applied the matrices obtained in Port-Cros populations.

Modelling the mass mortality effects on Medes Islands populations (λ=0.936), Cap de Creus population (λ=0.974) and a theoretical population (λ=0.999) showed drastic effects on persistence under a frequency of mass mortality events of 5 years, with near-certain quasi-extinction between 41 and 63 years (Fig. 3a). On the other hand, simulating a frequency of these events each 10 years, the near-certain quasi-extinction was 45, 84 and more than 100 years for Medes, Cap de Creus and the theoretical population, respectively (Fig. 2b).

The results clearly show that if mass mortality events affect populations with low λ values due to other man-induced impacts such as diving (as occurs for the Medes Islands and Cap de Creus populations; Coma *et al.*, 2004), they will substantially compromise population viability in the short and medium term. In contrast, lambda values close to 1 reduce the short-term risk for gorgonian populations when exposed to these global warming effects. These results suggest that effective management strategies could have large and lasting effects on the population viability of long-lived, and slow-growing coralligenous species facing recurrent mass mortality events.

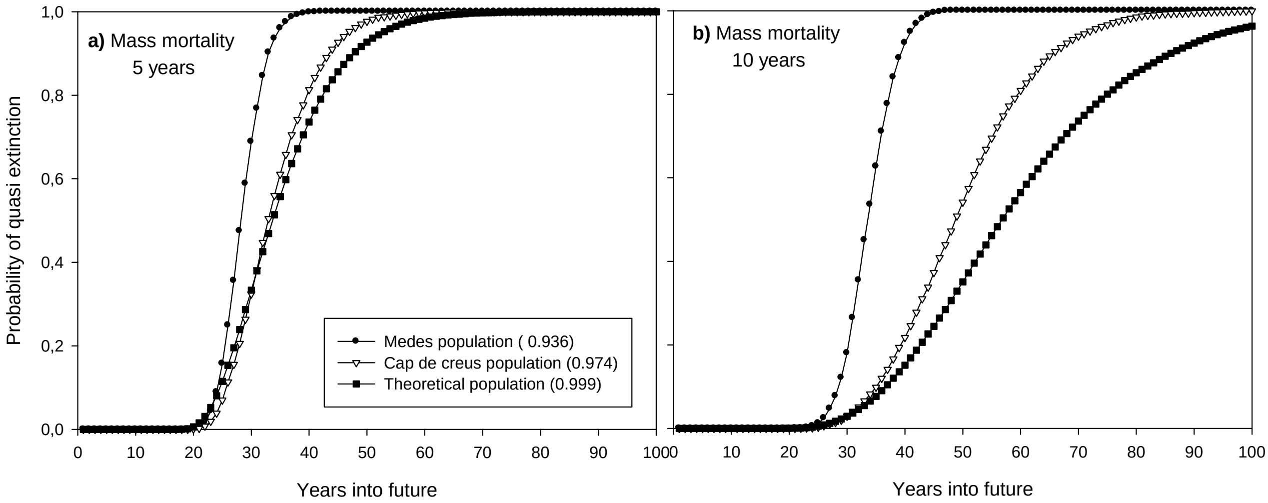

Fig. 3: Cumulative distribution function (CDF) for the time to reach a quasi-extinction threshold of 10% of initial population for for Medes Islands population (λ = 0.936), Cap de Creus population (λ = 0.974) and for a theoretical populations (λ = 0.999) under two mass mortality event frequencies. (a) Simulating a frequency of mass mortality event each 5 years. b) Simulating a frequency of mass mortality event each 10 years. The number in parenthesis represents the λ (the annual population growth rate) and indicates whether a population would grow (λ>1), go extinct (λ<1) or remain steady (λ=1) over time (Morris & Doak, 2002).

CONCLUSIONS

This study highlights the need for intensive (long-term) and extensive (large spatial-scale) studies to improve our knowledge of the response of coralligenous communities when faced with anthropogenic disturbances.

Although we present these methods as one of the most promising tools for the management of coralligenous communities, this study only focuses on the viability of gorgonian populations which represent only a small part of the diverse communities and facies included within the coralligenous assemblages (Ballesteros, 2006). This work opens up the way for the application of demographic and modelling methods to other species of coralligenous communities in view of their conservation. However, the application of these methods may be difficult due to the indeterminate growth displayed by most species dwelling in the coralligenous, and a supplementary effort would be necessary to select an appropriate pool of model species.

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INTEREST AND APPLICATION OF GENETIC MARKERS FOR THE STUDY AND CONSERVATION OF MEDITERRANEAN SESSILE INVERTEBRATES.

ABSTRACT

Population genetic studies are useful for the conservation and management of biodiversity. Nevertheless genetic data are still scarce for most marine invertebrates including some ecologically important species such as the long-lived sessile metazoans from coralligenous communities which are also impacted by environmental changes. We tested several genetic markers for the study of the Mediterranean Cnidarians: Corallium rubrum *and* Paramuricea clavata*. We present the relative efficiency of mtDNA, nuclear intron and microsatellite markers and the main results obtained concerning the diversity, genetic structure and dispersal abilities of these species. The extension and applicability of these approaches to other species from these ecosystems and their potential applications for management are discussed.*

KEY-WORDS: Octocorallia, microsatellites, introns, phylogeography, conservation genetics

INTRODUCTION

In a context of global change, including climate change and other anthropic pressures, coastal ecosystems from the Mediterranean Sea could suffer from increasingly frequent and severe disturbances (Schneider *et al.*, 2007). Some mortality events linked with thermal anomalies have already been observed and impacted several groups of marine sessile invertebrates (Garrabou *et al.*, in press). Many species from coralligenous ecosystems such as Octocorallia might be particularly vulnerable to such phenomena because of low recruitment and growth rates (Linares *et al.*, 2007). Moreover some of these species populations are situated at low depths and at the northern limits of the repartition area of the species. Thus the fate of such populations will mainly rely on *in situ* evolution (i.e. genetic change induced by natural selection) and on exchanges with surrounding populations (including deep ones) which might sustain locally declining demography. Gene flow can also enhance genetic diversity and mitigate the effects of local selection. Managing these ecosystems will then require information on species dispersal abilities and population diversity and connectivity. Nevertheless concerning marine organisms with planctonic larvae most of these parameters can not be directly measured. Indirect estimations based on genetic tools are therefore necessary. The use of genetic markers might provide information for various aspects of marine biodiversity management (reviewed in Féral, 2002):

1. Assessment of biodiversity: molecular techniques can help identify potential cryptic species. and barcode approaches could be useful for future studies on larval stages (Jones *et al.*, 2008). Intra-specific genetic diversity is also an important component of biodiversity which can be estimated with genetic markers, even if its interpretation is not straightforward (Hedrick, 2001).
2. Phylogeography: this approach can give insights in the evolutionary history of a species by revealing for example vicariance events, migration ways or bottlenecks.
3. Population structure and connectivity: identifying population limits and estimating gene flow is useful for defining marine protected areas and understanding local evolution.

Nevertheless for various species from coralligenous ecosystems, genetic data and markers are still scarce. In the context of the MEDCHANGE project studying the impact of global change on these communities, we developed and evaluated several molecular tools for the Cnidarians *Corallium rubrum* (Linné, 1758) and *Paramuricea clavata* (Risso, 1826). In this paper we present the present state and potential future developments of genetic studies on these species according to the different levels of analyses mentioned above.

MATERIALS AND METHODS

- Sampling: the sampling schemes for *C. rubrum* and *P. clavata* were designed to allow genetic comparisons at different geographical distances: from the distribution range of these species to local scales (i.e. for distances varying from hundreds of km to 20 m). For phylogeography we analysed 149 sequences of *C. rubrum* colonies originated from Croatia to North Africa (Ceuta). The mtDNA marker was tested on 16 distant individuals of *P. clavata,* from Turkey to Ceuta and 17 *C. rubrum* from Croatia to Ceuta. For microsatellites analyses we present results from 6 populations for *C. rubrum* (3 from Riou Island - Marseilles, 1 from Plane Island - Marseilles, 1 from Corsica and 1 from Medes – Northern Spain) and 6 for *P.clavata* (1 from Riou Island, 1 from Plane Island, 3 from Corsica and 1 from Banyuls – Southern France).

- Genetic markers:

- Mitochondrial and Intron loci : sequences of the mitochondrial gene coding for Cytochrome Oxidase I (COI) and of a nuclear intron of the Elongation Factor 1 gene (EF1) were used for phylogeography and species delimitation. Mitochondrial DNA is frequently used for phylogeography and introns are non-coding sequences which may provide sufficient variability for intra-specific comparisons. Sequences were obtained by direct sequencing and, for EF1, cloning of PCR products allowed to verify haplotypes sequences for some supposed heterozygous individuals.

- Microsatellite loci: these markers were chosen to assess the population structure and connectivity, especially at small spatial scales because of their high level of polymorphisms (Hedrick, 1999; Selkoe *et al.*, 2006). Ten microsatellite loci were used for *C. rubrum* (8 isolated by the companies Ecogenics GmbH (Zurich, Switzerland) and Bioprofiles Ltd. (Newcastle, U.K.), and 2 coming from Costantini *et al.*, 2007a) while 5 microsatellite loci were used for *P. clavata* (isolated by Ecogenics). The loci were amplified by Polymerase Chain Reaction (PCR), then allele sizes were estimated on an ABI 3130 Genetic Analyser for genotyping.

- Data analyses: Sequences were aligned using BioEdit 7.0.5.3 (Hall, 1999). A statistical parsimony network was built with the TCS 1.21 software (Clement *et al.*, 2000); gaps were treated as a fifth character. For microsatellites, unbiased expected heterozygosity (Hn.b), observed heterozygosity (Hobs.) and the F statistics estimates (Fis, Fst) of Weir and Cockerham's (1984) were computed using GENETIX software package version 4.05 (Belkhir *et al.*, 2004).

RESULTS AND DISCUSSION

Phylogeography:

The analysis of 547 bp of the mt COI did not reveal any polymorphism inside the two analysed species, even for the most distant comparisons (Turkey – Ceuta for *P. clavata*). This marker was then non informative as already observed for another Octocorallian, *Eunicella cavolinii* (Calderón *et al.*, 2006).

The sequencing of EF1 allowed the analysis of 494 bp including 346 bp for the intron. The number of variable sites was 41 and 32 different haplotypes were identified. The estimated nucleotide diversity was 0.006 with a maximum divergence value of 0.087. No clear phylogeographic structure was evidenced by the statistical parsimony network for samples coming from Croatia to North Africa (results not shown). Some haplotypes were shared among distant locations (such as Ceuta and Corsica) and most haplotypes were separated by low divergence. These results may indicate a lack of long term isolation among populations and an absence of cryptic species. They could also be the consequence of a recent expansion or a selective event on this marker.

Population structure and diversity:

Table 1 presents the parameters measuring the genetic diversity level. The mean number of alleles per locus per population and the unbiased expected heterozygosity found for the two species were comparable and within the range of values reported for other marine invertebrates with microsatellite markers (Duran *et al.*, 2004; Le Goff-Vitry *et al.*, 2004; Costantini *et al.*, 2007).

Multilocus Fis estimates (table 1) were significantly different from zero in all populations for *C. rubrum* and *P. clavata*, showing heterozygote deficiencies, except for one *P. clavata* population (PEL). Heterozygotes deficiencies may be the result of inbreeding, Wahlund effect (presence of different breeding units) or technical factors such as null alleles. Indeed some individuals which failed to amplify for some of the loci may be some null homozygotes. All these factors may contribute to explain the heterozygotes deficiencies as it is probably the case for *C. rubrum* (Costantini *et al.*, 2007a, b).

Tab. 1. Genetic diversity measures and multilocus Fis estimates at 10 microsatellite loci for *Corallium rubrum* and 5 microsatellite loci for *Paramuricea clavata*. N : number of individuals. Asterisks indicate significant values.

Species	Region	Population	Depth (m)	N	Mean alleles number per locus	Hn.b.	Hobs.	Fis
C. rubrum	Marseilles	RIO (Riou Island)	40	29	13,0	0,83	0,50	0,41*
		RIE (Riou Island)	20	30	7,7	0,67	0,53	0,21*
		RII (Riou Island)	20	36	10,7	0,79	0,52	0,35*
	Marseilles	PLA (Plane Island)	38-41	30	9,1	0,75	0,47	0,37*
	Corsica	GGU	43	32	8,8	0,74	0,52	0,30***
	Medes	POT	35	35	12,7	0,76	0,54	0,30*
P. clavata	Marseilles	RIO (Riou Island)	25	23	12,2	0,84	0,71	0,17*
	Marseilles	GPR (Plane Island)	18	39	12,0	0,82	0,67	0,19*
	Corsica	TOR	30	30	9,4	0,86	0,77	0,11*
		PEL	30	32	6,4	0,72	0,64	0,12
		TEM	30	29	8,4	0,87	0,74	0,16*
	Banyuls	SRE	20	32	10,0	0,73	0,66	0,10*

Population connectivity:

For *C. rubrum*, pairwise multilocus Fst estimates (table 2) were significantly different from zero for all comparisons except one (RII-RIO). Thus we found genetic differentiation between samples separated by 440 km for Medes and Corsica (POT-GGU) and 15 m for 2 sites at Riou Island (RII-RIE). This genetic structuring at very small spatial scales (few metres) has already been underlined in *C. rubrum* in Costantini *et al.* (2007a) and in other invertebrates such as the sponge *Crambe crambe* (Duran *et al.*, 2004) and the ophiuroid *Amphipholis squamata* (Féral *et al.*, 2003). Furthermore, spatial autocorrelation at such short distances was found for *C. rubrum* and *C. crambe* (Costantini *et al.*, 2007a; Duran *et al.*, 2004).

For *P. clavata*, not all pairwise multilocus Fst estimates were significantly different from zero. This could be due to the lower number of loci used (5 versus 10 for *C. rubrum*) for testing genetic differentiation between samples or to a different pattern of genetic structure for this species. Indeed the results presented for *P. clavata* are preliminary results and the analysis of more microsatellites loci will help testing these hypotheses.

Tab. 2. Pairwise multilocus Fst estimates between samples for *Corallium rubrum* and *Paramuricea clavata*. Asterisks indicate significant differentiation.

	Fst	RIO	RIE	RII	PLA	GGU	POT
C. rubrum	RIO		0,06*	0	0,04*	0,07*	0,04*
	RIE			0,05***	0,09*	0,17*	0,13*
	RII				0,046*	0,09*	0,07*
	PLA					0,09*	0,05*
	GGU						0,06*
	POT						
	Fst	RIO	GPR	TOR	PEL	TEM	SRE
P. clavata	RIO		0,03	0,03	0,13*	0,04	0,06*
	GPR			0,06*	0,14*	0,05*	0,09*
	TOR				0,08*	0,01	0,12*
	PEL					0,03	0,19*
	TEM						0,08*
	SRE						

CONCLUSIONS

We developed some markers useful for the study and management of genetic diversity of several cnidarian species from coralligenous ecosystems. The study of intron sequences suggest a general homogeneity of *C. rubrum* across its Mediterranean distribution area which is in contrast with the restrictions to gene flow at short distances evidenced by microsatellites. The sequencing of other nuclear markers should help understand the evolutionary history of these species and some other introns are currently tested for *P. clavata* and *C. rubrum*. Testing such markers will require less efforts as more genomic information will be available for different phyla. Microsatellites are powerful markers that enable insights into fine-scale ecological questions such as detecting genetic structuring at distances of few metres for these organisms. Indeed, assessing population limits and connectivity is of great importance to define the spatial scale for species conservation or to predict population recovery after disturbances. The results obtained with microsatellites suggest that the management of these species should integrate these low effective dispersal abilities. The local scale seems then the most pertinent for such organisms. However, as microsatellite markers need to be isolated from each species, the extension of this approach to other species is not straightforward. Some protocols exist to develop these tools (reviewed in Zane *et al.*, 2002) but they may require more or less time and money depending on the genome analysed. Other microsatellite loci have been isolated for *P. clavata* and will be soon used for genetic studies. Some microsatellites are also currently studied for another Cnidarian, *Eunicella singularis* and its associated photosynthetic symbionts (D. Forcioli, comm. pers.).

More efforts should also be done in order to analyse the adaptation abilities of these organisms in a context of climate change. Among other physiological approaches, some gene expression studies will then be realised combined with thermo-tolerance experiments.

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Actes du 1er Symposium sur le Coralligène et autres Bio-Concrétions calcaires de Méditerranée
(Tabarka, 15-16 Janvier 2009)

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LE RECIF A *NEOGONIOLITHON BRASSICA-FLORIDA* DE LA LAGUNE DES BIBANS (TUNISIE)

RÉSUMÉ

La rhodobionte encroûtante Neogoniolithon brassica-florida *est généralement signalée sous forme de placage le long des côtes rocheuses battues de Méditerranée. Sa présence dans la lagune hyperhaline des Bibans, située dans la partie Sud-Est de la Tunisie, revêt une importance particulière du fait de son extension. En effet, cette mélobésiée constitue une véritable construction récifale de plusieurs kilomètres de longueur en bordure du lido. Identifiée dans un premier temps le long du littoral occidental, cette formation se développe en fait de part et d'autre du grau.*

La mise en place de ce « monument naturel » est vraisemblablement très ancienne. Elle semble résulter d'une véritable série évolutive qui débute par l'installation de Sabellariidae*, qui peuvent constituer localement de véritables plates-formes au sein de l'herbier à* Cymodocea nodosa*. Ces plates-formes, caractérisées par la présence de nombreuses cavités dans leur partie inférieure, servent de substrat à plusieurs espèces de macrophytes, dont certaines ne se développent normalement que plus profondément. D'autre part, ces bioconstructions favorisent la fixation des premiers individus de* Neogoniolithon brassica-florida*. Ces rhodobiontes se développent ensuite et colonisent totalement ces plates-formes pour donner lieu, dans un premier temps, à des structures isolées, affleurant en surface, à quelques mètres du littoral. Par la suite ces structures se rejoignent et constituent un véritable récif en bordure du littoral isolant ainsi un petit lagon.*

Le caractère exceptionnel de cette formation bioconstruite, associé aux caractéristiques biologiques, culturelles et historiques de cette lagune, nécessite la mise en place de mesures de conservation permettant sa protection. En effet, la construction récente d'infrastructures hôtelières sur les îlots, situés à l'entrée de la lagune, est de nature à dégrader la qualité de ce site et à compromettre sa pérennité.

MOTS-CLÉS : Construction récifale, Tunisie, lagune, *Neogoniolithon brassica-florida*, cartographie, série évolutive.

INTRODUCTION

La rhodobionte *Neogoniolithon brassica-florida* (Harvey) Setchell & L.R. Mason est présente dans de nombreuses régions de la biosphère et notamment dans les îles des océans Atlantique, Indien et Pacifique, en Afrique du Sud, Asie du Sud-Est et du Sud-Ouest, en Australie, Nouvelle-Zélande (Silva *et al.*, 1996 ; Womersley 1996 ; South & Skelton, 2003 ; John *et al.*, 2004 ; http://www.algaebase.org).

En Méditerranée cette rhodobionte présente également une large distribution (Babbini & Bressan, 1997). *Neogoniolithon brassica-florida* se développe principalement sur les côtes rocheuses battues, sous forme de placage, dans l'étage médiolittoral inférieur (Molinier, 1960 ; Giaccone *et al.*, 1993). L'association, qu'elle constitue, figure dans les répertoires européens de conservation de la biodiversité (EUNIS Code : A1.232 – Région Méditerranée) et dans les habitats d'intérêt pour la conservation de la Convention de Barcelone (CAR-ASP code : II.4.2.8 ; PNUE-PAM-CAR/ASP, 2007).

La présence de cette espèce au niveau de la Bahiret El Bibane, lagune hyperhaline du Sud de la Tunisie (Keer, 1976 ; Medhioub, 1979), a été signalée, dès 1929 (Seurat, 1929). Cette lagune, d'une surface d'environ 230 km^2 et d'une profondeur maximale de 6 m, présente une salinité qui peut atteindre plus de 50, pendant l'été, malgré une ouverture sur la mer (grau), d'un kilomètre de large, traversée par de violents courants de marée (Medhioub, 1979 ; Guelorget *et al.*, 1982). La partie centrale de cette lagune est occupée par un vaste herbier à *Cymodocea nodosa* (Ucria) Ascherson associé localement avec la chlorobionte *Caulerpa prolifera* (Forsskall) Lamouroux (Zaouali, 1982); la surface couverte par cet herbier mixte est évaluée à 195 km^2, soit 84 % de la lagune (Vela *et al.*, 2008).

Neogoniolithon brassica-florida se développe dans la partie Nord de la lagune, de part et d'autre du grau, où elle constitue une structure parallèle à la côte, d'une trentaine de kilomètres de longueur, assimilable, dans sa structure, à un petit récif frangeant (Thornton *et al.*, 1978). Plus de trente années après sa découverte, il apparait judicieux (i) de faire un bilan quant-à l'extension actuelle de cette structure, (ii) de déterminer si elle présente une dynamique progressive ou régressive et (iii) d'essayer de mieux appréhender les conditions biotiques et /ou abiotiques à l'origine de sa mise en place. Même si la Bahiret El Bibane apparaît relativement protégée des activités humaine (Pilkey *et al.*, 1989), il conviendra, eu égard à ces éléments de s'interroger sur l'intérêt de conserver cette formation récifale.

MATERIEL ET METHODES

L'identification et la répartition des principaux peuplements et types de fonds ont été réalisées à partir d'une image du satellite SPOT5 (pixel de 2.5m) acquise en Mai 2004 et de données terrains (459 points géolocalisés) effectuées en Juin 2005 (Fig.1 ; Vela *et al.*, 2008).

Fig. 1 : Cartographie de la Bahiret El Bibane. Dans la lagune, les sédiments meubles, non végétalisés, sont représentés en blanc et les herbiers mixtes à *Cymodocea nodosa* et *Caulerpa prolifera* en gris.

Une attention particulière est portée aux limites d'extension de la formation à *Neogoniolithon brassica-florida*; les positions sont relevées, à partir d'une embarcation, à l'aide d'un « Gobal Positioning System » Garmin 276C™ (précision évaluée entre 5 et 10 m).

Une étude de cette formation récifale (dimension et forme, distance au littoral, coupe verticale) mais également de plates-formes, couvertes d'un peuplement de macrophytes, est réalisée en apnée. Des prélèvements de macrophytes sont également effectués pour détermination ultérieure au laboratoire.

RESULTATS

Le « récif » à *Neogoniolithon brassica-florida* s'étend sur une dizaine de kilomètres à l'Ouest du grau et sur près de 2 km à l'Est de celui-ci (Fig. 2). Dans la majeure partie de sa surface, cette formation constitue une barrière continue de 0.5 à 2.0 m de large, délimitant un petit « lagon » en bordure du littoral (Fig. 3). De part et d'autre de ce récif, une zone de transition, formant une barrière plus discontinue, est observée, en particulier dans la partie Est où le récif est moins développé (Fig. 4).

Les observations réalisées, montrent que la structure de cette formation n'est pas homogène ; en effet, si la partie supérieure correspond effectivement au développement de la rhodobionte *Neogoniolithon brassica-florida*, elle repose sur une base constituée par des Sabellariidae (Fig. 5). Cette base, également bioconstruite est plus fragile que la rhodobionte et elle a tendance à se dégrader au cours du temps (bioérosion) générant des structures en « champignon », pour les colonies isolées, ou en surplomb, le long du récif (Fig. 6).

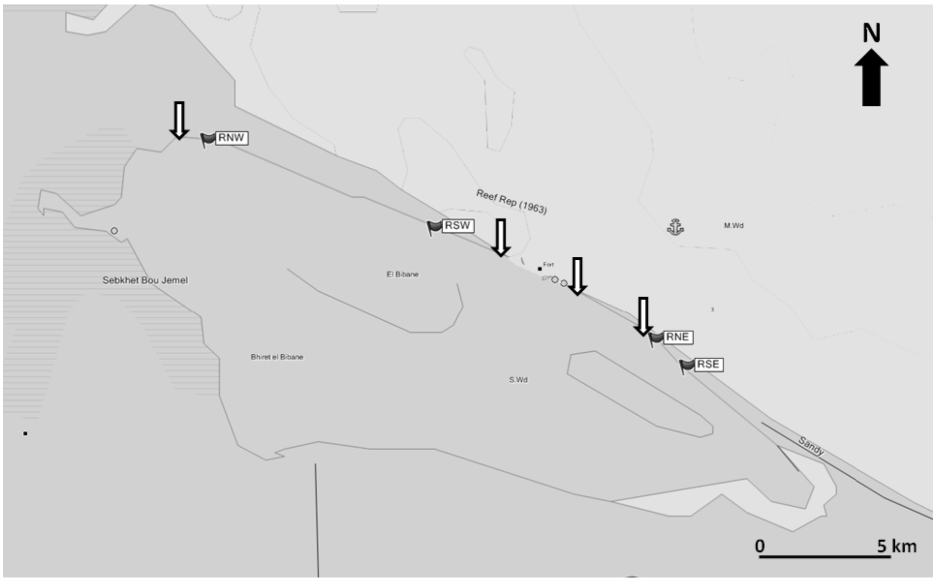

Fig. 2 : Extension du récif à *Neogoniolithon brassica-florida* dans la partie Ouest (RNW à RSW) et Est (RNE à RSE) de la lagune. Les flèches verticales indiquent l'extension passée du récif (Thornton *et al.*, 1978).

Fig. 3 : Récif à *Neogoniolithon brassica-florida*, aspect continu.

Fig. 4 : Récif à *Neogoniolithon brassica-florida*, aspect discontinu.

Des « plates-formes », bioconstruites par ces Sabellariidae, sont également observées à proximité du littoral; elles sont généralement couvertes par plusieurs espèces de macrophytes (Tab 1) et quelques individus de *Neogoniolithon brassica-florida*. Ces macrophytes sont aussi observées à la base du récif lui-même.

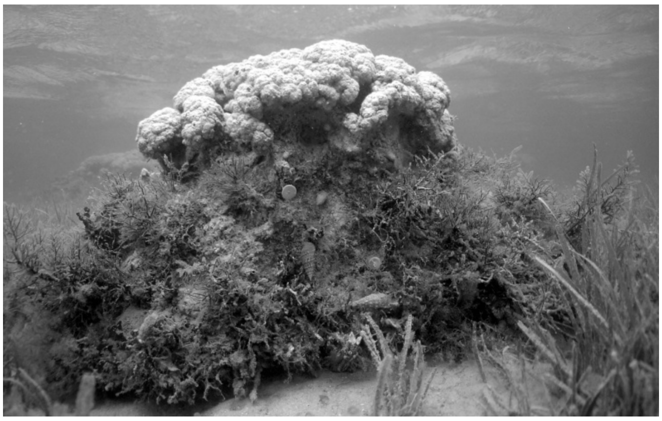

Fig. 5 : Structure verticale de la formation à *Neogoniolithon brassica-florida*

Fig. 6 : Structure du récif à *Neogoniolithon brassica-florida* (surplomb)

Tab 1 : Liste des macrophytes présentes sur les plates-formes bioconstruites et à la base du récif à *Neogoniolithon brassica-florida*

Classe	**Ordre**	**Genre & Espèce**
Florideophyceae	Ceramiales	*Laurencia obtusa* (Hudson) Lamouroux 1813
	Corallinales	*Jania rubens* (Linnaeus) Lamouroux 1812
	Gigartinales	*Hypnea musciformis* (Wulfen) Lamouroux 1813
		Peyssonelia dubyi Crouan & Crouan 1844
		Peyssonelia squamaria (Gmelin) Decaisne 1842
Bryopsidophyceae	Bryopsidales	*Halimeda tuna* (J. Ellis & Solander) J.V. Lamouroux 1812
Ulvophyceae	Cladophorales	*Anadyomene stellata* (Wulfen) C.Agardh 1823
	Dasycladales	*Acetabularia acetabulum* (Linnaeus) P. C. Silva 1952
Pheophyceae	Cutleriales	*Cutleria multifida* (Turner) Greville 1830
	Dictyotales	*Dictyota dichotoma* (Hudson) J.V. Lamouroux 1809
		Dictyota dichotoma var intricata (C. Agardh) Greville 1830
		Dilophus fasciola (Roth) M.A. Howe 1914
		Padina pavonica (Linnaeus) Thivy 1960
	Fucales	*Cystoseira compressa* (Esper) Gerloff & Nizamuddin 1975

DISCUSSION

L'extension actuelle du récif à *Neogoniolithon brassica-florida*, une douzaine de kilomètres, apparaît beaucoup plus réduite que celle rapportée en 1978 par Thornton *et al.*, 1978 (31 km). Cette régression semble affecter principalement le secteur situé de part et d'autre du grau, où l'hydrodynamisme est le plus important (Medhioub, 1979). A l'Est du grau, si la totalité du récif observé en 1978 semble avoir disparu, un nouveau récif, présentant une structure discontinue (plus jeune), est observé plus à l'Est (Fig. 2). La régression, observée de part et d'autre du grau, concerne près de 6.5 km alors que le nouveau récif ne s'étend que sur 1.5 km. Toutefois il semble que la méthode retenue par Thornton *et al.*, (1978) pour évaluer cette extension différe de celle utilisée dans ce travail (mesure du linéaire côtier) ; l'application de notre méthode aux observations de 1978 ramène l'extension passée du récif à environ 19 km; la régression serait alors d'environ 37 %.

Ormis *Anadyomene stellata*, les espèces de macrophytes relevées sur le récif sont déjà observées dans d'autres lagunes tunisiennes notamment la lagune de Bizerte (Djellouli *et al*., 2000) et semblent communes des milieux lagunaires tunisiens. Leur présence à la base du récif à *Neogoniolithon* suggère que le récif constitue un substrat favorisant l'installation d'une association dominée par *Cystoseira compressa* et réunissant plusieurs espèces de l'infralittoral supérieur.

Bien qu'il soit difficile d'identifier précisément les processus responsables de la mise en place de cette structure récifale, les observations réalisées sur le terrain permettent de proposer l'hypothèse suivante (Fig. 7) :

Phase 1 : Installation de Sabellariidae sur des débris coquillers en bordure de littoral donnant lieu à l'apparition de petits substrats durs

Phase 2 : Développement d'une colonie de Sabellariidae à l'origine de la bioconstruction de plates-formes sur lesquelles se fixent plusieurs espèces de macrophytes

Phase 3 : Des individus de *Neogoniolithon brassica-florida* s'installent sur ces plates-formes et se développent (horizontalement et verticalement) jusqu'à colonisation totale du sommet de cette structure

Phase 4 : Les colonies isolées de *Neogoniolithon brassica-florida*, réparties le long du littoral, à faible profondeur, puis finissent par se rejoindre et former le récif

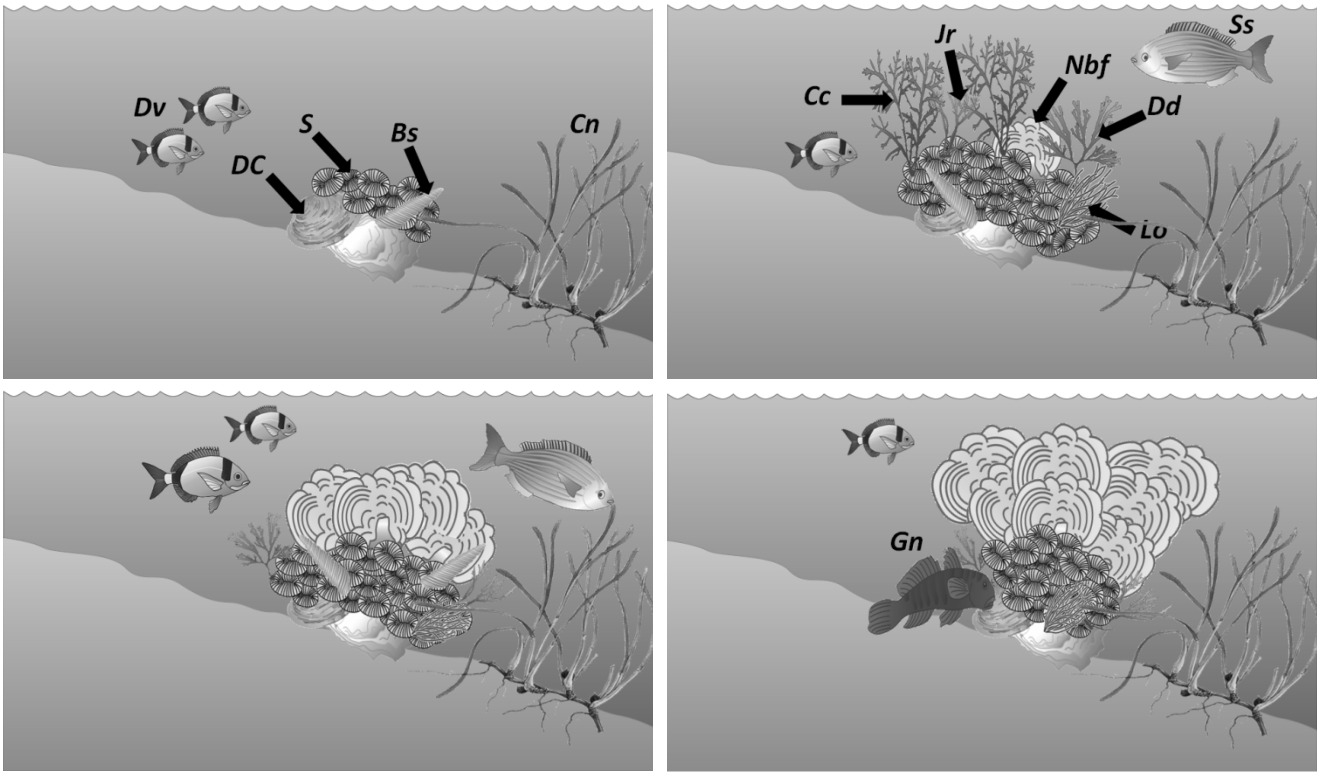

Fig. 7 : Installation du récif à *Neogoniolithon brassica-florida* dans la Bahiret El Bibane. DC = Débris coquillers ; S = Sabellariidae ; Bs = *Bittium scabrum* ; Cn = *Cymodocea nodosa* ; Cc = *Cystoseira compressa* ; Jr = *Jania rubens* ; Nbf = *Neogoniolithon brassica-florida* ; Dd = *Dictyota dichotoma* ; Lo = *Laurencia obtusa* ; Ss = *Sarpa salpa* ; Gn = *Gobbius nigra*.

La coupe d'une formation à base de *Neogoniolithon brassica-florida* fait apparaître cette superposition, avec à la base, une « couche » de Sabellariidae, sur laquelle se développent des macrophytes, surmontée par la rhodobionte encroutante (Fig. 5). Au cours du temps, la fragilité de la base de Sabellariidae, soumise à des phénomènes de bioérosion, et la croissance de *Neogoniolithon brassica-florida* donnent naissance à des structures en champignon pour les colonies isolées et à des surplombs en bordure du récif (Fig. 6).

CONCLUSION

La régression du récif à *Neogoniolithon brassica-florida* au cours de ces dernières décennies et la construction récente d'infrastructures hôtelières sur les îlots situés à l'entrée de la lagune, de nature à dégrader la qualité de ce site et à compromettre sa pérennité, justifient la mise en place de mesures permettant la conservation de ce monument naturel.

En outre, l'intérêt (i) biologique, avec un vaste herbier de *Cymodocea nodosa*, des micro-atolls de *Posidonia oceanica* (Linnaeus) Delile (Riveil *et al*., 2006) et une forte production halieutique, (ii) culturel, avec la présence de la plus grande bordigue de Méditerranée encore en exploitation, et (iii) historique, attestée par des fortifications côtières ottomanes sur les îlots de la passe, confère à ce site une importance majeure pour la Méditerranée. Son inscription récente sur la liste des sites sensibles de Tunisie, par l'Agence de Protection et d'Aménagement du Littoral (APAL), constitue une première étape en ce sens qui mériterait d'être poursuivie.

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THE CONTRIBUTION OF BRYOZOANS AND SERPULOIDEANS TO CORALLIGENOUS CONCRETIONS FROM SE SICILY

ABSTRACT

Bryozoans and serpuloideans and their role within coralligenous concretions originating from a depth of 35-55 meters off Avola (SE Sicily) were analysed. Species contribution within the calcareous bioconstruction was described through the Fagerström functional guilds including constructors, binders, dwellers and bafflers. Usefulness and difficulties in applying this approach are discussed. Species richness and abundance were evaluated and compared with the few available data on the extremely complex coralligenous ecosystem from other sites and settings in the Mediterranean, stressing heterogeneity of methods and information.

KEY-WORDS: Bioconstruction, Functional guilds, Biodiversity, Mediterranean, Recent.

INTRODUCTION

Bryozoans and serpuloideans are among the main constituents in biogenic concretions and usually co-occur with calcareous red algae in the Coralligenous Biocoenosis (C) due to their general need for hard-substrata to settle and grow and their preference for shadowed and sheltered cryptic habitats. Species from both taxa posses heavy mineralised skeletons and, consequently, their colonies and specimens are able to actively contribute to the development of concretions. The presence of some bryozoans and annelid polychaetes (but not specifically serpuloideans) within the coralligenous was first reported by Pérès & Picard (1961). Some information can be found in Pérès & Picard (1964) and in the extraordinarily comprehensive paper by Laubier (1966) on the "Coralligène des Albères". Further data on bryozoans can be found in Gautier (1962) and mostly in Harmelin (1976), and Zabala (1986) who summarised knowledge and recorded species from coralligenous bottoms with different expositions and depths along the Provencal coasts and the Medes Islands, respectively. Some papers deal with remarkable aspects of the biocoenosis, such as those dominated by Gorgonaceans and the Laminarians (Gautier, 1959; Di Geronimo *et al.,* 1988; 1990) and by some large-sized habitat-forming bryozoans, such as *Pentapora* sp. (see Cocito *et al.*, 1988; 2004). In contrast, less is known for serpuloideans as only a few papers focus on the coralligenous (Bellan, 1965; Laubier, 1966), and further information can be found in Amoureux & Katzmann (1971), Bazzicalupo et al. (1974), Bellan & Marinopoulos (1981) and Casellato & Stefanon (2008). Finally, further records for both groups are in synoptic papers (see Bianchi, 2001; Ballesteros, 2006, for a review) and in analyses of peculiar distribution pattern of high taxonomic groups (Balata *et al.*, 2005; Virgilio *et al.,* 2006, for instance).

Nevertheless, information is scant for bryozoans and serpuloideans thriving within the classical algae-dominated coralligenous facies and knowledge relies almost exclusively on the western Mediterranean basin. Particularly, in the Sicily area the coralligenous was only known from the eastern coasts, near Catania (Rossi, 1958) and the Gulf of Noto from where bryozoans and serpuloideans were recorded as involved in a columnar build-up from 30m deep bottoms, nearly exclusively made up by corallinaceans (Di Geronimo *et al.*, 2001; 2002). The present paper provides preliminary information about bryozoans and serpuloideans and the role they play in the bioconstruction, relative to the algae-dominated coralligenous from slightly deeper bottoms from the same area.

MATERIALS AND METHODS

Studied samples originate from fishermen nets dredging the shallow shelf off Avola (SE Sicily) at a depth of 35-55 metres where coralligenous communities largely occur in a relatively wide belt in between 30-65m depth and, locally, in a 90-100m deep string (Violanti *et al.*, 1990). Materials consist of centimetre to decimetre-sized fragments of concretions mostly constructed by an intergrowth of algal laminae, which represent the main carbonate-secreting constituent, and invertebrates, mainly bryozoans, serpuloideans and vermetids (Figs. 1 A-F). Several fragments, about four dm^3 in volume, were analysed to check for bryozoans and serpuloideans aiming to recognize species diversity and the role of individual species within the bioconstruction (Figs. 2 A-G), using the Fagerström (1988; 1991) functional guilds. Low magnification photos were acquired with a Zeiss Stereodiscovery V8 system equipped with Axiocam MRc and Axiovision acquisition system.

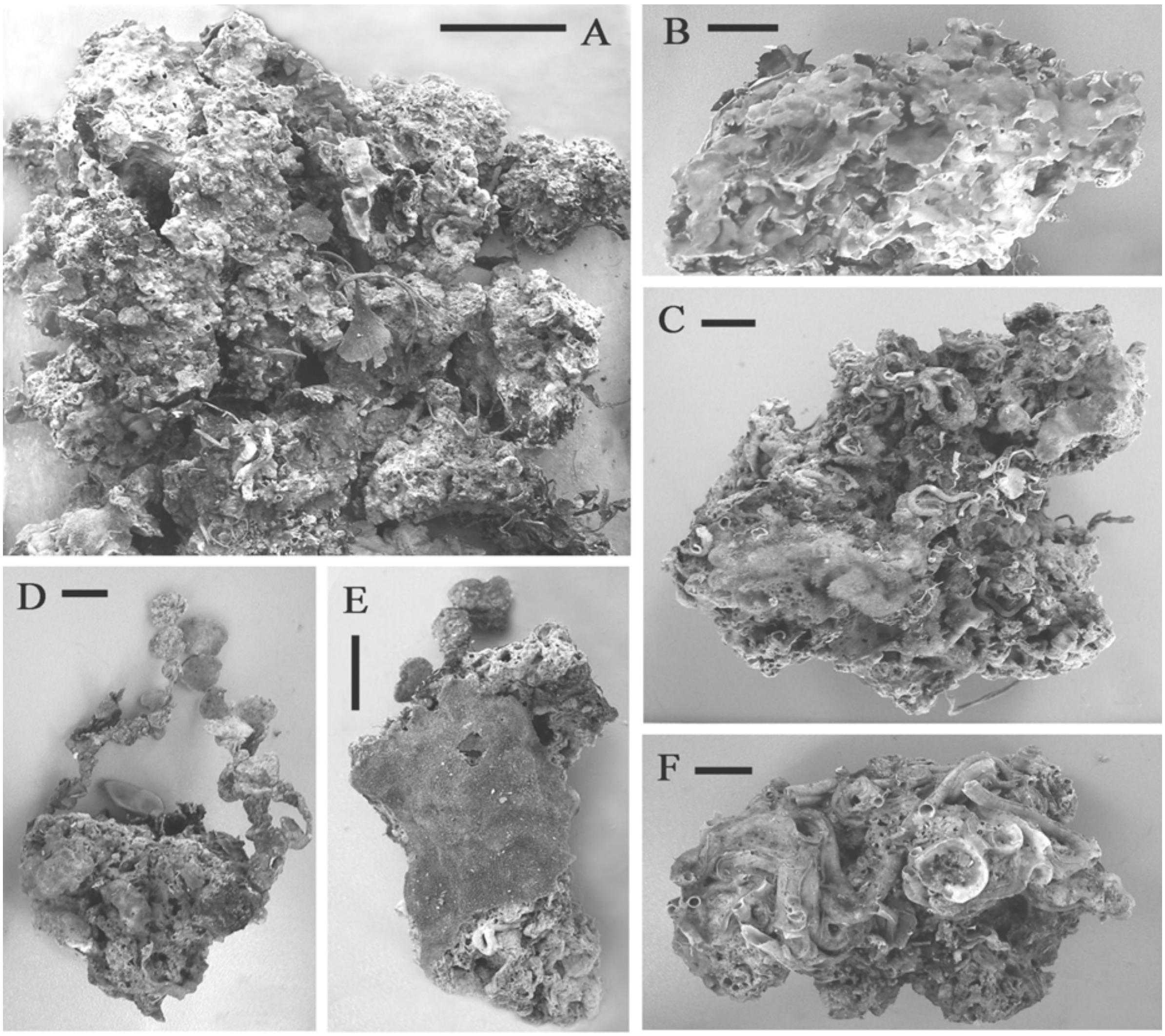

Figure 1: A. Fragments of the dredged coralligenous concretions. B. Algal laminae forming a loose framework with large cavities. C. Underside of algal concretion heavily encrusted by large sponges, serpulid tubes and bryozoans. D. Coralligenous fragment colonised on its upper part by the green algae *Halimeda tuna* and by sciaphilic organisms on sheltered crevices from the inner side. E. Wide sheet-like colony of the bryozoan *Reptadeonella violacea*, acting a s secondary constructor. F. Tubes of the large-sized serpulid *Pomatoceros triqueter* contributing to the framework as primary constructor. Scale bars: 5 cm (A), 1 cm (B-F).

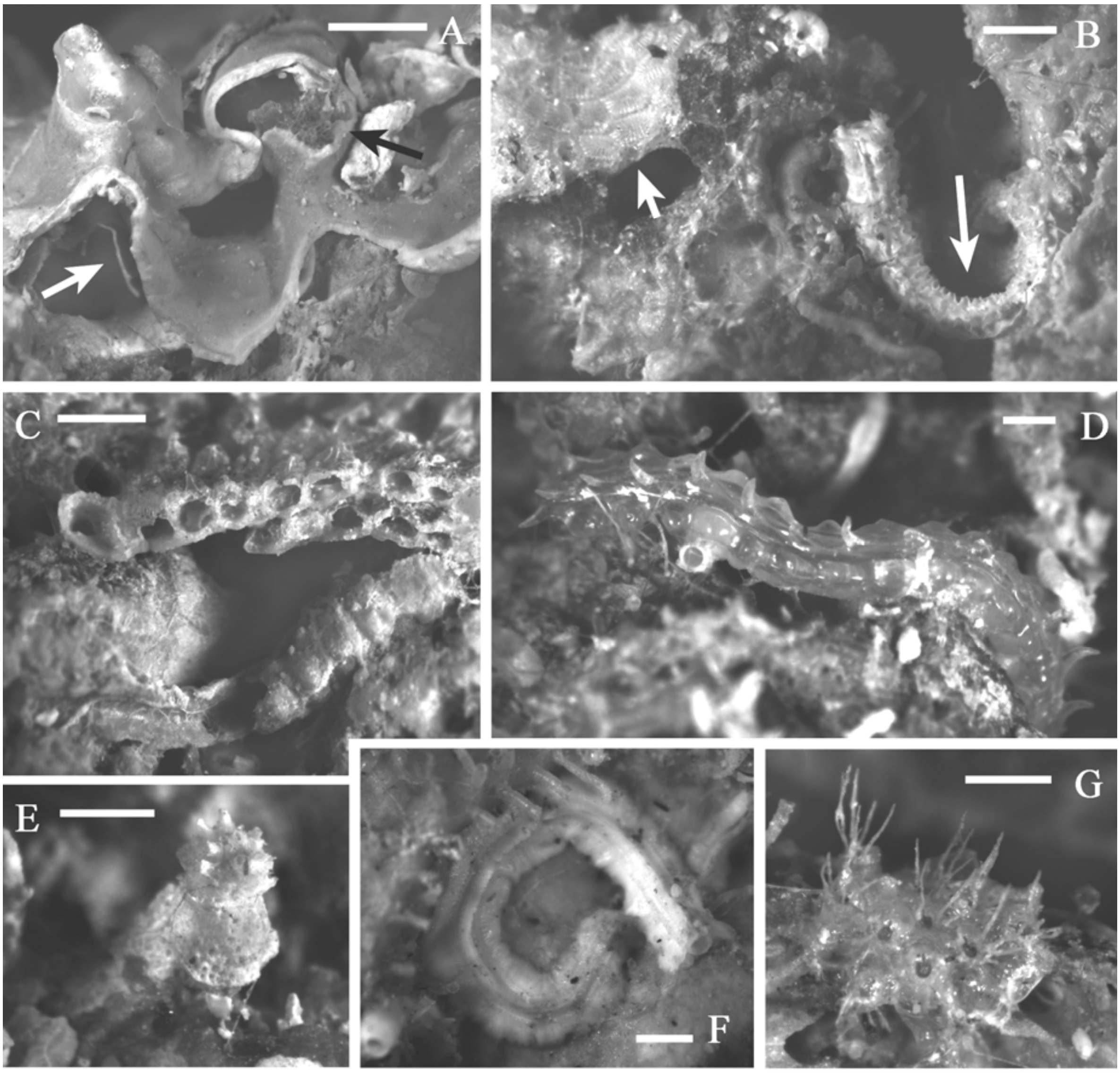

Figure 2: A. Convolute algal laminae including the foraminifer Miniacina (black arrow) and the microserpulid *Josephella marenzelleri* (white arrow). B. Bridge structures formed by the bryozoan *Puellina radiata* (short arrow) and the serpulid *Semivermilia crenata* (long arrow). C. Cross-section through a colony of the constructor bryozoan *Reptadeonella violacea*. D. Binding tube of the serpulid *Placostegus crystallinus*. E. Dome-shaped colony of the dweller bryozoan *Disporella sp.*. F. Coiled tube of *Semivermilia cribrata* dwelling in a small cavity. G. Juvenile colony of *Stefanollona armata* within a crevice. Scale bars: 1 cm (A), 500 µm (B-G).

RESULTS

The framework is mostly a loose structure of millimetre-thick well spaced, planar to convolute algal laminae locally connected by transversally lying tubular structures, and including large cavities. Both irregular cavities and, mostly, the tubular structures seemingly result from the wrapping of soft-bodied animals (mostly cnidarians and sponges) and algae (mainly *Flabellia petiolata* and *Halimeda tuna* and some peyssoneliaceans) which usually colonise the upward exposed algal surfaces. Fragments formed by densely packed laminae are extremely subordinate. Locally, the gastropod *Vermetus triqueter* is present with its large-sized, irregularly coiled tubes. Spaces are inhabited by a diversified association including some sponges, molluscs (among which isolated cemented specimens of the gastropod *Dendropoma anguliferum* and the bivalve *Chama sp.*, and some bissate arciid and anomiid bivalves). Encrusting agglutinant foraminifers are common, whereas specimens of the brachiopod *Megathyris detruncata* and juveniles of the scleractinian *Caryophyllia sp.* are rare.

Boring sponges can be common at places, but other macro-borers seem to be absent. Loose sediment is locally entrapped within cavities.

Bryozoans and serpuloideans are abundant and diversified. A few species directly colonise upward exposed algal thalli. They include serpuloideans, such as *Serpula vermicularis, Pomatoceros triqueter,* which posses relatively large sized tubes, *Janua pagenstecheri* and *Placostegus crystallinus*, and the bryozoans *Reptadeonella violacea* and *Mollia circumcincta*, all tolerating a certain lighting. *P. triqueter* tubes grow locally close each other to form densely aggregated patches. In contrast, other serpulid specimens have been commonly found isolated. *R. violacea* forms robust and thick laminar colonies wider than 15-20 cm^2 completely overgrowing animal and plant organisms whereas *M. circumcincta* forms delicate sheets of widely-spaced tube-connected zooids only slightly adhering to the algal laminae. Other bryozoans, such as *Rhynchozoon sp.*, developing irregular plurilaminar to celleporiform zoaria elevating up to over 1 cm, *Stephanollona armata* and *Plesiocleidochasma mediterraneum*, forming multilayered colonies, are found together with *Serpula concharum*. Nevertheless, these latter taxa are more abundant on the shadowed lower surfaces and/or within cavities together with the serpulids *Janita fimbriata*, *Semivermilia crenata, S. cribrata, Josephella marenzelleri* and several bryozoans growing in thin, more or less wide (usually 1-2 square centimetres) laminar sheets and/or more rarely developing additional superimposed layers. Among them *Chorizopora brongniartii*, *Gregarinidra gregaria*, *Onychocella marioni, Escharoides coccinea*, *Micropora coriacea* and *Watersipora complanata* are the most abundant species followed by *Crassimarginatella maderensis*, *Hippomenella mucronelliformis* and *Prenantia lygulata*. Cavities within the framework are colonised by a large number of bryozoan species forming spot-like or relatively small-sized encrustations, among which several cyclostomes, such as *Diplosolen obelium*, *Disporella sp*., *Annectocyma sp*., *Plagioecia sp.*, and cheilostomes, as *Copidozoum sp.* and *Puellina sp*., and rarely by delicate erect slender colonies of *Reteporella elegans, R. couchii* and *Mecynoecia delicatula*. Finally, articulate erect tufts formed by *Caberea boryi, Scrupocellaria* sp. and *Crisia* sp. up to 2-3 cm high, are common, mostly on the upward facing surfaces. Interestingly, additional bryozoans (*"Cardioecia" watersi, Celleporina mangnevillana, Puellina gattyae* and *Smittoidea reticulata*) and serpuloideans (*J. marenzelleri*) were exclusively or mostly found thriving as epibionts on erect soft-bodied algae, mostly *H. tuna* and peyssoneliaceans.

DISCUSSION AND CONCLUSIONS

Hong (1980, *fide* Ballesteros, 2006), distinguished four functional categories within Mediterranean coralligenous ecosystems, i.e. fauna contributing to the build-up (including main and minor contributors, relative to their size, and taxa which agglomerate carbonate particles); cryptofauna colonising holes and crevices; epi- and endo-fauna living over the concretion and inside sediments retained by the build-up; eroding species. Nevertheless, to better define relationships between species contributing to the frame-building and its strengthening, the functional guilds suggested by Fagerström (1991) seem to be more suitable, also allowing easy comparisons with tropical coral-reef ecosystems. Functional guilds include primary and secondary constructors, binding, dwellers, bafflers and destroyers. Accordingly, only a few bryozoan and serpuloidean species, from the analysed coralligenous fragments, can be strictly considered as constructors, which actually contribute to the main framework intergrowing with calcareous algae. Nevertheless, as such species are generally subordinate in terms of carbonate production, they mostly fit within the secondary frame-builders. The bryozoans *Rhynchozoon sp*., *R. violacea* and *S. armata* and the serpuloideans *S. concharum, S. vermicularis* and *P. triqueter* are involved, although the latter two species can locally become the main builders. Interestingly, all these species consistently elevating from their bases, usually grow on the upward–facing surfaces. A contribution to the construction is given also by binders and, quite subordinately, by dwellers. The former group includes a single serpulid species (*J. fimbriata*) and several bryozoans (*P. mediterraneum*, *G. gregaria*, *O. marioni, E. coccinea, M. coriacea*, *W. complanata*, *D. obelium*, *C. maderensis, H. mucronelliformis, P. lygulata* and *C.*

brongniartii,) whose sheet-like colonies coat algal laminae and the inner surfaces of cavities and crevices within the frame, sometimes forming bridge structures. The latter group is mostly constituted by the small-sized serpulids *J. marenzelleri, J. pagenstecheri, S. crenata, S. cribrata, P. crystallinus* and by several bryozoans among which *Annectocyma sp., Disporella sp., Plagioecia sp., Copidozoum sp., Puellina sp., Hippothoa flagellum,* forming small-sized colonies, either spots, small roundish or irregularly lobate sheets, or grow as uni-pauciserial runners. Further “dwellers” are present, such as *M. delicatula* and also *R. elegans* and *R. couchii*, which develop rigid erect colonies within larger cavities, though sensibly smaller than those from overhangs and cave walls (Di Geronimo *et al*., 2000; Rosso, pers. observ.). Finally, some bryozoans (*C. boryi, Scrupocellaria* sp., and *Cellaria salicornioides*) act as bafflers. The inclusion of individual species within the Fagerström functional guilds is sometimes difficult and not univocal for both serpuloideans and bryozoans. Some large-sized serpulids usually acting as binders can behaviour as constructors, mostly due to their occasional gregariousness. Analogously, several bryozoan species whose colonies can exhibit wide size ranges and morphologies due to their modularity, colony growth plasticity and longevity, could be included within different guilds.

Species distribution greatly vary within and among fragments, exhibiting a patchiness seemingly resulting from the gregariousness of some species and/or ecological succession pattern which need further investigation.

In the examined volume from the Avola corallinacean concretions, 60 bryozoan and 11 serpuloidean living species have been found including more than 200 colonies and 35 specimens. Nearly all species were already known from other Mediterranean coralligenous habitats, also including pre-coralligenous and very sciaphilic biotopes, such as semi-dark caves (Gautier, 1962; Bellan, 1964; Zibrowius, 1968; Harmelin, 1976; Zabala, 1986). Species richness and abundance of colonies/specimens appear to be high compared to those from coralligenous build-ups originating from slightly shallower depths, in a neighbouring area (Di Geronimo *et al*., 2001; 2002), including 9 bryozoan and 7 serpulid species, and less than 30 colonies and 10 specimens, from about 9 dm^3 volume. Comparisons of bryozoan and serpuloidean biodiversity with coralligenous concretions from other localities are difficult, even when such taxonomic groups are dealt with, owing to the ecological and bionomic complexity of the coralligenous itself, its wide range of bathymetric distribution in different physiographic and edafic settings and, last but not least, heterogeneity in sampling and analysis methods. For bryozoans, the total number of species is lower than the total bryodiversity reported for the Mediterranean (nearly 115 species by Gautier, 1962 and nearly 130 by Harmelin, 1976) and for the Medes Islands (171 taxa by Zabala, 1989 followed by Ballesteros, 2006). Nevertheless, values from the Avola unique sample seem to be high relative to those (5-15 species from 6-12 dm^3) for single stations from slightly shallower bottoms and the total bryozoan diversity (67 species) reported by Laubier (1966) for the NW Mediterranean. Similar assessments are impossible for serpuloideans, usually included within polychaetes in biodiversity evaluations but again 11 species from a single site clearly outnumber the few species usually reported from comprehensive surveys (6 species reported from the N Adriatic by Amoureux & Katzmann, 1971 and Casellato & Stefanon, 2008) and the overall 10 species from the NW Mediterranean reported by Laubier (1966).

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Actes du 1er Symposium sur le Coralligène et autres Bio-Concrétions calcaires de Méditerranée
(Tabarka, 15-16 Janvier 2009)

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AN IMPORTANT COMPONENT OF THE CORALLIGENOUS ASSSEMBLAGES: THE PRECIOUS MEDITERRANEAN RED CORAL. SOME FOCAL POINTS FOR THE STUDY OF POPULATION DYNAMICS.

ABSTRACT

The precious Mediterranean coral Corallium rubrum *is one of the main components of the highly bio-diverse coralligenous assemblages. This gorgonian, harvested and traded worldwide since some thousand years, is becoming a paradigmatic example of over-exploited marine resources. Also if the red coral bathymetric distribution is wider (20-350 meters depth), the shallower populations live within the coralligenous depth range. Such populations (some of which dwells in MPAs) have a limited economic value but, reproducing actively, are important for species conservation. In recent years a new source of mortality affected such populations: since 1999 some of them have been affected by anomalous mortality events associated with a sharp temperature increase recorded along the Italian and French North-Western Mediterranean coasts. In order to simulate the effects of such mortalities on the structure and dynamics of populations we developed demographic models, based on life-history tables (in which population structure, survival and reproductive output are reported) that allowed us to project the population trends overtime. Such demographic approach can supply useful tools to predict population dynamics in response to mass mortality events and harvesting and to forecast population availability overtime. As a thorough evaluation of the impact, in terms of mortality, of such events on long-lived species requires a long-time series of data collected before and after the event, few studies of the long-term effects of mass mortality exist. However, a demographic approach, based on sound population data, may provide a good prediction of the mass mortality impact on population dynamics. In this paper we focussed on some critical points of population data collection. The results we obtained suggest that a tight coordination between the different research teams is necessary to adjust the sampling methodologies in order to compare the structure and the dynamics of the different populations.*

KEY WORDS. Octocorals, Population dynamics, Growth rate, Recruitment, Reproductive output.

INTRODUCTION

Fostering conservation of long-lived, slow growing, low turnover species is one of the most difficult tasks for ecologists. Gorgonians are among the most long-lived marine organisms (Roak *et al.*, 2006). Provided of complex morphologies, they play a paramount role in community and ecosystem functioning (Gili & Coma, 1998). The precious Mediterranean red coral is one of the main components of the Mediterranean coralligenous assemblages (Ballesteros 2007). This species, harvested and traded since ancient times, is becoming a paradigmatic example of over-exploited marine resources as the majority of known populations have been over-exploited. The bathymetric distribution of red coral extends below the euphotic zone but the *shallower* populations live within the *coralligenous* depth range. Populations tend to be genetically structured (Abbiati *et al.*, 1993; Costantini *et al.*, 2007), crowded, composed by small colonies heavily affected by boring sponges and, also if their value is sparse, they are periodically harvested. Such populations (some of which dwells in MPAs) reproducing actively, are important for species conservation.

Since 1999 a new source of mortality affected such populations: some of them suffered anomalous mortality events associated with a sharp temperature increase in the North-Western Mediterranean (Calafuria and Capo Caccia MPA in Italy; Marseille and Western Corsica in France) (Garrabou & Harmelin 2002; Bramanti *et al.*, 2005; Torrens 2007). In order to simulate the effects of such mortalities on the structure and dynamics of the populations we developed demographic models, based on life-history tables (in which population structure, survival and reproductive output are reported) that allowed us to project the population trends overtime (Santangelo *et al.* 2007). Such demographic approach can supply useful tools to predict population trends in response to mass mortality events and harvesting and to forecast population availability overtime. As a thorough evaluation of the impact, in terms of mortality, of such events on long-lived species requires a long-time series of data collected before and after the event, few studies of the long-term effects of mass mortality exist (Linares *et al*., 2005). However, a demographic approach, based on sound population data, may provide a good prediction of the mass mortality impact on population dynamics. In this paper we focussed on some points critical for demographic data collection.

In order to perform reliable analyses of population structure and dynamics and to assess the performance of different populations a tight coordination between the different research teams studying different populations is needed. In this paper we examine some of the main points which should be improved to obtain comparable data and to set out reliable simulations of population trends overtime. In particular we examine three basic demographic descriptors: recruitment, colony growth rate and reproduction.

MATERIALS AND METHODS

Recruitment. It is considered as the supply of new individuals to a population by means of reproduction. Recruitment is one of the main processes determining both population structure and dynamics (Caley, 1996). For demographic studies it is extremely important to identify recruits determining their size and shape. Recruitment rates can greatly vary in space and time, therefore it is necessary to distinguish between natural and methodological variability. We examined the few papers in which data on red coral recruitment are reported: Cerrano *et al.*, 1999; Garrabou & Harmelin, 2002; Bramanti *et al.*, 2005 and Bramanti *et al.,* 2007. Net-recruitment rates and overall population density trends reported in Fig.1 were gathered from Garrabou & Harmelin, 2002 and from Bramanti *et al.*, 2005.

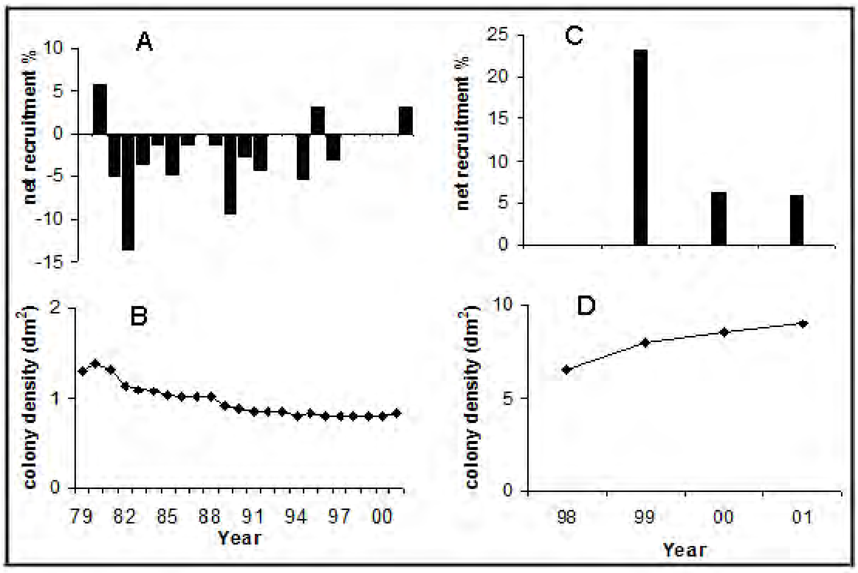


Fig. 1: Different trends of new settled populations: net recruitment (recruitment-mortality) A in a deep, horizontal cave (Marsiglia), C on a vertical cliff (Calafuria LI). B and D the two population trends.

Colony growth rate. *C. rubrum* is known to be a long-lived species but how "long" can be its life span is still controversial and object of investigations. Assessment of the annual growth rate of red coral colonies is essential to share out the individuals in different age classes and to determine age structure of the population. In this way a "static" life history table, based on the age rather than on the size of the colonies, can be set out (Ebert, 1999). Three different methods have been applied to determine the age of coral colonies: 1) Petrographic method (Garcia Rodriguez & Massò, 1988; Abbiati *et al.,* 1992; Santangelo *et al.,* 1993); 2) Organic matrix staining of thin sections from the base of the colony (Marschal *et al.,* 2004), which allows to read annual growth rings; 3) Direct measurements of colonies of known age, a not destructive approach to the study of colony growth rate, based on artificial or semi-natural substrates on which new settled colonies can be followed during their growth for a determined time interval (Cerrano *et al.*, 1999; Garrabou & Harmelin, 2002; Bramanti *et al*., 2005).

Reproduction. Assessment of colony and population reproductive output is necessary to set out "static" life history tables (Ebert, 1999) in which data on density, fertility and fecundity for each age class are reported (Tab. 2). The only papers on red coral reproduction (in addition to the beautiful, historical Lacaze-Duthiers' book of 1864) are the paper of Vighi (1972), Santangelo and coll. (Santangelo *et al*., 2003), Torrens (Torrens *et al.*, 2005, Torrens 2007) and that by Tsounis and coll. (Tsounis *et al*., 2006). These papers are examined in the following paragraph.

RESULTS

Recruitment. There are few studies on the recruitment process in red coral populations. Some preliminary data have been reported by Cattaneo –Vietti and coll., which found, on artificial substrates set out in Monaco an average density of 0.4-0.6 recruits dm^2 (Cerrano *et al*. 1999). A wider description of the recruitment process was reported by Garrabou and Harmelin (2002). The population studied settled on semi-natural limestone plates located in a horizontal, 25m long cave, a peculiar, partially isolated environment. Red coral planulae reached only seldom the inner part of the cave in which the settlement plates were located, thus recruitment was only occasional. This "pulse" recruitment happened once around 1979 (when 52 settlers were found); after that time recruitment events were sparse and only few settlers (1-5) added to the original population

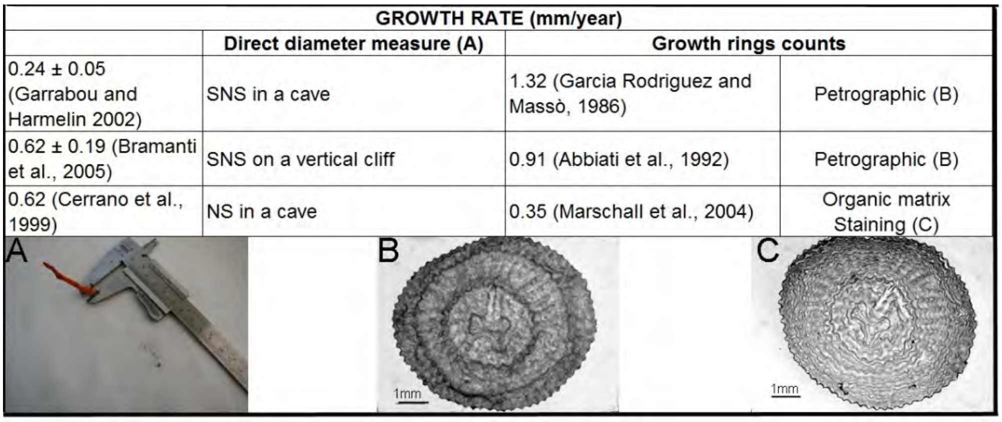
in each occasion. The findings reported in that paper are sketched in Fig. 1: Fig.1A represents the "net recruitment rate" (the difference between the number of died individuals and the new settlers in the same year), while the Fig. 1 B represents the trends over 22 years of the "new settled population". As can be seen the net recruitment rate is negative in the majority of years; this finding, confirmed by the densities reported in Tab.1 (left column) indicates that, during the 22 years of the experiment the new settled population reduced and could even extinguish if a new abundant larval input will not reach again (like in 1979) the inside of the cave.

More recently Bramanti and coll. (Bramanti *et al.* 2003; Bramanti *et al.* 2005) studied red coral recruitment of Calafuria population and successively (Bramanti *et al.* 2007) in the populations of Medes Islands (Spain) and Elba (Italy). They used semi-natural settlement plates made of Carrara-marble of a size (10x10 cm) suitable for macro photographs. On such macro photographs recruits were easily identified.

Tiles were fixed on the vaults of the crevices in which red coral colonies dwell just before the beginning of the reproductive period. The whole procedure was patented by the authors. As can be seen in Fig. 1 C and D the new settled population showed positive net recruitment rate and positive density trends during the 4 years of the experiment. Overall the findings from Bramanti and coll. indicate a high variability in recruitment rates between different populations and years with highest recruitment values (Tab.1) and positive net-recruitment and density trends (Fig. 1).

Tab. 1: Recruitment density measured in different habitats and in different areas by semi-natural substrates.

RECRUITMENT DENSITY (recruits/dm^2)	
Semi natural substrate in a cave near Marseille	**Semi natural substrate on a vertical cliff**
1,3 recruits/dm^2 (Garrabou and Harmelin, 2002, 1th year)	9.9 recruits/dm^2 (Bramanti et al., 2005) Calafuria.
0.178 recruits/dm^2 (Garrabou and Harmelin, 2002, years 2-22)	0.4-0.6 recruits/dm^2 (Cerrano et al. 1999) Monaco



GROWTH RATE (mm/year)			
	Direct diameter measure (A)	Growth rings counts	
0.24 ± 0.05 (Garrabou and Harmelin 2002)	SNS in a cave	1.32 (Garcia Rodriguez and Massò, 1986)	Petrographic (B)
0.62 ± 0.19 (Bramanti et al., 2005)	SNS on a vertical cliff	0.91 (Abbiati et al., 1992)	Petrographic (B)
0.62 (Cerrano et al., 1999)	NS in a cave	0.35 (Marschall et al., 2004)	Organic matrix Staining (C)

Fig. 2: A Direct measurement of growth on colonies of known age; B dark bands by petrographic method; C Growth rings by organic matrix staining methiod. SNS = semi-natural substrate.

Colony growth rate assessment. Red coral was generally defined as a "slow growing species" but, for a long while there was a lack of reliable measures of colony growth rate. Sclerochronology supplied the methods to measure red coral growth rate. In 1986 Garcia-Rodriquez & Massò proposed a petrographic method (Fig.2.B) based on the count, under polarised light, of the dark bands on thin-sections from the base of *C. rubrum* colonies (Garcia-Rodriquez & Massò 1986).

Only in recent years, after the petrographic thin-section methods overestimating age have been applied (Abbiati *et al.* 1992; Santangelo *et al.* 1993), a new, more reliable method to determine the annual colony growth rate was set out by Marschal and coll. (Marschal *et al.*, 2004). Such "organic matrix staining method" allowed to read growth rings which were checked to be annual (Fig. 2.C). The two methods are based on two different features of the red coral skeleton, *i.e.*, skeleton density and concentration of organic matrix, respectively.

On the basis of the relationship between basal diameter and number of the dark bands found by the petrographic method in each colony Santangelo and coll. (2001, 2004) assigned the colonies to different size/age classes and set out a life history table for the population of Calafuria (Tab. 2). Despite the contribution of this demographic approach to the study of *C. rubrum* population dynamics, the petrographic method resulted to underestimate the effective colony age as demonstrated by Marschal and coll. in 2004 by calcein labeling *in vivo* (Marschal *et al.* 2004).

Tab. 2: Life-history table of a red coral population (Calfuria-Italy) in which all the main demographic parameters are reported (modified from Santangelo *et al.* 2007).

Size/age class	N of individuals in each size/age class Xi	Fecundity (mean n of larvae produced by each polyp) q	Survival Xi/Xi-1 (S)	Mean number of planulae produced by each colony	Larvae produced by each class (biXi)
1	822	0.00		0.00	
2	731	0.00	**0.889**	0.00	0.00
3	463	0.87	**0.563**	2.89	1338.86
4	323	0.87	**0.393**	10.03	3240.58
5	167	0.87	**0.203**	21.59	3605.88
6	73	0.87	**0.089**	39.02	2848.47
7	21	0.87	**0.026**	56.41	1184.57
8	12	0.87	**0.015**	77.72	932.65
9	4	0.87	**0.005**	103.23	412.91
10	3	0.87	**0.004**	131.87	395.61
11	3	0.87	**0.004**	164.57	493.71
12	1	0.87	**0.001**	201.46	201.46
13	1	0.87	**0.001**	242.65	242.65

Calcein labeling allowed marking the yearly growth pattern in adult colonies. A further decalcification of thin sections and the staining with Toulidine-blue of the remaining organic matrix allowed to the researchers to highlight the annual growth rings. The results from Marschal and coll. (2004) indicate that for red coral late autumn and winter is the period when the dark ring, i.e., a high concentration of organic matter, developed. This period seems to correspond to the lowest red coral growth rate, suggesting that, this species, like other suspension feeders, responds to the marked seasonality of key environmental factors found in the NW

Mediterranean (Gili & Coma 1998). In contrast with other gorgonian species (e.g., Grigg 1974), growth rings were never observed in the central region of the red coral axial skeleton. The first growth ring always appeared at some distance from the centre probably because of the mechanism involved in calcium deposition change during growth in the first 3-4 years of growth (Marschal *et al.* 2004). Other reliable measures of colony growth rate were made by directly following new settled colonies on *ad hoc* settlement plates during some years and then measuring them (Fig. 2.A) (Garrabou & Harmelin 2002; Bramanti *et al.*, 2005). This last method, slow but not destructive, allowed to determine the colony growth rate along the first years of red coral life-cycle (1-4); as growth cannot be determined by the organic matrix staining-method during that period, the two methods give complementary information on annual growth rate in different phases of red coral life span. The colonies studied by Garrabou and Harmelin settled on limestone plates located in an horizontal, 25 long- cave, a peculiar, partially isolated environment and showed a lower growth rate than those studied by Bramanti and coll. (0.24±0.05 and 0,62±0.19 mm/y of basal diameter, respectively).

The results obtained by Cattaneo and coll. on the natural substrate at Portofino and those obtained by Bramanti and coll. on Carrara-Marble tiles overlap (Fig. 2) (Cerrano *et al.*, 1999; Bramanti *et al.*, 2005).

Reproduction. The basic reproduction features have been described (and drawn in a magnificent way!) by Lacaze-Duthiers (1864). A further description of reproduction was given by Vighi (1972). Torrens and coll. determined the age at maturity of a French red coral population. Moreover Torrens identified some environmental effects on colony reproductive output (Torrens 2007). The assessment of population sexual structure and the estimate of the reproductive output are basic for demographic studies. In particular sex ratio, size/age at sexual maturity, fertility (the percentage of fertile female colonies) and fecundity (the average number of planulae each female colony produces) must be determined. Fecundity of colonies in each size/age class must be calculated as the number of fertile polyps of each colony multiplied by the fecundity of each polyp (Tab.2) (Santangelo *et al.*, 2003). Some data about the reproductive structure of the red coral population at Medes Islands have been reported in a paper by Tsounis and coll.

(Tsounis *et al.*, 2006); but unfortunately such data, lacking the percentage of fertile polyps in a colony and a subdivision of colonies in small-scale size classes, cannot be matched with those collected by Santangelo and coll. and cannot be integrated in a life-table suitable to develop a transition matrix (Caswell 2001) for that population. In table 2 is reported the life-history table of the Calafuria population set out by Santangelo and coll. in which reproduction data are reported (Santangelo *et al.*, 2004; 2007).

DISCUSSION AND CONCLUSIONS

Demography focus on the specific dynamic behaviour of each population, hence a demographic approach needs to simulate population trends overtime and to set out conservation strategies for wildlife species (Dobson 1998; Caswell 2001). Demographic approach is particularly needed for a species that has been overharvested and is now subject to a new mortality source like red coral. The three topics on which this short paper is focused are basic for the study of red coral demography. As can be seen in the results section, few measures of recruitment are reported. They show a wide variability that, in the case of the cave described by Garrabou & Harmelin (2002), could be due to the isolation of this environment. Planulae supply could reach the inner part of the cave sporadically and the inner population, if not fostered, could even extinguish. Low recruitment rates were found also at Medes Islands.

Concerning growth rate assessment the "organic matrix staining method" (Marschal *et al.,* 2004) resulted to be the more reliable to determine colony growth rate. Also in this case the wide variability found should be explained by differences between habitats. Moreover old *C. rubrum* colonies have been witnesses of stochastic environmental events, such as the mass mortalities in 1999 that could have affected their skeleton deposition and/or their growth rate. Analysing the growth ring pattern of colonies of different populations it could be possible to detect environmental changes over large geographic (the Mediterranean basin) and temporal scales. Direct measurements of young colonies of known age could supply information about the growth rate during the first year of colony life which cannot be gathered by the latter method.

Assessing the reproductive output of the different age/size classes give precious information about the role they have in fostering population survival; in the life-table in Tab.2 it can be seen that the first reproductive classes, also if composed by smaller colonies, account for the majority of the population larval output. As our simulations suggest (Fig. 3), shallow-water red coral population composed by small/young colonies could foster population survival after a mortality event but an increased frequency of such morality events could lead local populations even to extinction (Santangelo *et al.,* 2007).

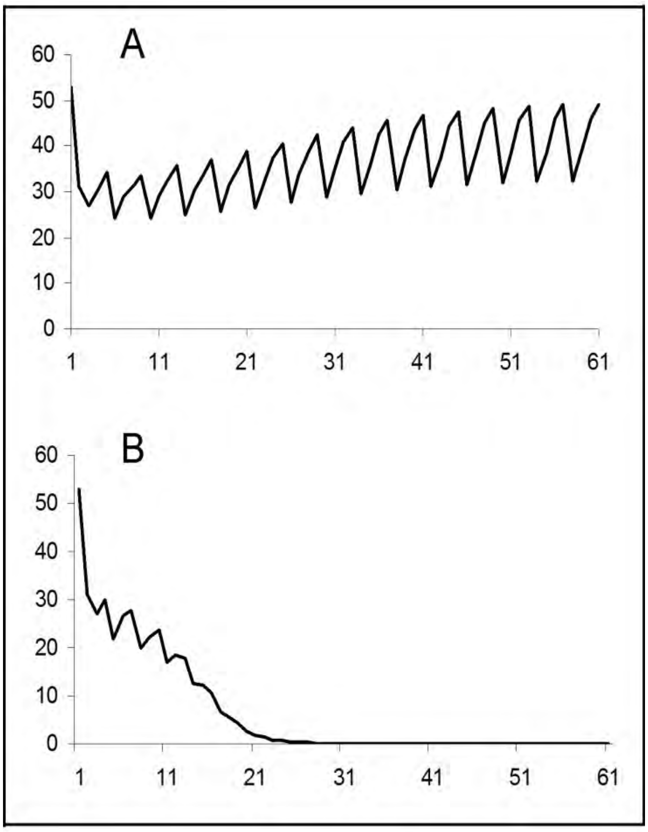


Fig. 3: Overall population density trends over 60 years period. A: Simulation of a mortality event affecting the population with a 5 year periodicity; the population survive. B: a periodicity of 3 years is simulated; the population goes to extinction.

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ROLE OF A *PARAMURICEA CLAVATA* FOREST IN MODIFYING THE CORALLIGENOUS ASSEMBLAGES

ABSTRACT

Foundation species or ecosystem engineers modify their own habitat increasing the fitness of associated species. The true effect of these species on the ecosystem is difficult to define because, generally, experimental works on positive interactions among species are uncommon. The presence of foundation species can often reduce flow velocity as demonstrated for algal canopy and seagrass meadows and this effect reduces resuspension processes stabilizing and enriching of fine sediments the substrate. As a consequence several organisms can find a habitat characterized by peculiar physico-chemical features, a more stable habitat where modifications occur slower respect to the surrounding ambient. In the Marine Protected Area of Portofino and S. Stefano shoals (Ligurian Sea, Italy) we compared by photo analysis the coralligenous assemblage inside and outside a Paramuricea clavata forest. Plaster-ball method for measuring time-averaged velocities of the current, analysis of sediment granulometries and artificial panels working for four months allowed highlighting some effects of the most important Mediterranean gorgonian on coralligenous assemblages. Its presence reduces flow current, enhance the development of coralligenous algae and the diversity of bryozoans. Recent mass mortalities events, dramatically decreasing the density of this species in several areas of the Mediterranean sea, could compromise the the equilibrium of coralligenous accretions.

KEY-WORDS: foundation species, Octocorals, water movement, habitat heterogeneity

INTRODUCTION

In the Mediterranean Sea the environments hosting the higher biodiversity are *Posidonia oceanica* meadows and coralligenous accretions. Seagrass meadows, coral reefs, kelp forests, mussel and scallop beds, typically modify their own habitat (Goreau *et al*., 1979; Cerrano *et al*., 2006) increasing the fitness of associated species (Bruno & Bertness, 2001). These organisms are defined foundation species (Dayton, 1972) or ecosystem engineers (Jones *et al*., 1994).

Although anthropogenic impacts and climate anomalies are playing highly negative effects on coralligenous structures, the real consequences of this degradation are still poorly known. In the last ten years extended mass mortality events have affected the benthic populations in many areas around the northwest Mediterranean, affecting mainly sessile suspension feeders (Cerrano *et al*, 2000; Perez *et al*., 2000; Garrabou *et al*., in press). During mortality events, local populations of Porifera, Cnidaria, and Bryozoa, completely disappeared, changing the specific composition and structure of coralligenous communities. *P. clavata* (Risso, 1826) is a skiophilous octocoral and is considered among the most important structuring key species of the Mediterranean coralligenous (Balestreros, 2006) owing to its capacity to shape dense populations amplifying the biomass and the biogenic substratum of the benthic communities (Cupido *et al*., 2007).

Here we evaluate how *P. clavata* can affect its surrounding ambient and if there are species facilitated by its presence. How the regression of *P. clavata* will affect coralligenous assemblages?

MATERIAL AND METHODS

Study site

The study was carried out at Punta del Faro, in the Marine Protected Area of Portofino and partially at the Santo Stefano shoal, about 200 Km far away (Ligurian Sea, Italy).

Experimental work

To evaluate the role of *P. clavata* towards coralligenous assemblages, three different approaches were followed at 40 m depth.

Photosampling. In order to analyze the local diversity in term of species presence/absence photosampling of standard areas (15x20 cm^2) in (30 photos) and out (30 photos) a gorgonian forest at Punta del Faro was performed by a digital camera (Sony). The same sampling procedure was repeated at the S. Stefano shoal. The photographs were analyzed by a computer grid of 32 small squares of 1.25×1.25 cm^2 each. Each square filled by a species counted as 3.25% cover, a square half filled count for 1.62% cover and organism filling less than 1/4 square counted for 0.5%. This method eliminates the need for decision rules such as any square>half filled is counted as filled (Dethier *et al.*, 1993).

Artificial panels. Six plastic panels (15x10 cm^2) were positioned in and out a gorgonian forest to evidence eventual effects of sea fans on the dynamics of colonization of a substratum. Before the collection of the 12 panels, four months after positioning, they were photographed. In laboratory panels were dry preserved and analysed at the stereomicroscope by a grid with a mesh of 1 cm^2.

Plaster balls dissolution. To evaluate the entity of the current reduction by the colonies of *P. clavata*, previously dry weighed plaster balls (Muus, 1968) were positioned at three different depths, inside and outside a gorgonian forest (11 ± 0,37 col/m^2): balls in triplicate on the top, in the middle and at the base of two colonies 60 cm high and balls in triplicate on the top, in the middle and at the base of two stakes fixed two meters away in an area completely free from sea-fans. The experiment was repeated twice during summer 2008, always during periods of calm sea. In total the dissolution of 72 plaster balls was measured. After 48 hours, the balls are removed, transported to the lab, immediately dried in an incubator at 90°C temperature for 24 hours, and weighed.

RESULTS

Photosampling, Comparing the assemblages measured inside and outside of the *P. clavata* population at Portofino Promontory (Fig. 1) and at Santo Stefano shoal (Fig. 2), it is evident that coralline algae, sponges and vertical bryozoans are more frequent inside the gorgonian forest while algal mat is common especially outside.

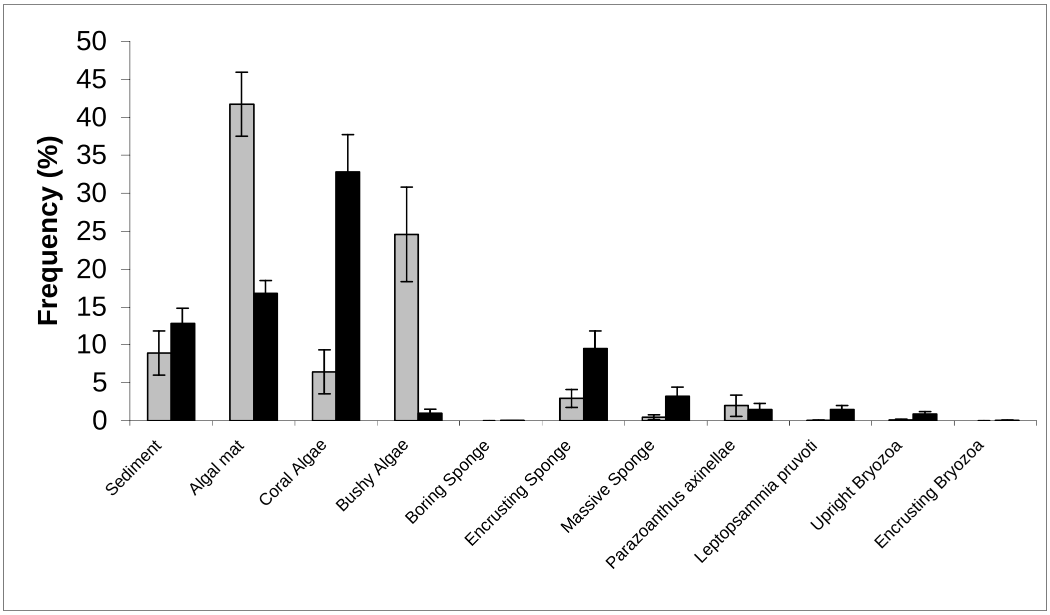

Fig. 1: Portofino Promontory. Percentages of the different categories considered in (black bars) and out (grey bars) of the gorgonian forest.

In both sites *Parazoanthus axinellae* seems to be facilitated by the absence of gorgonian.

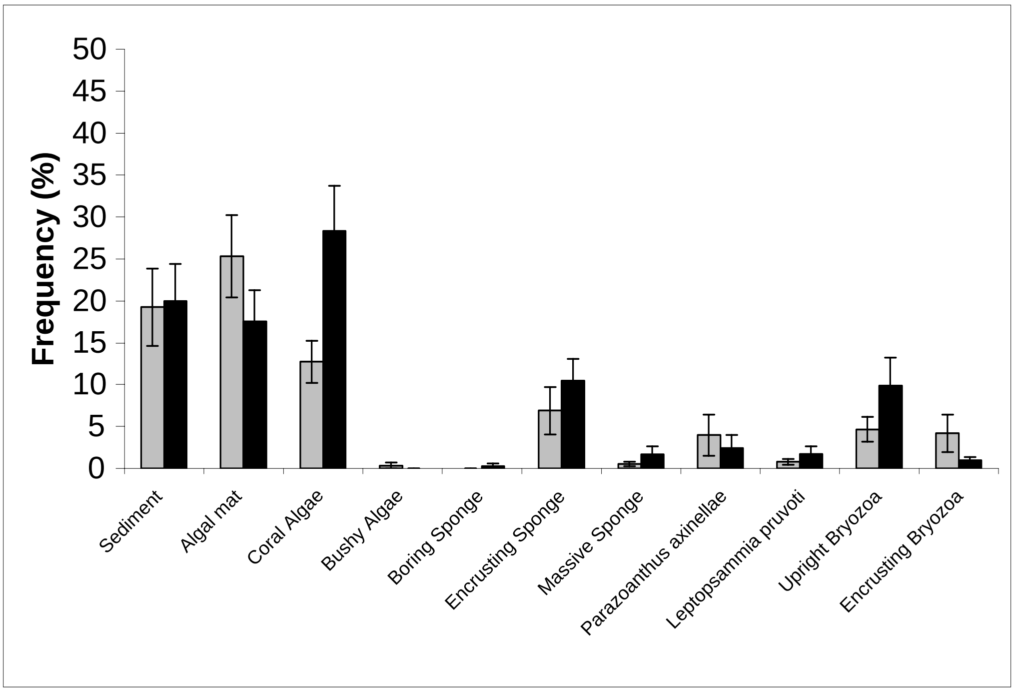

Fig. 2: Santo Stefano shoal. Percentages of the different categories considered in (black bars) and out (grey bars) of the gorgonian forest.

Artificial panels. Four months after the positioning of panels it is evident that green algae settle mainly outside the gorgonian forest and a similar pattern is shown also by serpulids. The groups that settled more frequently inside the *P. clavata* population are coralline algae and bryozoans (Fig. 3).

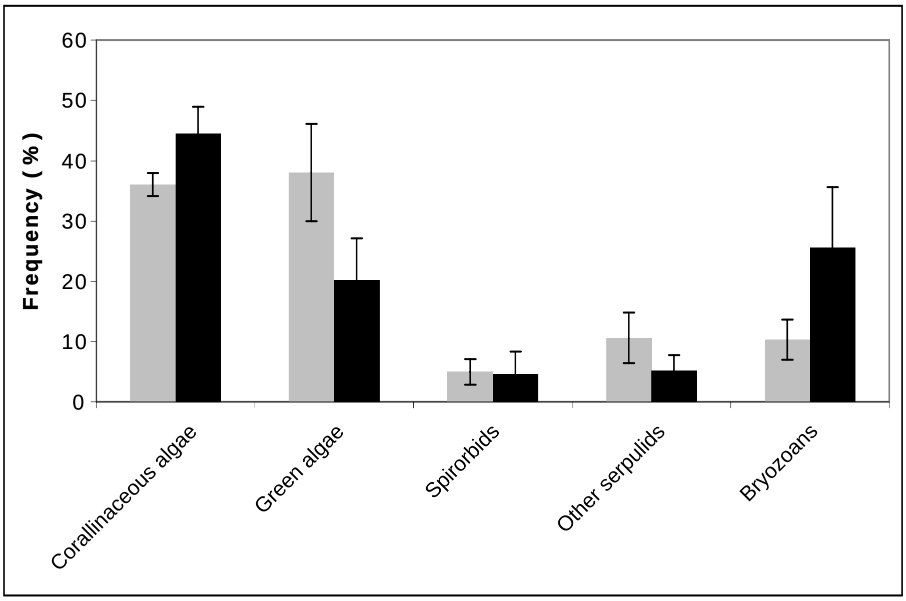

Fig. 3: Percentages of the different categories considered on the panels in (black bars) and out (grey bars) of the gorgonian forest.

Plaster balls dissolution. Out of the gorgonian forest the percentage of plaster ball dissolution is, two days after their positioning, 17.5% at the base, 12.4% in the middle, and 6.2% at the top. At the base, inside gorgonian population, water movement decreased of 5.72% respect outside during very calm sea periods.

DISCUSSION

Anchorage and fishing activities represent one of the most important risks for vertical growing organisms such as gorgonians (Bavestrello *et al*., 1997) even if, in these last years, also climate change is threatening the survivor of this group. *P. clavata* is among the most damaged species by mass mortalities occurred during the summer 1999 and 2003 related to thermal anomalies (Garrabou *et al.,* in press). Besides this species has little resilience respect to other gorgonians (Fava *et al.,* in press), according to some studies after the mortality events, the gorgonian population showed different recruitment dynamics and pattern of recovery (Cerrano *et al*., 2005; Linares *et al*., 2005; Cerrano & Bavestrello, 2008). Because of these different dynamics, the structural complexity and consequently the biodiversity of several areas are changing. Tridimensional structures of sea-fans can increase the fitness of associated species and several organisms can find an habitat characterized by peculiar physico-chemical features, a place where modifications occur slower respect to the surrounding ambient.

The real effect of foundation species on the ecosystem is difficult to detect owing to the little attention towards facilitation processes. Data here reported for *P. clavata* allowed to consider this species a true ecosystem engineer, able to affect water movement and local diversity and biomass. Moreover we can highlight that the reduction or disappearance of *P. clavata* colonies from 40 m depth coralligenous accretions will lead to a shift from a hard coralline dominance to a fleshy green algae one, negatively affecting the development of upright bryozoans. In this way we can hypothesize that *P. clavata* regression could alter the bioconstruction/bioerosion ratio in the coralligenous accretions, reducing their growth.

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DEMOGRAPHIC SYNAMICS OVER LONG-TERM PERIOD OF THE CORALLIGENOUS COMMUNITIES IN THE NW MEDITERRANEAN SEA

ABSTRACT

*Long-term data series in marine ecosystems are scarce. They are fundamental to provide meaningful ecological data and to determine the overall dynamics of species and forecasting the effects of global change. We assessed throughout 5 to 25 years different parameters of population dynamics (mortality, recruitment, and growth) for ten long-lived benthic species dwelling in Coralligenous communities in the north-western Mediterranean Sea. This study was based on the analysis of photographic series monitored yearly in two study areas: the Medes Island (Catalan coast, NE Spain) and Riou Archipelago (Provence coast, SE France). The species were six sponges (*Aplysina cavernicola, Chondrosia reniformis, Haliclona fulva, Petrosia ficiformis, Scalarispongia scalaris, *and* Spirastrella cunctatrix*) and four anthozoans (*Alcyonium acaule, Caryophyllia inornata, Corallium rubrum, *and* Leptopsammia pruvoti*). These species were selected because are representative and contribute largely to the Coralligenous communities. The data from this long-term study indicated that the species studied 1) were long-lived (they persisted during all the study periods), 2) showed low mortality rates (mean value for the 10 species of 1% ± 0.11), 3) exhibited low recruitment via larvae (e.g. no recruits for the sponges *A. cavernicola, C. reniformis *and* P. ficiformis*, while the soft coral A. acaule exhibited 94 recruits for the study period), and 4) were slow growing species. Low mortality combined with the slow growth indicates that these species may live for several decades. This study provides rigorous baseline information necessary to uncover general patterns in marine sessile species demography and better predict the long-term fate of populations of Coralligenous communities under the threat from global change.*

KEY-WORDS: Cnidarians, Coralligenous, Sponges, Long-term studies, Population dynamics

INTRODUCTION

Human activities have extensively altered the global environment, changing biological cycles, transforming land and oceans, and enhancing the mobility of biota (Chapin *et al.,* 2000, Vitousek *et al.,* 1997, Sala *et al.,* 2000). The need to collect long-term data sets has been stressed by marine ecologists because such data provide baselines to verify trends in marine communities. This information is fundamental to determine whether observed events are catastrophic, unusual, or just infrequent (Sebens & Lewis, 1985). Furthermore, these baselines are especially important to identify if changes in populations or communities occurred due to anthropogenic (*e.g.* overfishing) or natural causes (Dayton, 1989, Dayton *et al.,* 1998, Jackson *et al.,* 2001). Long-term approaches produce meaningful data, essential for the conservation of biodiversity and the successful management of marine ecosystems.

The Coralligenous rocky benthic communities are among the most characteristic Mediterranean benthic communities (Pérès & Picard, 1964, Ros *et al.,* 1985, Ballesteros, 2006), which develop in deep waters or wherever the irradiance is reduced. These coralligenous communities are highly diversified and structured and they are dominated by benthic suspension feeders (*e.g.* sponges, cnidarians, bryozoans, and tunicates) (Gili & Coma, 1998, Garrabou *et al.,* 2002). These valuable from the ecological viewpoint, beautiful as seascapes, and unique communities exhibit great complexity in spatial patterns and locally a complex three-dimensional structure (Garrabou *et al.,* 2002). There are mainly characterised by the presence of perennial animals and coralline algae species with low and asynchronous growth rates, long life spans, and highly variable recruitment rates (Turon & Becerro, 1992, Coma *et al.,* 1998, Garrabou & Harmelin, 2002). The coralligenous communities are among the most endangered Mediterranean ecosystems due to overexploitation of living resources, urban development, anthropogenic effects on water quality (*e.g.* pollution), and the increase of diving tourism (Harmelin & Marinopoulos, 1994, Sala *et al.*, 1996, Bianchi & Morri, 2000). In addition to this scenario, the mass mortality event of invertebrates detected in 1999 and 2003 has been associated with positive seawater temperature anomalies supposedly related to global climate change (Cerrano *et al.*, 2000, Perez *et al.*, 2000, Garrabou *et al., in press*). Therefore, to better understand the population dynamics and to properly manage the diversity and the biological conservation of these communities, a detailed study over long-term periods is crucial. In this study, we investigate the population dynamics of *six sponges* (*Aplysina cavernicola, Chondrosia reniformis, Haliclona* [*Reinera*] *fulva, Petrosia ficiformis, Scalarispongia [Cacospongia] scalaris*, and *Spirastrella cunctatrix*) and four anthozoans (*Alcyonium acaule, Caryophyllia inornata, Corallium rubrum,* and *Leptopsammia pruvoti*).For this purpose, we assessed throughout 5 to 25 years different parameters of population dynamics (mortality, recruitment, and growth) for these ten long-lived benthic species dwelling in Coralligenous communities in the north-western Mediterranean Sea.

MATERIAL AND METHODS

This study is based on the analysis of three photographic series of NW Mediterranean coralligenous communities over long-term period in two study areas: Riou Archipelago (43º 10’40’’N, 5º 23’50’’E, SE France, 1 site with 25 yr and 3 sites with 5 yr of data) and the Medes Islands Protected Area (42º 3´N, 3º 13´E, NE Spain, 1 site with 15 yr of data). The studied populations are distributed within the Coralligenous communities, dwelling on a north-facing sublittoral wall in the Medes Islands (depth ~ 20 m) and on the entrance of semi-dark caves in the Riou Archipelago (depths:18 - 26m). Detailed descriptions of the sites have been published by Harmelin *et al.* (1970) and Garrabou *et al.* (2002).
Demographic parameters of the 10 species (mortality, recruitment, growth) were quantified using digital images, which, for the colour slides, were obtained by scanning the originals (300 dpi, 1632 x 1080 pixels resolution). All specimens analyzed were individually labelled and followed annually throughout the study period.

RESULTS AND DISCUSSION

Relatively few demographic studies of long-lived, marine clonal sessile invertebrates consider sufficiently long time intervals to provide an accurate estimate of their demography. In this study, we initially identified 502 individuals belonging to the 10 species studied that could be tracked throughout 5 to 25 years. Table 1 summarizes the general results. After 25, 15 and 5 years, approximately 65% ± 9.6 of the total populations were still alive. *Scalarispongia scalaris* showed the highest (90%) whereas *Caryophyllia inornata* exhibited the lowest survivorship value (12%) after 25 years, respectively. Interestingly, the annual mortality rate for all the species was 1% ± 0.11 and did not differ significantly among years. This natural mortality rate provides solid information that can be contrasted with mortality values observed during mass mortality events of invertebrates in the NW Mediterranean Sea(>10%). Moreover, most of the species studied did not reach the half life time at the end of the study (Tab. 1). This study contributes to give evidences of the long lifespan of these sponges and cnidarians.

A total of 257 recruits were observed over the study period. Larval recruitment was low, oscillating between 0 (e.g. no recruits for the sponges *A. cavernicola*, *C. reniformis* and *P. ficiformi*) and 94 (the soft coral *A. acaule*). However, most of these recruits died during the 2 following years, indicating very high post settlement mortality.

Populations of slow-growing, long-lived sessile species do not often undergo marked declines and even populations with little or no regeneration capacity are projected to survive for decades or even centuries (Linares *et al.*, 2007, Mitri, 2007). In particular, when rates of change are very slow or when crucial events occur rarely (*e.g.* severe disturbances or exceptional recruitment), detecting their effect on populations requires long-term records (Connell *et al.*, 1997, Rees, 2001). Therefore, detailed long-term studies following the fate of species may be the only reliable way to uncover general patterns in sessile species demography and better predict the long-term fate of populations. The results of the present study offered detailed, long-term data providing new insights into the life history traits of this species. This work contributed to the general knowledge of marine communities characterized by long-lived species

Tab. 1. The ten species under long-term study in Mediterranean coralligenous communities. * Group: D: Demosponges; A: Anthozoans. **Growth forms: C: cup, E: encrusting; T: tree; M: mound.

Species	*	**	**Morphological description**	**Half-life (year)**	**% of ind alive at the end of the census (n)**	**Measured period (yr)**
Aplysina cavernicola	D	M	Yellow-massive sponge, with irregular disposed digitate extensions	not reached yet	87% (85)	5
Chondrosia reniformis	D	M	Spoted sponge with dark-brown and white spots, lobate with firm consistency	not reached yet	84% (11)	15
Haliclona fulva	D	E	Orange encrusting sponge, oscula at the end of short oscular chimeneys	not reached yet	92% (71)	5
Scalarispongia scalaris	D	M	Light to medium grey, massive sponge, with an unarmoured and conulose surface.	not reached yet	85% (24)	25
Spirastrella cunctatrix	D	E	Soft-orange encrusting sponge, with vein-like surface canals	not reached yet	82% (52)	15
Petrosia ficiformis	D	M	From ficiform shaped to irregularly globular forms, with fused globes, red color due to cyanobacteria	not reached yet	87% (30)	15
Alcyonium acaule	A	T	Red colonial alcyonacean with a massive treelike growth form	10 yr	37% (50)	15
Caryophyllia inornata	A	C	Solitary, azooxanthellate cup-coral	10 yr	12% (100)	25
Corallium rubrum	A	T	Red colonial octocorallian with arborecent growth form	not reached yet	28% (52)	25
Leptopsammia pruvoti	A	C	Solitary, azooxanthellate scleractinian coral	16 yr	25% (27)	25

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POSTERS

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DEEP-SEA CORALLIGENOUS BEDS OBSERVED WITH ROV ON FOUR SEAMOUNTS IN THE WESTERN MEDITERRANEAN

ABSTRACT

*In 2006 and 2007, Oceana carried out several investigations on four Western Mediterranean seamounts, finding red algae bio-concretions down to 150-160 meters depth. The areas surveyed were the Ausias March seamount and the Emile Baudot seamount in the Mallorca Channel (Balearic Islands), the Chella Bank (Andalusia-Alboran Sea) and the Palos seamount (in front of Palos Cap, in Murcia). More than 40 hours of video material was collected with an ROV. Species known only to be in shallow waters, like carnivorous sponges (*Asbestopluma hypogea*), were found on small seamounts with peaks between 80 and 170 meters depth. Sponge aggregations were filmed on coralligenous beds and new data on the distribution of anthozoans (e.g.,* Paramuricea macrospina*) was recorded. Nearly 300 species living on these bottoms were identified, giving new perspectives on their range and habitat dependence and preferences.*

KEY WORDS: seamounts, coralligenous, bio-concretions, maërl, carnivorous sponge.

INTRODUCTION

Red calcareous algae have been widely studied in the shallow waters of the Western Mediterranean (Ballesteros, 2006), but there is very little information about their distribution and function in deep areas. Two main infralittoral and circalittoral ecosystems created by calcareous red algae have been mentioned: maërl and coralligenous beds (Pérès & Picard, 1964; Picard, 1965). These have been described as areas of high diversity and ecological importance (Bosence, 1983; Barberá *et al*., 2003), being two of the most productive ecosystems in temperate regions (Martin *et al*., 2007). Seamounts and smaller marine elevations are considered hotspots, “stepping stones” and zones with high biodiversity (Matthiessen *et al*. 2003; Butler *et al*. 2001; Morato & Pauly, 2004). Those with shallow peaks are often found to be areas of high biological productivity (Rogers 1994), as in the four seamounts researched, with tops between 80 and 100 m. depth, where red algae can grow and develop.

MATERIALS AND METHODS

The research was carried out during from June to September of 2006 and 2007 on board the Oceana “Ranger" catamaran, equipped with a HSB2-plus Raymarine digital sonar with a high-powered transducer, linked to software to create bathymetric maps. Nineteen dives were carried out on four marine seamounts (Tab.1). Transects were filmed by a camera with 750 lines of resolution, a F1.2 lens and a 1:12 zoom, attached to an ROV Phantom H2+2. The ROV provided real time data on its position, depth, course, day and time. All of the identifications were made visually.

Tab.1 Summary of dives, time and areas observed with the ROV on the four seamounts

	Ausias March **38º44’N-001º48’E**	**Emile Baudot** **38º42’N-002º20’E**	**Palos seamount** **37º53’N-000º01’W**	**Chella Bank** **36º31’N-002º51’W**
Dives	3	4	6	6
Nautical miles	1.85	3.7	1,77	1.96
Area observed m^2	5,140	10,278	4,917	5,445
Filming time	5h29m	9h40m	8h24m	14h57m

RESULTS

Two main red algae formations were registered: (i) maërl or rhodolith beds and (ii) coralligenous formations. Most of the rhodolith beds found on these mounds and seamounts reached down to 140-150 meters depth, although the most important ones were between 80 and 120 meters. The formations were especially common over the top of Ausias March, but could also be found on Emile Baudot and the Chella Bank; they were absent from the Palos seamount. Three forms of coralligenous beds were detected: (i) large bio-concretions, (ii) “cobbled” bio-concretions and (iii) thin sheets and small patches. Although some smaller patches were found at 160-170 meters depth, large concretions were more common between 80 and 120 meters depth. Flat areas on the top of the seamounts showed the largest bio-concretions, normally formed by red calcareous algae of the genera Lithophyllum, Mesophyllum and Neogoniolithon, usually with other red algae, like *Peyssonnelia sp*. and the green algae *Palmophyllum crassum*. The most important ones were found on Ausias March and Chella Bank. Large bio-concretions forming round circles of around two meters in diameter and ten to 20 centimetres high were found on top of the Ausias March mound. These kinds of geometrical concretions were not found over the other seamounts. Coralligenous beds did not always form large bio-concretions but instead small, spotted blocks of some 10 to 30 centimetres in diameter fixed in the substratum. It was very often found as a transitory substratum between maërl and large coralligenous beds. They were very common on Ausias March and Emile Baudot. Patches of red algae were found on all of the seamounts. They were very common on the Palos mount, but were also the most common bio-concretion over the 120-130 meter range.

Some 300 species were identified. 150 of them were most commonly found in red algae bio-concretions, but none of them were exclusive from these beds. Two biological communities were widely distributed on bio-concretion beds: sponge aggregation (genera Haliclona, Aplysina, Tedania, Axinella, etc.) and fields of dead man´s fingers (*Alcyonium palmatum* and *Paralcyonium spinulosum*). Species like *Paramuricea clavata, P. macrospina, Anthias anthias, Muraena helena, Lappanella fasciata* and *Phycis phycis* were recorded mainly on coralligenous beds. The carnivorous sponge *Asbestopluma hypogea* was first found in deep areas, but not always connected to bio-concretions. The specimen found on Ausias March was on a coralligenous bio-concretion at 100 meters depth, but the one found in Chella Bank was at 167 meters in a rocky area on a small pinnacle beside the main summit (Fig. 1). Some other protected species included in the annexes of BARCOM-SPAM were also found. For example, the elephant ear sponge (*Spongia agaricina*) was found on Emile Baudot and the triton snail (*Charonia lampas*) on Ausias March (Fig. 1).

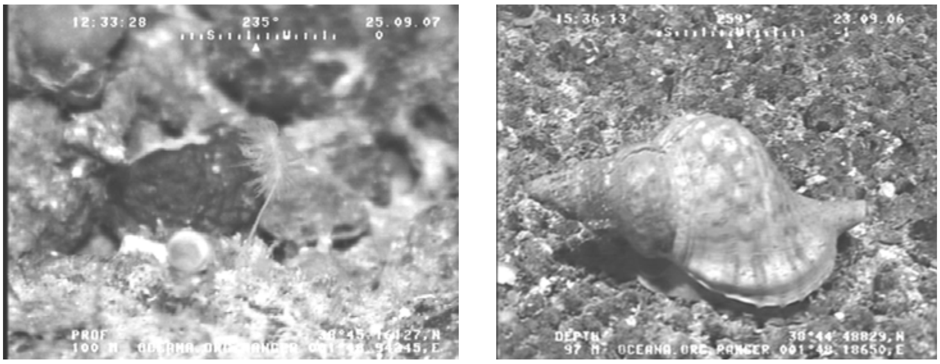

Fig.1:
1 *Asbestopluma hypogea*, &
2 *Charonia lampas* on the Ausias March seamount’s bio-concretions

DISCUSSION AND CONCLUSIONS

Maërl was mainly formed by rounded rodoliths, instead of the branched forms more common in shallower areas. Hydrodynamism and bathymetric distribution can determine morphology and maërl ramification (Bosence, 1983, Steller & Foster, 1995, Yabur-Pacheco & Riosmena-Rodríguez, 2007). Coralligenous concretions went from thin patches to large concretions -including circular geometric formations not yet described - many times looking like steps or visible different stages as it builds up.

As Laborel (1961) affirms, morphology and interim structure could depend on depth, topography and algae species. Some concretions give an aspect of a cobbled seabed, likely due to the lack of fusion or coalescence between several patches of algae, as in the large bio-concretions. Although red algae bio-concretions were found in all of the areas researched, from the surface down to 160-170 meters depth, distribution of the communities had a spatial segregation.

Most of the species found associated with the coralligenous beds were also found in surrounding areas without red algae, including *Anthias anthias*, *Lappanella fasciata*, *Muraena helena* and *Phycis phycis*, although they were apparently less abundant, showing their preferences for irregular bottoms. Only a few species, like *Paramuricea clavata,* seem to be strongly related to these bio-concretions, although depth distribution is probably a more important factor. Sponge aggregations were more common on maërl and "cobbled" coralligenous beds, while dead man's finger colonies were more often found on "cobbled" coralligenous, large coralligenous and rocky areas. *Asbestopluma hypogea*, since it was discovered in 1995 (Vacelet & Boury-Esnault, 1996), was so far only recorded in shallow caves in France and Croatia. Although Bakran-Petricioli *et al*. (2007), mentioned the possibility, this is the first time this species has been found in deep areas, both in coralligenous beds and rocky bottoms.

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DISTRIBUTION OF *ACANTHOGORGIA CF. HIRSUTA* ALONG THE CALABRIAN COAST (SOUTHERN TYRRHENIAN SEA, ITALY)

ABSTRACT

The discovery of wide populations of the gorgonian Acanthogorgia cf. hirsuta *(Acanthogorgiidae, Gorgonacea), in the waters off the Calabrian coast (Southern Tyrrhenian Sea, Italy) is herein reported. The colonies of this coral species are single or grouped in patches as far as 30 specimens growing on small boulders on soft bottoms. The specimens have been filmed and photographed with the aid of a ROV (Remotely Operated Vehicle), equipped with a high definition digital camera. Two areas in front of Vibo Marina and Cetraro (middle of Calabrian coast) have been monitored and quantitative data have been collected concerning the bathymetric distribution of the species, its habitat and parameters describing colony morphology. Colonies are located between 80 m and 130 m. The assemblage is characterized by of both large (about 20 cm high) and small (about 4-8 cm high) colonies. Composition of the assemblages varies following depth. Moreover,* A. cf. hirsuta *has been observed to grow on different types of hard substrata, natural and man made, such as tires, wood, and abandoned fishing nets present on the sea floor.*

KEY-WORDS: *Acanthogorgia cf. hirsuta*, ROV, Southern Tyrrhenian Sea

INTRODUCTION

A study aiming at monitoring the biodiversity of hard bottom substrata of the coastal waters of Calabria in a depth range between 50-200 m allowed us to report the presence of *Acanthogorgia cf. hirsuta* (Acanthogorgidae, Gorgonacea). Little is known about the biology and ecology of deep water corals, especially deep water gorgonians (Mortensen & Mortensen, 2004) and few ecological studies have been conducted because of the difficulty of working at greater depths where these corals grow (Genin *et al.*, 1992). Recent development of ROVs and towed video-equipped gear has provided an opportunity for controlled sampling and detailed observation of specific deep-water habitats.

This study is based on direct observations with a Remotely Operated Vehicle (ROV) of wide population of the gorgonian *Acanthogorgia cf. hirsuta* (Fig. 1). We describe size, density and distribution of species in relation to depth and associated fauna in two areas of Calabria.

MATERIALS AND METHODS

Three ROV surveys of the middle Tyrrhenian Calabrian coast area on R/V Astrea were carried out during summer 2007 and 2008 and photographic sampling was made at 6 random sites in front of Vibo Marina and Cetraro (Fig. 2) at depths range between 60 and 130 m. ROV was designed for scientific purposes, and equipped with an underwater acoustic tracking position system; a digital camera (Nikon D80, 10 megapixel); underwater strobe (Nikon SB 400); a 3 jaw grabber to take samples; and 2 parallel laser pointers providing a 10 cm scale. Calibrated distance between lasers was used in the photos to delimit and measuring the sampling areas on the substrate and to determine the density and the parameters describing colony morphology (mean height and width). Density of colonies was estimated by dividing the number of colonies within a photograph with its

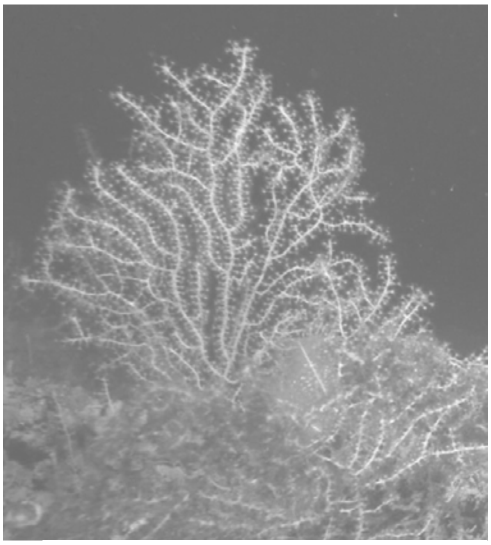

Fig. 1: ***Acanthogorgia cf. hirsuta***

approximate area. Moreover the frequency of the species (presence / absence within each photo) was estimated.

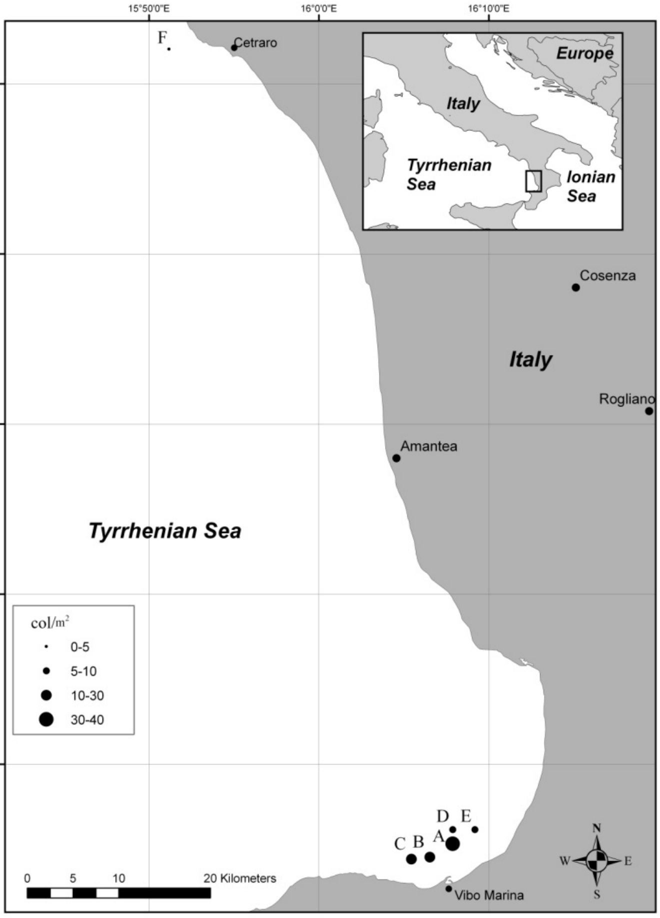

Fig. 2: Distribution and density of Acan*thogorgia cf. hirsuta*

RESULTS

Acanthogorgia cf. hirsuta is a small, light yellow coral species, irregularly branched on one plane only, that grows on hard substrate, and forms patches. Maximum and minimum height respectively were 39,32 cm and 1.86 cm with a mean value of 12,00 cm and mean width of 9,64 cm. 44 % of colonies measured and counted were smaller than 10 cm and only 12,5 % was bigger than 20 cm. Large and small size were mixed, but the corals were generally higher in dense patches than in sparse patches (Parrish, 2007). Mean density of colonies was 28,75 col m^{-2}, and ranged between 0,5-112 col m^{-2} and it varied with sites. Density values were related to depth and to hard substrate and gorgonian assemblage composition; however, the mean size of the coral colonies did not vary. Most part of substrate in the survey areas consisted of sand or detrital bottom with isolated rocks, cobbles and boulders. In the Mediterranean Sea the species were reported between 100 m and 260 m (Carpine & Grasshoff, 1975). We recorded *A. cf. hirsuta* between 80 m and 130 m, with only one exception of site A where specimens were found at about 60-70 m. The analysis of density and frequency values in relation to depth (Fig. 3), highlights the succession of three ecological sets. In the superficial sector (up to 80 m) *A. cf. hirsuta*, associated with *Paramuricea clavata*, *Eunicella cavolinii* and some colonies of *Corallium rubrum*, had high density but low frequency.

At a depth of 90 m *A. cf. hirsuta* was dominant. Below 90 m, density and frequency were inversely proportional to depth (Fig. 4).

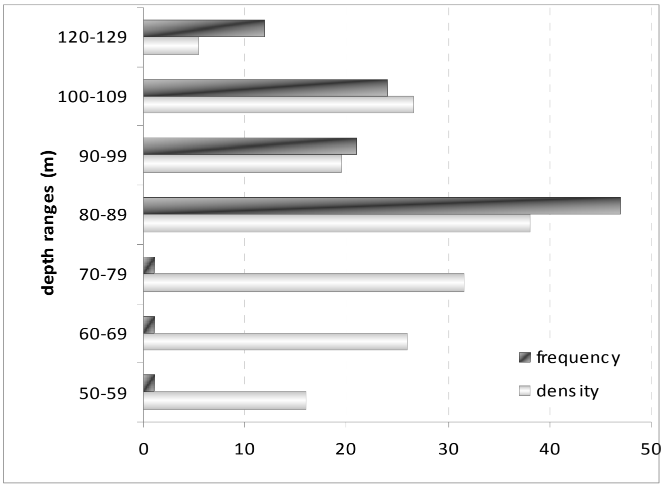

Fig. 3: Density and frequency

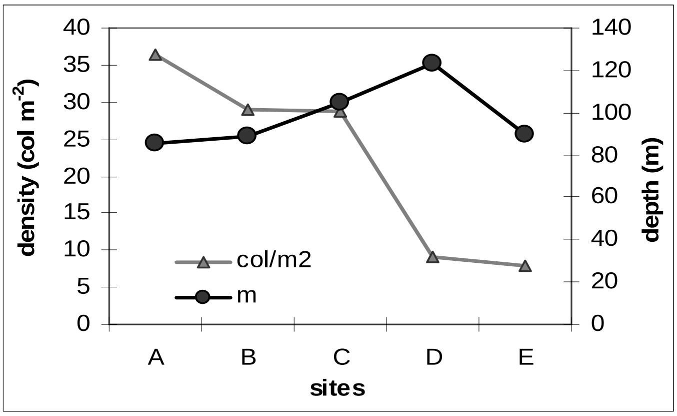

Fig. 4: Trend of depth and density values in each sites

Around 120 m *A. hirsuta* growed in association with a population dominated by *Callogorgia verticillata.*

In this site it has been reported the presence of 4 specimens of the antipatharian *Antipathes dicothoma.* Here *A. cf. hirsuta* was rare and grew below *C. verticillata* or on their skeleton. At the site F *A.hirsuta* has low density and frequency values associated to the *Eunicella sp* facies.

CONCLUSIONS

The use of ROV allowed to describe the communities directly in situ. These data provided a baseline for the ecological study of this species and integrated knowledge on its distribution.

ACKNOWLEDGMENTS

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CHALLENGES AND PERSPECTIVES OF CALCAREOUS BIO-CONCRETIONS INVENTORY IN CROATIA

ABSTRACT

The Eastern coast of the Adriatic Sea is characterised with a great diversity of marine habitats. Among them, due to the rocky nature of the coast, habitats (biocenoses, facies, associations) based on or containing calcareous bio-concretions like Lithophyllum lichenoides *rim, coralligenous, maerl beds or rhodolithes are not rare. However, due to lack of funds and specialists a systematic inventory of these valuable and endangered habitats has never been made. In the process of Natura 2000 preparation for the Republic of Croatia it is necessary to have such an inventory - not only for the bio-concretion habitats but also for the other important habitat types - as good and as fast as possible. Having that in mind we produced the Handbook for Marine Habitats - one in the series of handbooks for inventorying and monitoring which was published by the State Institute for Nature Protection and promoted earlier in 2008. The publication of the handbook was supported by the European Union under the CARDS programme. The handbook is primarily oriented towards people that are not professionally involved in nature protection with the aim to encourage them to collect data about important habitats such as Posidonia meadows and calcareous bio-concretions during their regular activities and forward them in standardised form to the Institute. Therefore the handbook contains description of data collection methodology, description of important habitat types and field forms for recording the data. At the moment the State Institute is in the process of establishment of the interactive database in which all the collected data will be saved. We expect that in this way it will be much easier and faster to obtain knowledge necessary for designation of Natura 2000 sites in Croatia. The collected data will then represent the basis for the future management plans for such sites.*

KEY-WORDS: Adriatic Sea, marine habitat mapping, Natura 2000, volunteers, data collecting

INTRODUCTION

Biodiversity of the Eastern part of the Adriatic Sea on a habitat level is very high due to the geomorphological characteristics of the coast. Most of the Croatian Adriatic coast is formed in karstified limestone and belongs to the Dalmatian-type coast: a few chains of islands and islets parallel to the coast. Also, the Adriatic Sea is the northernmost part of the Mediterranean and its longitudinal SE-NW position results in notable climatic differences along it. Combined with the specific direction of sea currents all of the above generates a great number of marine habitats. Due to the rocky nature of the coast, habitats - on different classification levels: biocenoses, facies, associations - based on or containing calcareous bio-concretions are quite common although they occupy small areas. Various sessile organisms (algae and invertebrates) build such organogenic structures but coralline algae are the most common builders. Although determination of species in this group needs specialistic knowledge, *Lithophyllum lichenoides* rim (biocenosis G.2.4.2. in Tab. 1), coralligenous (biocenosis G.4.3.1. in Tab. 1), maerl beds (biocenoses G.3.3.2. and G.4.2.2. in Tab. 1) or rhodolithes (biocenoses G.3.3.1., G.3.3.2. and G.4.2.2. in Tab. 1) are recognizable, after a little practice, even for a non-specialist. Due to very slow growth and vulnerability such habitats are considered endangered both on national as well as international level (Tab. 1). In the process of accession to the European Union it is necessary for the Republic of Croatia to have - as good and as fast as possible - maps and an inventory of such habitats in order to designate Natura 2000 sites in marine areas. However, due to the lack of funds and specialists a systematic inventory of these habitats has never been made.

Tab 1. Marine Natura 2000 habitats in Croatia and corresponding habitats in the National Habitat Classification for Croatia that encompass associations and/or facies with calcareous bio-concretions (for clarity codes of marine habitats classification according to Barcelona Convention as well as codes of Palearctic habitat classification are added)

Natura 2000 habitat[1]	**Corresponding Croatian marine habitat**[2]	**Palearctic habitat**[3]
1. COASTAL AND HALOPHYTIC HABITATS		
11. Open sea and tidal areas		
1110 Sandbanks that are slightly covered by sea water all the time	** G.3.3.1. Biocenosis of coarse sands and fine gravels mixed by the waves (III. 3. 1.) ** G.3.3.2. (also G.4.2.4.)Biocenosis of coarse sands and fine gravels under the influence of bottom currents in infralitoral (III. 3. 2.), also in circalittoral (IV. 2. 4.) G.4.2.2. Biocenosis of coastal detritic bottoms (III. 3. 2.1)	11.125 !11.22
1170 Reefs	G.2.4.2. Biocenosis of the lower mediolittoral rock (II.4.2.) ** G.3.6.1. Biocenosis of infralittoral algae (III.6.1.) ** G.4.3.1. Coralligenous (IV.3.1.) ** G.4.3.3. Biocenosis of shelf-edge rock (IV.3.3) G.5.3.1. Biocenosis of deep-sea corals present in the Adriatic bathyal (V.3.1.)	!11.24 !11.25
8. ROCKY HABITATS AND CAVES		
83. Other rocky habitats		
8330 Submerged or partially submerged sea caves	** G.2.4.3. Biocenosis of mediolittoral caves (II.4.3.1.) ** G.4.3.2. Biocenosis of semidark caves (IV.3.2.) ** G.5.3.2. Biocenosis of caves and ducts in total darkness in bathyal, also occurring as enclaves at less deep levels (V.3.2.)	11.294 !11.26 !12.7

[1] - Annex 1 of Habitats Directive (Interpretation Manual EUR 27, 2007); n°. in front: Natura 2000 habitat code
[2] - No. in front: National classification code and name according to Croatian Official Gazette No. 07/2006; n°. in brackets: code of habitat according to Barcelona Convention UNEP(OCA)/MED WG.154/7)
[3] - Codes of Palearctic habitat classification (CORINE)
** - Endangered and rare habitat types that require special protection measures (according to Croatian Official Gazette No. 07/2006)
! - Endangered natural habitats that require special protection measures (according to Annex I of the Resolution No. 4 of the Standing Committee of Bern Convention, 1996)

RESULTS

In order to speed up the process of collecting data about these valuable and endangered habitats as well as about other important marine habitat types like *Posidonia* beds we produced the Handbook for Marine Habitats in the series “**Biodiversity of Croatia – Handbooks for Inventorying and Status Monitoring” (Bakran-Petricioli, 2007). The Handbook was published by the State Institute for Nature Protection and promoted in early 2008.** The publication of the handbook was supported by the European Union under the CARDS programme "Capacity Building of the State Institute for Nature Protection." The idea was to encourage people that are not professionally involved in nature protection like enthusiastic individuals – especially divers, non-governmental organizations, schools and diving clubs/centres to take part in collecting data about important habitats, such are *e.g.* those with calcareous bio-concretions, during their regular activities. Therefore the handbook contains instructions and guidelines together with a description of simple data collecting methodologies and appendix sheets with the basic description of individual important habitat types illustrated with photos as well as field forms for recording the data. The importance of collecting the data and reporting to the Institute in standardised form is stressed in the handbook. In order to obtain better results, a number of workshops has been organised with interested groups by NGO Sunce from Split (www.sunce-st.org), in collaboration with NGO BIUS from Zagreb (www.bius.hr), both of which have so far gained a considerable experience and knowledge in inventory of marine habitats and species. Sunce recently produced another useful Handbook on Marine Species (Jakl *et al*., 2008). To gain a satisfactory amount of quality results the education of volunteers and their encouragement to collect data about marine habitats should be a continuous task that needs a lot of time and effort. In collaboration with scientists and professionals the State Institute for Nature Protection is currently in the process of establishing the interactive database in which all the data collected in standardised way will be saved. In this way data about endangered marine habitats such are: *Lithophyllum lichenoides* rim, coralligenous, maerl beds or/and rhodolithes will be collected on one spot optimising effective use of the data for nature protection.

CONCLUSION

By involving volunteers (enthusiastic individuals, divers, non-governmental organizations, schools, diving clubs/centres) in marine habitat inventory, provided that they are constantly encouraged, instructed through simple workshops and supplied with necessary handbooks, we expect that it will be much easier and faster to obtain basic knowledge necessary for the designation of Natura 2000 sites in Croatia, especially for habitats that do not encompass big areas like those with calcareous bio-concretions are. We also expect that the collected data will represent the basis for the future management plans for such sites.

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DONNEES PRELIMINAIRES SUR LA REPARTITION ET LA COMPOSITION DE LA BIOCENOSE DU CORALLIGENE DU LITTORAL D'EL KALA (ALGERIE).

RÉSUMÉ

Une évaluation du patrimoine biologique de la partie marine du Parc National d'El Kala s'étendant entre le Cap Rosa à l'ouest et le Cap Segleb à l'est, est réalisée. Le Coralligène couvre une surface importante des fonds rocheux. On le rencontre essentiellement au niveau de l'étage circalittoral, toutefois il peut être observé à plus faible profondeur, dans l'étage infralittoral, lorsque la luminosité est faible, sous les surplombs rocheux, le long des parois des failles et à la base des herbiers de Posidonies (Caps Rosa et M'Zarae). Les principaux agents constructeurs sont des algues rouges calcifiées dont les Rhodophytes - Corallinacées qui regroupent dans le secteur étudié les espèces Mesophyllum lichenoides, Pseudolithophyllum expansum *et* Pseulithophyllum cabiochae*. L'algue calcaire* Peyssonnelia squamaria, *caractéristique de cette biocénose est aussi fréquente dans la zone étudiée. On rencontre également un certain nombre d'espèces cibles telles que* Corallium rubrum, Centrostephanus longispinus, Epinephelus marginatus, …

MOTS CLÉS : Coralligène, biodiversité, protection, Sud-est méditerranéen

INTRODUCTION

La situation géographique des côtes algériennes à l'échelle de la Méditerranée et leur diversité climatique font qu'elles comprennent de nombreux sites d'intérêt stratégique d'un point de vue écologique (Chalabi *et al.*, 2002). Parmi ces pôles de diversité biologique, la zone côtière marine d'El Kala au nord-est du pays, classée Réserve de la biosphère par l'UNESCO comprend de nombreux sites d'intérêt stratégique au point de vue écologique et se place au premier rang national concernant les pôles de diversité biologiques. Peu de travaux ont été entrepris dans la région d'El Kala et ont soit concernés des études partielles ou préliminaires (Vaissière & Fredj, 1963 ; Pergent *et al.*, 1991) soit n'ont pas aboutit aux résultats escomptés (Alcyona I, 1996).

Dans le cadre du Projet régional pour le développement d'Aires Marines Protégées dans la région méditerranéenne (Projet MedMPA), une étude destinée à actualiser les connaissances relatives à l'écosystème marin de la région d'El Kala est entreprise dans le but d'étendre le Parc National d'El Kala au domaine maritime.

Par ailleurs, second écosystème méditerranéen marin du point de vue de l'importance de sa diversité, le coralligène couvre une surface importante dans cette zone marine. Cependant, il est peu voir pas étudié en Méditerranée sud occidentale. L'objectif de ce travail est de dresser un premier inventaire de la diversité biologique du coralligène.

MATERIELS ET METHODES

La région d'El Kala est située à la frontière algéro-tunisienne (Fig 1). La partie marine du PNEK, objet de la présente étude est délimitée à l'ouest par le Cap Rosa et à l'est par le Cap Segleb. La zone côtière majoritairement constituée de substrat dur est caractérisée par une côte découpée, prolongée en récifs, îlots, falaises, traduisant un milieu physiquement diversifié.

Fig : Carte de la région d'El Kala

Trois campagnes ont été réalisées entre les mois de juillet et d'août 2004 et en juin 2007. L'ensemble du linéaire côtier (40 km) du parc national, soit 41 stations ont été explorées en plongée sous-marine entre la surface et 64 m de profondeur. Chaque secteur a fait l'objet d'un transect partant du large vers le rivage. L'identification des espèces a été réalisée in situ ou après récolte sauvage.

RESULTATS

Dans la zone d'étude, l'écosystème du Coralligène couvre une surface importante des fonds rocheux dans les secteurs des Caps Rosa, El Alem et Segleb, de M'Zarae, de Boutribicha et de la plage Vergès. Il se rencontre essentiellement au niveau de l'étage circalittoral, cependant il est également observé à plus faible profondeur, dans l'étage infralittoral, lorsque la luminosité est faible, sous les surplombs rocheux, le long des parois, des failles et à la base des herbiers de Posidonies (Caps Rosa et M'Zarae). Les principaux agents constructeurs sont des algues rouges calcifiées dont les Rhodophytes - Corallinacées qui regroupent dans le secteur étudié les espèces *Mesophyllum lichenoide*, *Pseudolithophyllum expansum* et *Pseulithophyllum cabiochae*. L'algue calcaire *Peyssonnelia squamaria*, caractéristique de cette biocénose est aussi fréquente dans la zone étudiée. Des constructeurs secondaires, hôtes des charpentes algales, contribuent plus ou moins significativement, selon les espèces, à l'édification ou à la consolidation du concrétionnement. Il s'agit des invertébrés sciaphiles à test ou squelette calcaire tels que les grands Bryozoaires *Myriapora truncata*, *Reteporella couchii*, *Schizotheca serratimargo* et *Sertella septentrionalis*, les Polychètes *Sabella* sp. et *Spirographis spallanzii*, les Cnidaires sessiles telles que les gorgones *Eunicella cavolinii* , *Eunicella. singularis* et *Lophogorgia ceratophyta*, les éponges *Axinella polypoïdes* et *Crambe crambe*; le madréporaire *Astroides calycularis* rencontré sur des parois rocheuses ombragées de Cap Rosa et l'alcyoniidae *Parerythropodium coralloides*. Comme tout substrat calcaire en mer, le Coralligène subit une érosion physique et biologique qui est causée par de nombreux organismes destructeurs tels que l'oursin violet *Sphaerechinus granularis* qui broute la partie vivante des algues calcaires et représente un facteur important de bioérosion. Par ailleurs, les éponges perforantes du genre *Cliona* qui fragilisent ces formations sont également observées. Les espèces ichtyologiques les plus typiques du coralligène rencontrées durant notre étude sont *Anthias anthias*, *Labrus bimaculatus*, *Serranus scriba* et *Scorpaena scorfa*. Dans les cavités on a noté la présence de *Conger conger*, *Muraena helena* et *Phycis phycis*. D'autres espèces plus fréquentes sont observées telles que *Diplodus sargus*, *D. vulgaris*, *Pagrus pagrus*, *Spondyliosoma cantharus* et *Dentex dentex*. Le mérou brun *Epinephelus marginatus* est également observé ainsi que *Seriola dumerlii*. Plus rare mais néanmoins présente est le saint pierre *Zeus faber* observé au large de M'Zarae. D'autre part, il est à noter la présence d'espèces cibles telle que l'oursin diadème *Centrostephanus longispinus* qui est rencontré sur le coralligène profond à 56 m avec *Corallium* *rubrum* et au niveau de l'épave du Chalutier Bougarouni. Cette espèce n'a fait l'objet que de rare signalisation en Algérie (îles Habibas (Grimes *et al.*, 2000), Cap Matifou, île de la fourmi (Chalabi *et al.*, 2002)). Enfin, dans la région étudiée, bien que la présence et l'abondance de *Corallium rubrum* ne soit pas à démontrer (Belbacha et *al.*, 2003), nous n'avons pu observer cette espèce qu'à l'ouest du cap Rosa à -56 m de profondeur, ce qui s'expliquerait par le fait que les autres points d'observation ne sont pas assez profonds. Il est vrai que la pêche constitue la source principale de perturbation dans les populations de *C. rubrum* bien que des mortalités à grande échelle aient aussi été signalées (Garrabou *et al.*, 2001). Plus alarmant encore, est le braconnage par le chalutage spécifique à l'aide de « la barre italienne » qui est fortement destructif pour la faune benthique et pourtant fortement pratiqué dans la région.

CONCLUSION

Le coralligène représente la communauté benthique la plus remarquable de la partie marine du parc national en raison de sa qualité paysagère et de sa richesse biologique. Il n'en demeure pas moins que cet écosystème est considéré comme fragile du fait que sa persistance est liée au maintient de facteurs biotiques et abiotiques particuliers (Hong, 1983). Dans certains secteurs de la côte algérienne, le système du coralligène, subit des dégradations dues à l'envasement, à l'exploitation halieutique ainsi qu'à la pollution générale du littoral. En effet, la pollution diminue aussi quantitativement le nombre d'espèces infralittorales dans les fonds de concrétionnement coralligènes et augmente les espèces à large distribution écologique (Hong, 1980; 1983). De plus les espèces qui agissent dans la bio-érosion sont plus abondantes dans les zones polluées (Hong, 1980).

Ces éléments traduisent l'importance de cette zone marine qu'il faut impérativement protéger et préserver.

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Actes du 1^{er} Symposium sur le Coralligène et autres Bio-Concrétions calcaires de Méditerranée
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BIOGENIC STALACTITES IN SUBMARINE CAVES AT THE CAPE OF OTRANTO (SOUTH EAST ITALY): DATING AND HYPOTHESIS ON THEIR FORMATION

ABSTRACT

*Submarine caves at the Cape of Otranto host pseudostalactites projected from the ceiling and lateral walls toward the centre of the halls. Only recently have they been recognised as biogenic concretions mainly due to marine tube worms (*Protula tubularia*, Serpulidae, Polychaeta). The dating of Polychaeta calcareous tubes in the pseudostalactite core represents the first attempt to reconstruct the formation of such bio-construction. Three pseudostalactites removed from the cave lu Lampiùne (Otranto, SE Italy) have been sectioned longitudinally for the dating of calcareous tubes constituting cordons along their core axis. ^{14}C measurements established a range of 2,600 - 5,000 years stories for such 3 tube cordons. Their formation started approximately 6,500 years ago when the cave was invaded by the sea, and ended about 1,500 years ago. This extremely long period (in comparison with life span of each worm) suggests that each tube cordon is the result of short growth periods alternated with long standstill phases. Only at the death of Protula tube-worms and the end of a cordon growth-period the brownish concretion completely envelopes the cordon forming a complete pseudostalactite. The duration of the process suggests that* P. tubularia *is only accidentally introduced in the innermost portion of marine caves, where the species becomes gregarious (so producing the cordons) and probably does not produce larvae.*

KEY-WORDS: serpulid concretions, ^{14}C dating, pseudostalactite, submarine caves,

INTRODUCTION

In some cases a small number of species (or even only one) dominate the marine bio-constructions (Laborel, 1987). Among Polychaeta Serpulidae (which build calcareous tubes) about 10 % of the 300 known species are reported to assume a gregarious existence (ten Hove & van den Hurk, 1993). The gregarious behaviour is facultative and it is enhanced by local conditions. Serpulid aggregations are generally reported from unstable environments (ten Hove, 1979; Bianchi *et al*., 1995) realized by euryoecious species probably as an answer to competition and/or predation (Ten Hove & Van Den Hurk, 1993). Polychaeta Serpulidae strongly characterize the macrobenthos in the most confined portions of submerged caves (Riedl, 1966; Harmelin, 1985; Bussotti *et al*., 2006) where the environmental conditions are considered as not suitable for the majority of other benthos organisms. In a Belizean submerged cave serpulid tubes have been identified as the main responsible for the "club like pseudostalactites" which cover entire walls and are associated with sponges, bryozoans, bivalves, and epizoic algae (Macintyre *et al*., 1982). Calcareous tubes of the internal portion of each pseudostalactite were recognized as empty, abandoned structures, and the authors attributed them a ^{14}C age of 820 years. Recently the presence of biogenic stalactites (pseudostalactites) has been reported from the Mediterranean Sea in the Cape of Otranto caves, at different distances from the entrance (Onorato *et al*., 2003). The Otranto pseudostalactites appeared longer (up to 2 m), with a core of *Protula tubularia* tubes, embedded and concealed in a brown-grey calcareous matrix, and they were almost lacking in macro-organisms on their surfaces. Bianchi & Morri (1994) used the term "cordon" to describe aggregations of *Protula tubularia* in an Italian submarine cave. Ten Hove & Van Den Hurk (1993) reported aggregations formed by *Protula sp*. (probably *tubularia*) in the Mediterranean Sea (Cyprus submarine caves). These tube aggregations, differently from the Otranto ones, assume the structure of hummocky stalagmites, and they are not covered by concretions. The present study proposes to use the dating the ^{14}C deposited in the tubes of biogenic structures to reconstruct the story of pseudostalactite formation in the caves at Cape of Otranto and, consequently, that of a gregarious behaviour in *Protula tubularia*.

MATERIAL AND METHODS

Three pseudostalactites, detached from an internal wall of the *lu Lampiùne* submerged cave (Cape of Otranto, South East Italy), were sectioned longitudinally. They were labelled A, B, and C, and were 43, 50, and 42 cm long respectively. Fragments of calcareous tubes have been removed from the longitudinal core-axis at increasing distances from the basis, to be dated by ^{14}C Accelerator Mass Spectrometry (AMS). Positions were distanced about 7-14 cm from each other to reduce the probability of isolating fragments of the same tube/individual from successive positions. The isolated tube fragments were successively ultrasonified in alternate H_2O - H_2O_2 baths. Each cleaned fragment was processed to obtain CO_2, and successively reduced to graphite. The ^{14}C concentrations have been corrected for isotopic fractionation effects (see Calcagnile *et al*., 2005). A cordon of tightly aggregated calcareous tubes of still living *Protula tubularia* was detached from the ceiling of Tau-Manhattan submarine cave, near to the lu Lampiùne one. Two calcareous fragments were isolated from different parts of a single tube to be dated with the ^{14}C method and successively compared with those isolated from the pseudostalactite cores. In the case of recent tubes, the ^{14}C dating gives a value (years) which has to be added to 1950 to obtain the correct date. The maximum linear distance between internal walls of each tube section along the pseudostalactite core axis were measured by using a callipers to evaluate differences in tube section densities.

RESULTS

The core-axis of pseudostalactites is mainly composed by tightly aggregated serpulid tubes which do not reach the pseudostalactite external surface. In fact, the cordon like aggregation of calcareous tubes is coated by a thick concretion also containing a network of tiny tubes (average diameter, 1.0 mm). All the sectioned pseudostalactites did not show eroding organisms and/or structures. The ^{14}C dating of the core tubes gave values ranging between 6,612 ± 80 years, at the base of the pseudostalactite B, and 1,530 ± 80 years at the tip of the pseudostalactite A, thus allowing us to collocate the formation of these spelaeothemes within a period of about 5,100 ^{14}C years. The basis of the three pseudostalactites differed of 641 ^{14}C years, whereas at the opposite extremity (in a range of 1-9 cm from the tips) was of 2,396 ^{14}C years. The shape of the tube sections was different in different parts of the pseudostalactite core-axis. Tubes with longitudinal axis orthogonal to the basis alternated to parts where tube longitudinal axis was parallel to the basis. In the first case tubes appear sectioned mostly tangentially. In the second case tubes appear sectioned mostly transversally. A naked cordon-like aggregation (without the concretionary coating) of *Protula tubularia* was collected in the Tau-Manhattan cave. It was composed by 8 individuals at least, whose tubes were tightly jointed for a total length of 13.5 cm. Tubes showed spiralled/chaotic parts alternated to straight ones. The longest tube segment had a linear length of 22.0 cm. Five tubes of the cordon were still occupied by living worms. Fragments from distant positions of the same living worm tube gave ages ranging from 54 ± 4 to 60 ± 5 ^{14}C years from AD 1950.

DISCUSSION

Generally, Serpulidae are better adapted than other organisms to confined environments (*sensu* Guelorget & Perthuisot, 1992) where a general diminished biodiversity is common. The confinement theory has been proposed for the zonation of submarine caves, too (Bianchi & Morri, 1994; Morri, 2003), where the “trophic depletion” (*sensu* Zabala *et al*., 1989), or the diluted salinity (Moscatello & Belmonte, 2007), could represent the limiting factor for the development of a rich benthic community in the innermost portions. In such confined environments Serpulidae develop gregarious behaviour which produces buildings of calcareous tubes. During about 5,100 years which have been established as necessary for the formation of the tube cordons studied, the first 17 cm (near the bases) were realized at a speed of 2.8 cm * 100 years^{-1}, while the last 15 cm (near the tips) were realized at a speed of 0.7 cm * 100 years^{-1}. The deceleration is probably correlated with the progressive rise of the sea level during this period, and the progressive distance of the site from the upper and generally more dynamic sea layer. In fact, the ^{14}C dating of the present study well agrees with the paleo-reconstructions of the Quaternary variations in the Mediterranean sea level which passed from -10 to -4 m about 6,500 years ago (Alessio *et al*., 1994; Antonioli *et al*., 2001; Antonioli & Ferranti, 2003; Lambeck *et al*., 2004). This date is very close with the measured birth date of the Otranto pseudostalactites (which have been detached from a depth of -8 m). In addition to external constraints on the whole process, also individual and/or intrinsic properties of each worm aggregation (Hughes *et al*., 2008) were probably responsible for the observed difference in the length of the three pseudostalactites.

According to a hypothesis suggested by Macintyre *et al*. (1982), in a marine cave the species recruitment could not depend on the cave population, but only on propagules coming exceptionally from the outside during storms. A point which remains to be clarified is the surprising life span of the aggregates (thousand years) if compared with those of each single worm in the tube cordon of each pseudostalactite. Considering the average tube length of *Protula tubularia,* and its life cycle features (Kuprijanova *et al*., 2001), the pseudostalactites could easily have surpassed a length of 40-50 cm during thousand years of existence of each tube cordon. We can only admit the possibility of a non continuous growth, with standstill phases longer than the growth ones. The hypothesis of a storm driven recruitment sustains the hypothesis of not continuous growth, and implicitly admits the impossibility of reproduction of the cave individuals.

If the alternate growth-standstill hypothesis is valid, the Otranto pseudostalactites could be only temporarily “non living” structures and they could further elongate in future when/if other Protula propagules would aggregate on their tips.

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RÉSUMÉ

*L'étude menée a pour but d'identifier les différents types de bioconcrétions existant dans la région centre algérienne notamment au niveau de la Wilaya de Tipaza à 80km à l'Ouest d'Alger, il s'agit essentiellement des trottoirs à vermets édifiés par le gastéropode de la classe des Vermidae (*Vermetus triqueter*), les bourrelets à base de Rhodobiontes ou algues rouges de nature calcaire (*Corallina elongata*), et à moindre degré les encorbellements à Lithophyllum* lichenoides *(rhodobionte). Le travail a concerné les régions suivantes de la Wilaya de Tipaza : Chenoua, Anse de Kouali et Ain Tagourait (Bérard). Une étude de la biodiversité, par l'établissement d'un inventaire des espèces faunistiques et floristiques associées à ces biocénoses remarquables, permettra une meilleure connaissance et caractérisation des trottoirs. Les résultats préliminaires présentés dans ce document consistent en un inventaire de la biodiversité algale et de la macrofaune commune aux trois sites étudiés ; avant l'échantillonnage prévu pour Janvier 2009.*

MOTS-CLÉS: bioconcrétions, faune et flore associée, Tipaza, bio indicateurs, médiolittoral

INTRODUCTION

Les peuplements benthiques du médiolittoral et de l'infralittoral supérieur sont des indicateurs biologiques de la qualité des eaux marines selon Pérès et Picard (1964). Parmi ces peuplements, certaines biocénoses remarquables, de par l'importance de la biodiversité qu'elles renferment ainsi que leur accessibilité à l'étude constituent des outils biologiques « intéressants » pour la biosurveillance du milieu marin. C'est ainsi que notre choix a porté sur l'étude des trottoirs au niveau de la région de Tipaza ; où ils ont été signalés par Seurat (1927) au pied de la falaise du grand rocher canon. Guilcher (1954) ; Molinier et Picard (1952) in (Pérès et Picard, 1964) ont observé un aspect traduisant l'existence d'une margelle de la roche sous le vermet du rebord extérieur de la plate-forme dans la même région. Une bande ininterrompue d'une formation à coquille brisées est rencontrée en direction sensiblement parallèle au rivage dans la baie de Boue Ismail ex Castiglione (Caulet, 1972), l'épaisseur de la couche édifiée par le gastéropode (vermetus triqueter) est variable, selon la nature du substrat, l'hydrodynamisme et la formation topo-géomorphologique.

La région de Tipaza, hautement soumise aux activités anthropiques, est inscrite dans le Programme d'Aménagement Côtier (P.A.C.) qui vise la création d'aires marines protégées, entre autres dans les sites d'étude : Chenoua, Anse de Kouali et Bérard.

Il est important de signaler l'absence d'études antérieures relatives aux trottoirs et aux bioconcrétionnements en Algérie, hormis les signalisations citées ci-dessus.

MATERIELS ET METHODES

9 stations ont été choisies sur les trois sites prédéfinis : Ain Tagourait, anse de Kouali et Chenoua, tous caractérisés, relativement, par les mêmes caractéristiques géomorphologiques et hydrodynamiques. Dans chaque site, trois prélèvements horizontaux sur le long de la plate forme de substrat dur de la zone médiolittorale, ont été effectués par des quadrats de 20x20cm. Les organismes ont été collectés par grattage jusqu'à la roche, puis triés et conservés au formol selon la méthode de Bellan (1969). Ces premiers prélèvements ont concernés la saison estivale de l'année 2008.

RESULTATS

Pour les trois sites étudiés, il a été relevé la présence de trottoirs à *Vermetus triqueter* ; ces derniers atteignent une largeur d'un mètre et sont d'épaisseur moyenne de 2cm à Bérard ainsi qu'à Kouali et de 3 cm au Chenoua. Quelques recouvrements importants à *Lithophyllum* ont néanmoins été observés, mais ne peuvent être assimilés à des trottoirs en raison de la fine couche dépassant très rarement le premier centimètres qui tapisse les grès. Le bourrelet à *Corallina elongata* est très marqué à Chenoua, les thalles très condensés, sont de couleur tendant au violacé et renferment des concrétions à moules, notamment *Mytilus galoprovencialis* et *Perna perna*. La faune et la flore recensées au niveau des trois sites, confondus, est présentée dans le tab.1 :

Tab.1: Faune et flore recensées

Rhodobiontes
Acrosorium uncinatum
Amphiroa rigida
Antithamnion sp
Asparagopsis armata
Calithamnion granulatum
Ceramium diaphanum
Ceramium rubrum
Ceramium sp1
Chondria scintillatus
Corallina elongata
Corallina officinalis
Gastroclonium clavulatum
Gelidiella acerosa
Gélidium latifolum
Gélidium sp1

Gigartina acicularis
Gigartina tedeii
Herposiphonia secunda
Hypnea musciformis
Jania adherens
Jania corniculata
jania longifurca
Jania rubens
Laurencia obtusa
Laurencia papillosa
Laurencia pinnatifida
Lithophyllum incrustans
Lithophyllum sp1
Lithophyllum sp2
Lithophyllum tortuosum

Polysiphonia martensiana
Pterosiphonia complanata
Peysonnelia sp
Stylonema alsidii
Chromobiontes
Cystoseira stricta
Cystoseira mediterranea
Cystoseira compressa
Cystoseira sp1
Dictyota dichotoma
Dictyota linereis
Sphacelaria sp
Halopteris filicina
Ectocarpus sp

Chlorobiontes
Dictyopteris membranacea
Padina pavonica
Colpomenia sinuosa
Sargassum vulgare
Bryopsis sp
Acetabularia acetabulum
Cladophora rupestris
Cladophora laetevirens
Cladophora sp
Ulva lactuca
Valonia bullata
valonia utriculosa
Enteromorpha intestinalis

Mollusques
Acanthochiton crinita
Acanthochiton fasicularis
Aplysia sp
Brachiodonte minimus
Cardita calyculata
Cassis undulata
espèce indeterminée
Fussurella nubecula
Gibbula phorcas varia
Lithophaga caudigera
Lithophaga lithophaga
Littorina punctata
Mantellum hians
Monodonta articulata
Monodonta osilinus spp
Musculus costulatus
Mytilus galloprovencialis
Patella caerulea
Perna perna

Tricolia sp
Vermetus cristatus
Vermetus sp1
Vermetus triqueter
Crustacés
Balanus perforatus
Amphitoe ramondi
Caprella sp
Carcinus meanas
Chtamalus stellatus
Clibanarius erythropus
Dynamene sp
Empelisca brevicornis
Ericsonella sp
Espèce indéterminée 1
Espèce indéterminée 2
Espèce indéterminée 3
Gammarus sp

Hyale sp1
Hyale sp2
Hyale sp3
Idotea sp
Jassa falcata
Coscinasterias tenuispina
Meara inaequipes
Pisa nodipes
Pisa tetraodon
Pollicipes pollicipes
Spheroma serratum
Spheroma sp
Echinodermes
Arbacia lixula
Ophioderma longicaudum
Ophiura sp
Paracentrotus lividus

Annélides
espèce non déterminée1
espèce non déterminée2
Glycera sp
Nereis sp
Perenereis cultrifera
Phascolion strombus
Phascolosoma sp
Platinereis dumerili
Syllis sp
Tharyx marioni
Spongiaires
Cliona sp
Non déterminée
Foraminifères
Miniacina miniacea
Cnidaires
Actina equina
Anemonia sulcata

DISCUSSION

Les résultats préliminaires actuels permettent de donner un aperçu qualitatif des peuplements associés aux trottoirs à *Vermetus triqueter* .

Par ailleurs, les bioconcrétions à vermets relevés semblent présenter une épaisseur de moindre importance que celles citées dans la littérature, celles de 5 à 10 cm relevées par. J. Molinier & J.Picard (cf. J.M.Peres & J.Picard, 1952) in (Pérès & Picard, 1964).

Cette différence d'épaisseur, pourrait être expliquée par des perturbations du milieu, dues aux impacts anthropiques croissants dans la région ainsi qu'au réchauffement des eaux qu'a connues la Méditerranée, freinant la croissance du gastéropode.

CONCLUSION

Cet inventaire de la faune et de la flore, associées aux trottoirs à V*ermetus triqueter***,** est une première partie du travail qui consistera à faire le dénombrement de tous les taxons, et à appliquer les analyses multivariées pour une meilleure différenciation entre les sites étudiés en fonction des affinités écologiques des espèces et leur abondance. Les Cystoseires (chromobiontes), *Cystoseira stricta/mediterranea* sont sans conteste des espèces accompagnatrices constituant d'excellents indicateurs de la qualité du milieu, affectionnant particulièrement les eaux claires, agitées à modérément agitées. Par ailleurs, des espèces comme *Corallina elongata* (Rhodobiontes) et *Mytillus galloprovencialis* (bivalve) tendent à remplacer des espèces constituant les trottoirs telles que le *Lithophyllum sp.* et le *vermetus triqueter* ainsi que les *Cystoseira sp*, reflétant une dégradation du milieu par un enrichissement en matière organique.

L'objectif essentiel du travail étant une contribution à la connaissance des bioencorbellements de la Wilaya de Tipaza, en mettant en évidence l'importance de ces formations dans le fonctionnement de l'écosystème marin.

La création d'une première base de données sur la localisation des trottoirs, leur nature et la biodiversité qu'ils renferment est un premier pas pour la cartographie de ces formations, cette dernière étant actuellement une méthode « efficace » pour la surveillance et la protection de ces habitats remarquables fragiles et dont la destruction est irréversible.

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WARMING TRENDS, REGIONAL FINGERPRINTS AND FUTURE TRAJECTORIES OF NW MEDITERRANEAN COASTAL WATERS

ABSTRACT

Getting sound knowledge on past and present coastal waters climate is key to anticipate the future trajectories of coastal communities face to the current environmental change. Here we provide analysis of 3 long term (30 years), and of 4 high resolution (4 to 9 years, 1/hour, every 5m from 5 to 40 m depth) temperature time series conducted in NW Mediterranean sites with contrasted climate conditions. All long term series converged towards a surface warming around 0.3°C per decade and showed an increase of the frequency of positive anomalies at all depths investigated. The high resolution time series permitted a fine characterization of coastal waters climate at the 4 areas and showed contrasted regional fingerprints. Characterization of the 1999, 2003 and 2006 positive anomalies attested of differential regional hydrological and biological response to extreme climatic events. It also confirmed that key structuring species dwelling in the coralligenous may be submitted to their upper thermal thresholds and are very sensitive to extreme temperatures. Implications regarding future climatic projections and the concerted strategies needed to address this fundamental issue are discussed.

KEY-WORDS: NW Mediterranean temperature regimes, climate change, warming trends

INTRODUCTION

In 1999 and 2003 two unprecedented mass mortality events have strongly affected species dwelling in the coralligenous communities in the NW Mediterranean (Garrabou *et al.*, in press). Anomalous high temperature conditions along the Spanish, French and Italian coasts were evoked as the main triggering factor of the mortality outbreaks. Bearing in mind the warming trend in the NW Mediterranean (Salat & Pascual, 2002) and the likely increasing occurrence of summer heat waves over Europe (Scharr *et al.*, 2004), new events may likely occur in the near future raising concern for the conservation of coralligenous communities.

In order to better understand the potential responses of benthic communities to the current climate change in the NW Mediterranean coastal areas we conducted (1) the analysis three 30-year temperature series (1975-2004) and (2) the characterization of temperature regimes of coastal waters (5-40 m depth) through the analysis of high resolution time series (hourly measurements).

MATERIAL AND METHODS

Temperature trends. We analyzed three 30-year temperature series (1975-2004) recorded at three coastal sites in the NW Mediterranean: Estartit (EST; surface to 80m; Catalan Coast), Villefranche-sur-Mer (VIL; surface to 75m) and Levant (LEV; surface only). Temperature series were based on daily to biweekly records with a fair continuity along the analyzed period allowed a consistent examination of their common/divergent evolution.

Characterization of temperature regimes. Since 1998, temperature recorders were progressively deployed at 8 sites encompassing different areas in the NW Mediterranean. T was recorded hourly by autonomous, permanently operated sensors (Stowaway Tidbits, precision 0.2°C) deployed and recovered annually or semi annually by divers. Since 2004, the sensors were systematically set up every 5 m from 5 to 40 m depth including thus depth were coralligenous communities develop. Four series are presented here: Medes islands (N Spain), Riou island (Marseilles, France), Port-Cros island (National Park, Var, France) and Scandola natural reserve (Galeria, Corsica, France). Data were collected since 1999 in Riou and Port-Cros and since 2002 in Medes since 2002 at all or some of the following depths: 10, 25 and 40 m.

RESULTS

Temperature trends. The three series showed a significant warming trend over the 30-year period: +1°C EST, +0.8°C VIL and LEV resulting thus in about 0,3 °C increase per decade. It is noteworthy that EST displayed the lower temperatures compared to the other two sites but showed the highest warming rates. This regional warming trend was based on the increase of the number of warm anomalies for the three surface records and at all depths at EST and VIL. In general, warm anomalies were detected at the three study sites evidencing that the detected warming was driven by regional phenomena over the local conditions.

Characterization of temperature regimes. Temperature regimes in the four sites analyzed here shared the seasonal dynamics associated to NW Mediterranean waters. However, the inter-annual study of temperature series allowed to detect specific patterns (mean and variability) for each site. These patterns showed contrasted temperature conditions to which the populations could have been adapted to. Furthermore, the temperature series allowed to characterize the 1999, 2003 and 2006 positive anomalies which were related to the occurrence of large-scale mortality events of key structuring species such as gorgonians. These events confirmed that populations may be submitted to their upper thermal thresholds and are very sensitive to extreme temperatures.

CONCLUSION

Overall, the study of temperature trends and temperature regimes coupled with researches on the response of populations to temperature warming are key to anticipate the future of coastal communities under the current climatic projections. In this sense continuing and extending the acquisition of high resolution temperature time series in the Mediterranean will provide (1) new insights on thermal conditions and warm episodes that have direct consequences on benthic communities; (2) relevant information on conditions to which species have adapted; (3) data bases to better understand the modalities of current warming of the Mediterranean coastal waters.

ACKNOWLEDGEMENTS

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CORALLIGENOUS FORMATIONS IN THE MARINE PROTECTED AREA OF TAVOLARA PUNTA CODA CAVALLO (NE SARDINIA, ITALY)

ABSTRACT

Scuba diving surveys, carried out in 46 sites between 1989 and 2005 down to 57 m depth, allowed the recognition of 5 different typologies of coralligenous formations (coralline algae buildups): i) enclaves within infralittoral assemblages on vertical walls, either carbonatic or granitic; ii) on limestone pinnacles between 25 and 40 m depth; iii) on granite inselbergs and other erosional remnants 38 to 56 m deep; iv) organogenic platforms at 42-44 m; v) on beach-rocks at 27, 40 and 54 m. The exuberance of a "typical" coralligenous community, with tall gorgonians and/or large sponges, was not correlated with an important accretion of the basal layer of coralline algae.

KEY-WORDS: coralligenous, bioconcretion, diving survey, Marine Protected Area, Mediterranean Sea.

INTRODUCTION

The coralligenous represents the principal biocostruction in the Mediterranean sea, in terms of power and of connect biodiversity (White, 2002). For oneness and ecological importance, the coralligenous has often been compared to the Posidonia seagrass but the " Habitat Directive " 93/43/CEE don't assign him the same status of priority habitat for the maintenance (Bellan-Santini et to the., 2002). The knowledges on the coralligenous have been seen by Ballesteros (2006): further searches are necessary for the characterization of the different typologies, in relationship either to the ecological division either to the geographical distribution. In the Marine Protectet Area (MPA) of Tavolara Punta Coda Cavallo we are found notable varieties and abundance of coralligenous (Navone and Bianchi, 1992; Navone *et al*., 1992). In this job physiognomy and development of the bioconcretion are shortly described , in operation of the depth and of the geomorphology (Orrù & Pasquini, 1992).

MATERIALS AND METHODS

Among 1989 and 2005 96 underwater surveys have been effected in 46 sites, up to 57 m depth. The bioconcretion has been esteemed through a hand penetrometro, distinguishing 3 cases: absent or scarce (void penetration); moderate (millimeters penetration); important (centimeters penetration). We have been diversified 4 physiognomies of the elevated layer: absent or inconspicuous ; monospecific to *Eunicella cavolinii* (EC); oligospecific to great sponges (GS), like *Spongia agaricina*, *Sarcotragus foetidus* and *Axinella polypoides*, accompanied sometimes by *Eunicella singularis*; multipecific to *Paramuricea clavata* (PC), which *Eunicella cavolinii* can be added, *Eunicella singularis*, *Salmacina dysteri*, *Spongia agaricina*, *Aplysina cavernicola* and *Alcyonium acaule*. A detailed description of all the sites and the different observed populations can be found in Bianchi *et al*. (2007).

RESULTS

Coralligenous affinity populations has been observed in 29 sites, on 5 different morphologies: the) vertical faces to depth infralitorali (7-33 m in depth); ii) calcareous pinnacles from 25 to 40 m depth; iii) inselberg and other granite residual forms between 38 and 56 m depth; iv) organogenic bases to 42-44 m in depth; v) beach-rock to 27, 40 and 54 m in depth. The faces coralligenous (i) it essentially shapes him as an enclave, favored by the vertical inclination or overhang of substratum, inside algal populations infralitoral; the bioconcretion is scarce (above all on granite) or moderate (above all on limestone), and the elevated layer is almost always EC. The calcareous pinnacles (ii), fragments of the bancata of the island of Tavolara, introduce moderate bioconcretion or main point and layer elevated PC. The inselbergs (iii), located especially in the Channel of Tavolara, they constitute different types of rocky shoals to affinity coralligeneous: those relatively more superficial they can have moderate bioconcretion but absent elevated layer or scarce bioconcretion and elevated layer EC; the deepest always have scarce bioconcretion, with layer elevated PC (toward the apex) or GS (to the base). The organogeneous bases (iv) are a little wide, they always have important bioconcretion and elevated layer EC (more rarely PC). The beach-rock introduces coralligeneous aspects (v) beginning from 27 m, where the bioconcretion is moderate but the elevated layer is absent; to 40 m situations are found with scarce bioconcretion and elevated layer GS or with important bioconcretion and absent elevated layer; to 54 m the bioconcretion is always important and the elevated layer, very developed, always PC.

CONCLUSION

Different Geomorfotipes offer installation to different coralligeneous, independently from the depth (with the evident exception of the enclaves infralitoral). The differences concern both the bioconcretion, is the elevated layer: the two aspects don't absolutely result correlated, to the point that important bioconcretion can have absent elevated layer or incospicuous while "typical" populations coralligeneous, characterized by the exuberance of *Paramuricea clavata* and from the variety of the cortege of characteristic kind, they can develop in absence of bioconcretion. The aspect to great sponges, recurrent on low rocks little bioconcretion in proximity of the sedimentary substratum, is unfamiliar and necessitate more deeper studies.

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LES FORMATIONS DE TYPE « CORALLIGENE DE PLATEAU » DANS LES EAUX AGATHOISES (HERAULT, FRANCE). SITE NATURA 2000 FR 910 1414 « POSIDONIES DU CAP D'AGDE ». DONNEES PRELIMINAIRES

RESUME
Le classement en site Natura 2000 « Posidonies du Cap d'Agde » de la zone marine agathoise a pu être réalisé du fait de la présence d'herbiers de posidonies dans ce secteur du littoral héraultais, Habitat Prioritaire de la Directive européenne Habitats.
De plus, la présence de bioconstructions au large du Cap d'Agde, connues par les plongeurs et les pêcheurs locaux a conduit l'ADENA à pousser plus loin les investigations sur cette biocénose afin de mieux la caractériser. Ainsi, des inventaires faunistiques et floristiques systématiques, une étude sur les poissons, une étude sur les pêches professionnelles et de loisir, ainsi qu'une cartographie bathymétrique du site ont été réalisés pour mieux connaître l'état des lieux de ces formations bioconcrétionnées, s'apparentant visiblement à du coralligène. Une expertise menée en 2005 en collaboration avec l'Université de Nice a permis de préciser qu'il s'agissait bien de bioconcrétionnements de type coralligène de plateau, ayant ces caractéristiques propres.

MOTS-CLÉS : Coralligène de plateau, Natura 2000, effort de pêche, biomasse ichtyofaune, cartographie, gestion

INTRODUCTION

En raison des conditions de forte turbidité et à l'instar de la région de Banyuls (Pyrénées-Orientales) ou du golfe de Fos (Bouches du Rhône), un bioconcrétionnement de type « coralligène de plateau » tel que décrit par Laborel (1960, 1961), Peres et Picard (1961) et Sara (1968, 1971) se développe dans la zone marine du Cap d'Agde (Hérault). Ce type de coralligène particulier apparaît localement dès 18 m de profondeur, à une distance de la côte d'environ 2 milles marins. Il se développe principalement sur le Roc de Brescou (Fig. 1) sous l'apparence de récifs patatoïdes et de petites murettes (Blouet *et al*, 2008, Foulquie *et al*, 2008). Le coralligène de plateau agathois ne semble pas, a priori, être producteur de corail rouge, l'espèce n'ayant encore jamais été observée sur les sites connus et fréquentés de la zone. Il est néanmoins peuplé des espèces caractéristiques de cette biocénose (Francour, 2005).

ETAT DES CONNAISSANCES ET ELEMENTS SUR L'ETAT DE CONSERVATION

La confirmation récente de la présence de ces formations coralligènes au large du Cap d'Agde ne permet pas l'établissement d'un diagnostic précis quant à l'état de santé de cet habitat. Néanmoins, l'étude préliminaire commandée par l'ADENA en juillet 2005 et les différentes plongées effectuées depuis, montrent une biocénose riche d'une cinquantaine d'espèces avec notamment la présence de l'espèce protégée *Lithophaga lithophaga* ou d'autres espèces à haute valeur patrimoniale comme la langouste ou le homard. Le point le plus préoccupant reste le taux d'envasement de certains sites qui s'avère parfois relativement important.

Les sites les plus connus (Muraillette, Casier, Vivier) sont assez fréquentés par les clubs de plongée du Cap d'Agde mais les dégâts occasionnés par les ancres et les plongeurs eux- mêmes semblent assez limités.

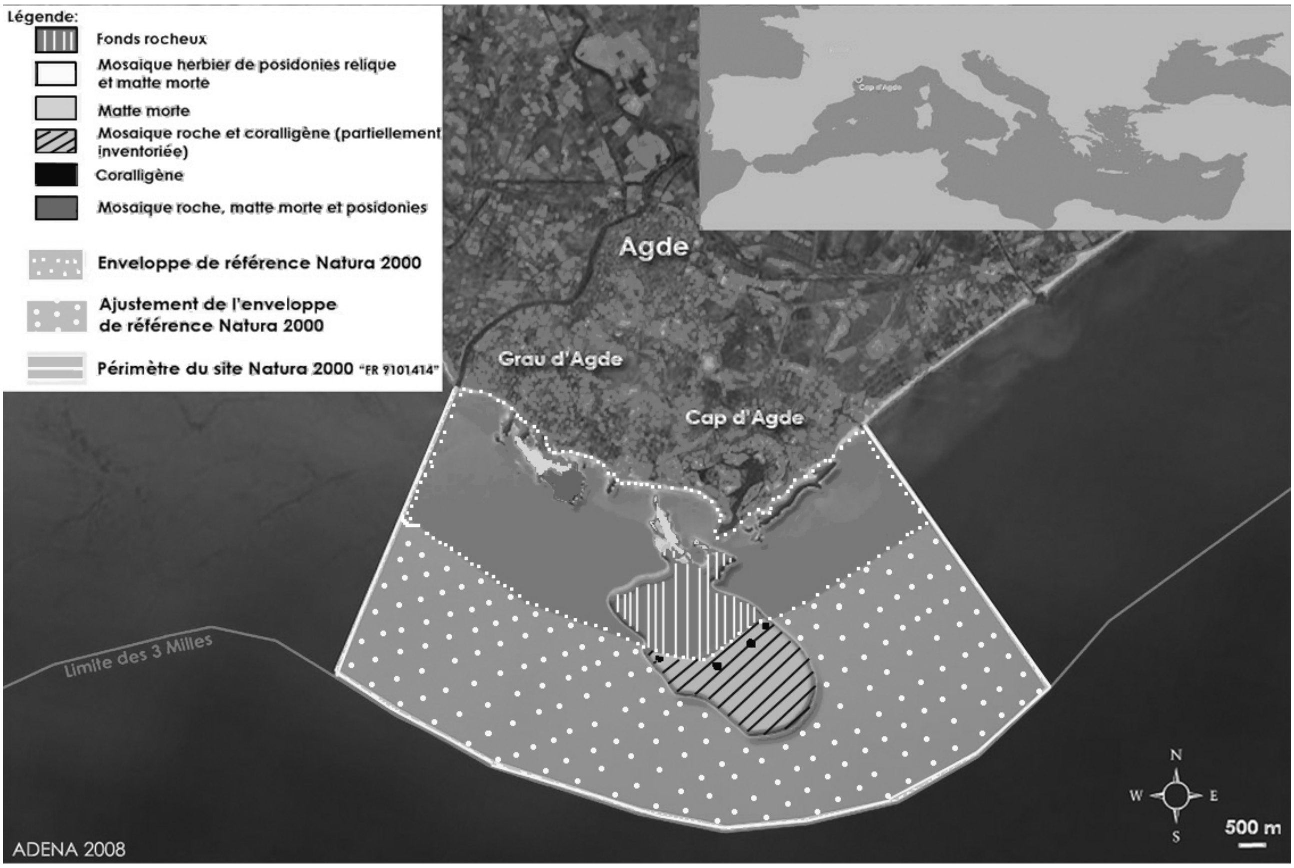

Fig. 1 : Localisation des habitats naturels dans le site Natura 2000 « Posidonies du Cap d'Agde »

Les pêcheurs professionnels « petits métiers » fréquentent également ces sites. La présence d'espèces cibles comme le sar, la mostelle, le chapon ou encore le homard et la langouste offre des possibilités de captures intéressantes et économiquement viables.

La densité de filets sur les secteurs montre l'intérêt de la pêche sur ce type d'habitat (Fig. 2) (Dupont *et al.*, 2006). La présence d'une grande diversité biologique notamment au niveau de la faune est confirmée par une Diversité Par Unité d'Effort élevée. (DPUE) (Fig. 3).

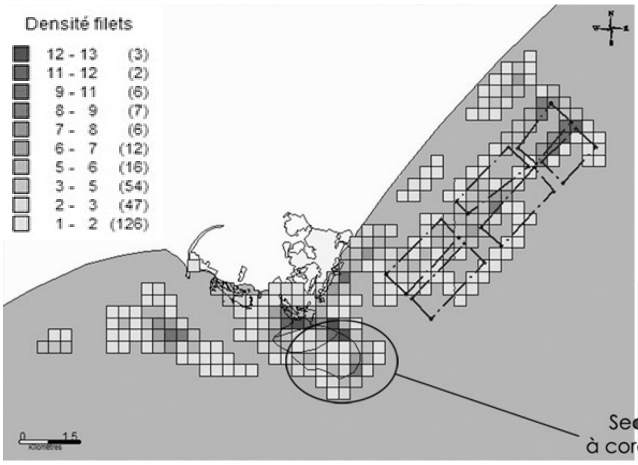

Fig. 2 : Répartition spatiale des densités de filets

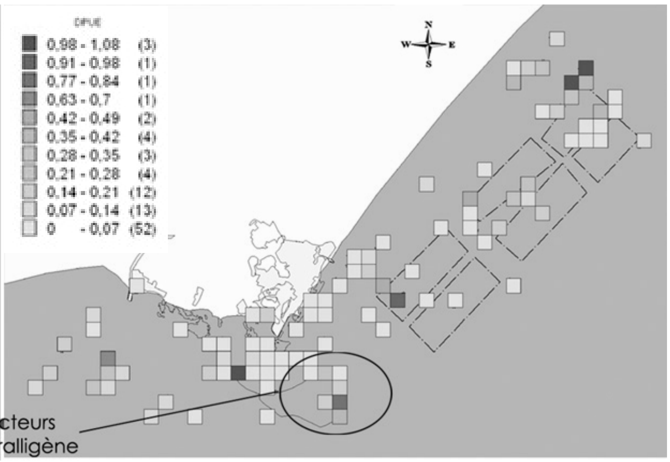

Fig. 3: Répartition spatiale de la DPUE

Néanmoins, l’utilisation des filets maillants est à l’origine de dégradations avec notamment l’arrachage d’espèces dressées comme les gorgonaires ou certaines éponges arborescentes.

Outre les espèces patrimoniales et cibles, cet habitat abrite la plus importante biomasse ichtyologique de la zone sur deux saisons : été et printemps.

La biomasse relative en été a été estimée à près de 900 g/are et à 370 g/are au printemps. On y observe principalement des espèces permanentes au regard des autres habitats. Si les herbiers de posidonies peuvent être considérés comme une zone de recrutement des juvéniles en saison chaude, le coralligène peut se définir comme secteur pivot pour le maintien de certains individus adultes.

PERPECTIVES ET ELEMENTS DE GESTION

Dans le cadre des mesures de gestion du Site Natura 2000 validées en 2008 plusieurs actions sont prévues à court terme sur cet habitat :

- un traitement des données de la campagne au sonar latéral multifaisceaux est en cours et permettra de cartographier l’ensemble des formations coralligènes présentes sur le Roc de Brescou et ainsi de connaître un peu mieux leur répartition.
- la gestion des mouillages des bateaux de plongée est envisagée en partenariat avec les structures de plongée.
- une étude concernant l'impact de l’activité de pêche plaisancière sera lancée (évaluation de l’effort de pêche).
- des méthodes de pêche professionnelle mieux adaptées aux sites à coralligène seront expérimentées avec des pêcheurs partenaires.

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MEADOWS OF *ANTIPATHELLA SUBPINNATA* (ANTIPATHARIA, MYRIOPATHIDAE) IN THE CALABRIAN CORALLIGENOUS (SOUTHERN ITALY, TYRRHENIAN SEA)

ABSTRACT

The lower portion of the Mediterranean coralligenous assemblage (twilight zone) commonly hosts the white colonies of the black coral Antipathella subpinnata*. The colonies of this species are generally single or grouped in small patches. Here we describe one of the rare wide populations of this species found in the Mediterranean Sea, forming meadows of thousands of colonies in the waters off Favazzina in the northern border of the Messina Strait (Tyrrhenian Sea). The specimens have been photographed and filmed with the aid of a ROV, while detailed georeferenced bottom profile 3D maps were obtained by means of multibeam data. Up to 50% of the Antipathella colonies are covered by masses of epibionts due in part to the damages produced on the branches by lost long-lines moved by the strong currents of the area.*

KEY-WORDS: Black corals, Antipathella, Endangered species, Twilight zone, Mediterranean Sea.

INTRODUCTION

In the Mediterranean Sea research on deep coral assemblages was until now limited to the white coral banks mainly composed of madrepores of the genus Lophelia and Madrepora (Tursi *et al.*, 2003), while the populations of flexible deep corals (black corals, gorgonians) are almost unknown. Among the five species of black corals known in the Mediterranean Sea, *Antipathella subpinnata* is probably the most widespread species and a common component of the lower fringe of the circalittoral twilight environment, where hard substrata are available. In its habitat, Antipathella is generally present with sparse specimens although some large group of colonies were recorded (Bo *et al.*, 2008). Here we describe one of the widest populations of this species ever recorded in the Mediterranean Sea, forming a meadow of thousands of colonies in the waters off Favazzina in the northern border of the Messina Strait (Tyrrhenian Sea).

MATERIALS AND METHODS

Three ROV surveys of the middle Tyrrhenian Calabrian coast area were carried out during September 2007, June and July 2008 and both video transects and photographic sampling were made on 2 shoals in front of Favazzina in the northern border of the Messina Strait (Tyrrhenian Sea) at depths range between 55 and 100 m. ROV was equipped with an underwater acoustic tracking position system; a digital camera (Nikon D80, 10 megapixel); an underwater strobe (Nikon SB 400); a high definition video camera (Sony HDR-HC7) and 3 jaw grabber to take samples. Calibrated distance between lasers was used in photos to measure the sampling areas on the substratum and to determine the parameters describing colony morphology (mean height and width). From both films and photographs density of colonies, composition of the coral community and presence of epibionts was estimated for each of the 5 depth ranges investigated.

RESULTS

The Antipathella meadows are situated on the western side of the explored shoals between 55 and 100 meters depth, with higher densities on the most inclined substrata. In the upper part of the slope, until 65 meter depth *A. subpinnata* lives in a mixed assemblage together with the gorgonian *P. clavata*. Around 70-80 m depth the seascape is completely dominated by the white, arborescent colonies of the black coral (densities up to 5 colonies/m^2). The population is made of both adult colonies of big dimensions (more than 1 m high) and small juveniles (around 20-30 cm high). Pink coloured patches of fertile polyps are randomly distributed on the branches of mature colonies. Sizes and density of specimens decrease with depth, and around 100 m only small, sparse colonies have been reported, together with the gorgonian *E. cavolinii*.

Up to 50% of the larger colonies hosts a large amount of epibionts as serpulids, massive bryozoans, sponges and ascidians (Fig. 1 C-F).

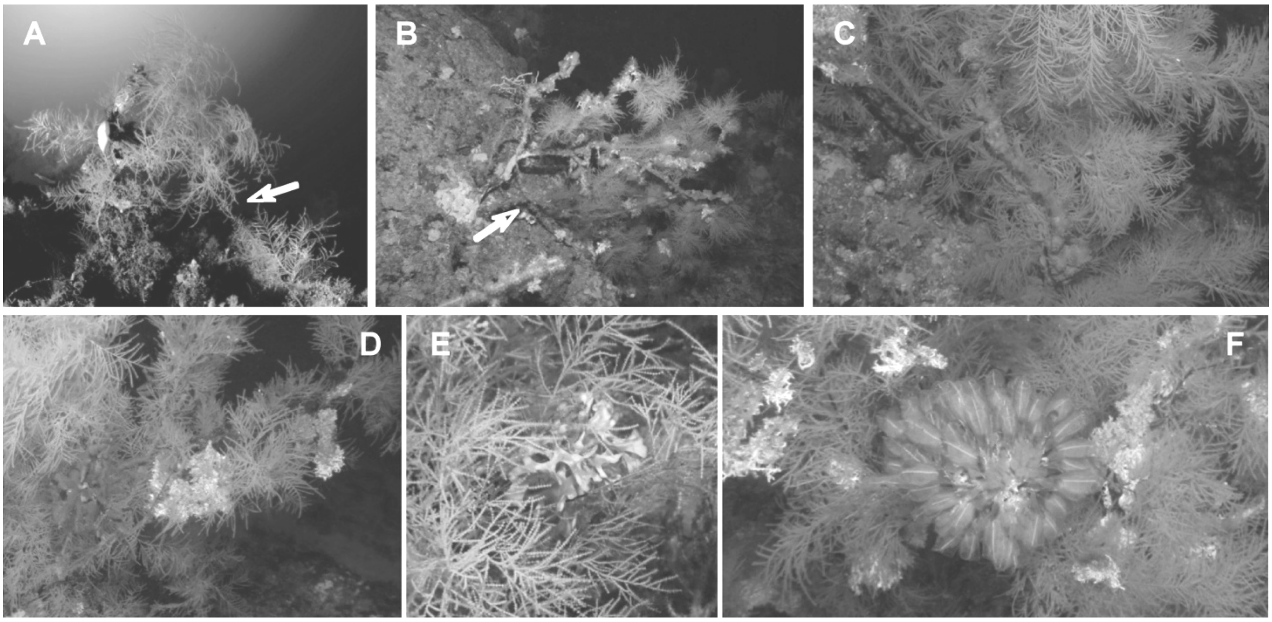

Fig. 1: Underwater photographs of *A. subpinnata* and its epibionts. A-B, damaged colonies twisted together with lost fishing lines (arrows); C, an encrusting sponge on the axis of a colony; D-E, the serpulid *Filograna sp*., the massive bryozoans *Schizoporella sanguinea* and *Pentapora fascialis* and the tunicate *Clavelina sp.* on Antipathella branches.

CONCLUSIONS

Although it was recently shown that *Antipathella subpinnata* is a common element of the lower fringe of circalittoral habitats the species was generally recorded as sparse large colonies or group of them (Bo *et al.*, 2008). On the Favazzina shoals, on the contrary, Antipathella is the main element of the biocoenosis constituting one of the rarest large antipatharian assemblages ever recorded in the Mediterranean Sea.

Several Mediterranean deep coral assemblages are endangered by trawling activity and the situation is particularly problematic in some areas where the coral assemblages host populations of important target species for commercial fisheries. The antipatharian assemblage of Favazzina develops on hard substrata therefore avoiding the direct damage acted by trawling. Nevertheless we have observed numerous lost lines twisted together with the colonies branches (Fig. 1A-B). Bavestrello *et al.* (1997) have demonstrated that the populations of flexible corals are deeply damaged by lost long-lines that, under the action of strong currents, scrape the living tissue of cnidarians branches. The scraped portions become suitable for the settling of epibiontic organisms. In the Favazzina population we have recorded up to 50% of colonies with portions interested by a strong epibiosis, mainly serpulids, bryozoans and sponges. The epibiosis increases the friction of the water on the colonies thus resulting in the breakage of the branches. This datum indicates that also fishing methods generally considered very selective can be highly destructive on communities of branched corals. For these reasons we strongly recommend the institution of a Marine Protected Area including the Antipathella community.

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CHARACTERISATION OF CORALLIGENOUS CONCRETIONS WITH X-RAY MICRO-TOMOGRAPHY

ABSTRACT

Red coralline algae have an essential role in the composition and the cohesion of the coralligenous buildups, where this algae function as a sort of binding. The growth and succession of different thalli are still not properly known. Commonly used techniques for ultrastructural studies of Corallinales require lengthy and destructive procedures. We developed a protocol for a not destructive method of studies regarding morphology, structure, ultrastructure and bio-construction process of Corallinales, based on X-ray computed micro-tomography (micro-CT). In our approach, micro-CT is used as a primary investigation tool to locate interesting sites in the specimen where to carry out a deeper analysis by means of one of the above-cited high resolution techniques. Experiments have been carried out at the Elettra synchrotron light source, where two facilities for micro-CT with complementary uses are available: the SYRMEP beamline and TOMOLAB, a new μ-CT laboratory based on a micro-focus source.

KEY-WORDS: Corallinales, bio-builders, structural analysis, X-Ray microtomography, Synchrotron radiation

INTRODUCTION

Coralline algae (Corallinales) have an important role in the ecology of Coralligenous as main bio-builders (Laborel, 1961; Laubier, 1966; Sartoretto, 1996; Ballesteros, 2006), where they provide calcareous material for the structure of the assemblage. These algae also represent an important source of primary production and food for grazers, and take part in the carbon bio-geochemical cycle. Conventional methods utilised for studies of the structure and morphology of these algae are based on destructive microscopy techniques such as SEM and TEM.

Micro-CT is a non-destructive imaging technique that produces a three dimensional digital map of an object. The distribution of regions with different density and/or chemical composition inside the specimen can be visualized by means of virtual slicing or using 3D volume rendering. The development, in the last years, of high resolution digital detectors, based on CCD technology, as well as of micro-focus X-ray generators, makes it possible to realize tomographic systems able to solve details of the order of a few micrometers inside a specimen.

MATERIAL AND METHODS

The specimens were collected by scuba divers, air dried and transferred to Elettra, where two facilities for X-ray micro-tomography (micro-CT) are available.

A micro-CT system has been operational at the SYRMEP beamline since several years (Fig. 1a). This set-up greatly benefits from the high spatial coherence of the X-ray beam, the monochromaticity and the energy tunability typical of a third generation synchrotron radiation source like Elettra.

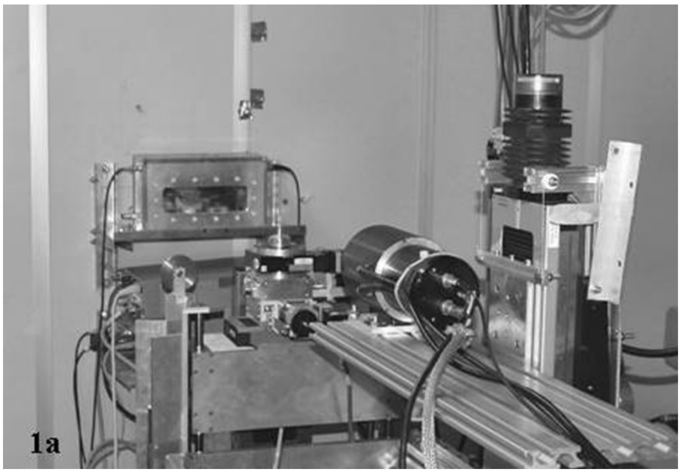

Fig. 1a: Micro-CT set-up at the SYRMEP beamline of Elettra.

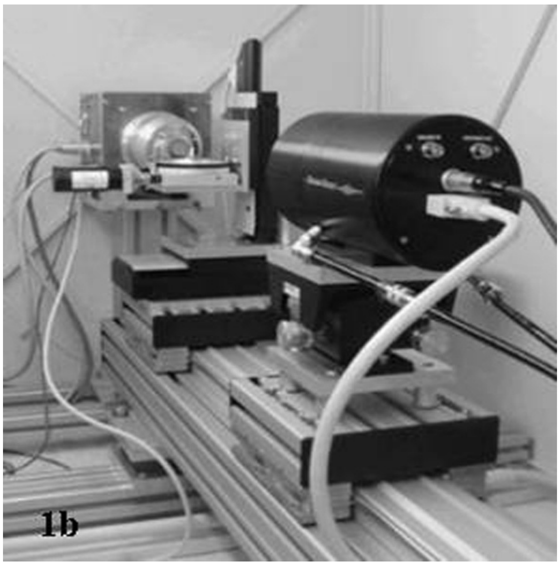

Fig. 1b: Micro-CT set-up of the TOMOLAB facility.

The specimen, mounted on a rotation stage, was illuminated by monochromatic and parallel X–ray beam ranged from 25 to 32 keV. The distance between the specimen and the detector was 40 cm. For each tomographic scan, 1440 projections of the specimen were acquired for equally spaced rotation angles over a total rotation of 180 degrees.

The detector used was a cooled charge-coupled device (CCD) camera coupled to a Gadolinium Oxysulphide scintillator placed on a straight fiber optic coupler. High dynamic range and low noise is achieved through 16-bit digitization and deep cooling, whereas the 4008 × 2672 pixels CCD is characterized by a pixel size of 9 μm.

Some others micro-CT scans were performed by using the TOMOLAB station. TOMOLAB is a micro-CT laboratory device equipped with micro-focus X-ray tube which operates at high energy range (40 ÷ 130 kVp), complementary to the one of the beamline, with a minimum focal spot size of 5 µm. The experimental set-up composed by the source, the motorized specimen stage and the detector is located in a shielded cabinet (Fig. 1b). The detector is a 12/16 bit CCD camera which provides a good combination between a large field of view (50.1 mm × 33.4 mm) and a small optical pixel size (12.5 x 12.5 µm^2). The cone-beam geometry allows studying centimeter-sized specimens and the maximum spatial resolution achievable is determined by the focal spot size.

A user-friendly software package written in the Interactive Data Language (IDL) has been developed to reconstruct the tomographic slices from the projection images acquired at SYRMEP and applying the filtered backprojection algorithm (Kak & Slaney, 1988).

The images obtained by the TOMOLAB were reconstructed by using COBRA_Exxim, a commercial cone beam reconstruction software package based on Feldkamp's algorithm.

The reconstructed slices can be visualized as stacks of 2D images, or 3D views of the specimen can be obtained by volume rendering procedures. Rendering process was performed using the ImageJ software (Natl. Inst. of Health, Bethseda, Md., U.S.A. ImageJ software is in the public domain and is available from: http://rsb.info.nih.gov/ij or ftp://rsbweb.nih.gov/pub/imagej) and Volume Graphics VGStudio 1.2.1 (commercial software).

The SYRMEP beamline, is suited to study calcareous algae with a maximum thickness of about 1.5cm. TOMOLAB source, can examine the whole specimen, with a dimension up to 3-4cm, in a single CT scan. Our approach was, first to investigate the specimens at TOMOLAB and to examine a subset of ones, with a lower thickness, containing some relevant features, at the SYRMEP beamline.

RESULTS

Three-dimensional reconstruction of a thallus of *Mesophyllum alternans* (Foslie) Cabioch & Mendoza is shown in fig. 2a. The reconstruction reveals both prominent active reproductive structure and hidden multipore conceptacles, were pores can be easily recognized. The pore dimensions were measured by using SEM and μ-CT images and the average diameter results to be around 9µm. In the reconstruction it is also possible to observe two different thalli: *M. alternans*, with larger conceptacles, epiphyte on *Lithothamnion minervae* Basso, with smaller conceptacles. The SEM analysis confirmed the observations made thanks to 3D rendering.

Furthermore, micro-CT studies can be useful for detecting both lager organisms included in the thalli, like anthozoa, and also small bioeroders (Fig. 2b).

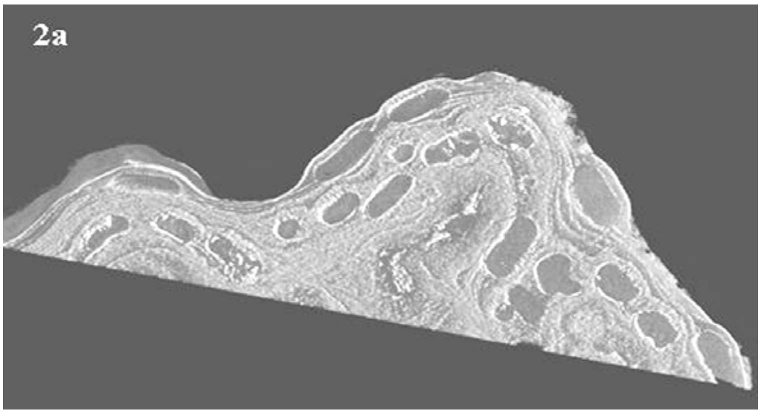

Fig. 2a: 3D rendering of *M. alternans* epiphyte on *L. minervae*, where multipore conceptacles are easily detected (1158x900x350; voxel 9x9x9 microns).

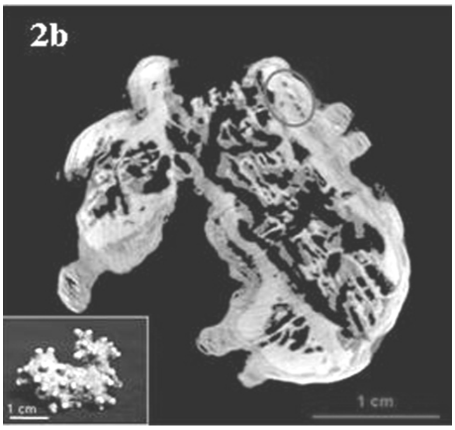

Fig. 2b: A slice obtained at TOMOLAB reveals the presence of an anthozoan coated by *L. minervae,* and a small bioeroder in the thallus (circled).

CONCLUSIONS

The application of μ-CT analysis to structural studies of small specimens of Coralligenous buildups, where coralline algae play a major role, is an innovative approach.

This method allows to recognize the internal structure of the micro-assemblages and of its component species: both biobuilders, like anthozoa and coralline algae (epiphyte and epibiont), and bioeroders (Bressan *et al.*, 2007).

Furthermore, it can be useful for a better interpretation of the ecology, the space - time successions, and the species - specificity in the epibiosis phenomena.

The two facilities available at ELETTRA result to be really complementary, TOMOLAB thanks to the large filed of view and the higher energy can be use for explore the entire specimen and with SYRMEP the attention can be focalized on some details.

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OBSERVATION OF FISH ASSEMBLAGES IN CORALLIGENOUS HABITATS ALONG THE CALABRIAN COAST BY MEANS OF A REMOTELY OPERATED VEHICLE

ABSTRACT

In 2005 we started a project aiming at monitoring marine biodiversity in the deep waters off the Calabrian coast. A Remotely Operated Vehicle (ROV), equipped with a high definition digital camera (Nikon D80 – 10 megapixels) with underwater strobe (Nikon SB 400), was used to investigate the coralligenous habitats from 30 to 150 meters depth. These habitats are until now poorly studied and little information is available concerning fish species' presence and distribution. During the research 52 sites were investigated for a total of about 75 hours of observations.

Fish were identified to the lowest possible taxon through the analysis of the video footage and the high definition pictures. Here we present the results concerning the species richness and the bathymetric distribution for each species.

A total of 34 species of fish species were recorded. Among these, Gobius kolombatovici was observed for the first time in Italian waters. The most common species observed were Anthias anthias, Serranus cabrilla, Callanthias ruber and Lappanella fasciata.

The ROV has great potential as a tool for studying fish populations that live at depths greater than 40 meters, depths out of the range of SCUBA divers.

KEY-WORDS: coralligenous, ROV, fish distribution

INTRODUCTION

This study is part of a project, started in 2005 and still in progress, aiming at monitoring marine biodiversity in the waters off the coast of Calabria (Southern Tyrrenian Sea and Jonian Sea). One of the objectives of the study is to gain further knowledge concerning coralligenous habitats at depths between 30 m and 150 m. Here we present the results concerning fish species richness and their bathymetric distribution.

MATERIAL AND METHODS

The study area includes the coastal waters of both the Tyrrenian and the Jonian coasts of Calabria. A total of 52 sites in 12 areas have been investigated (Fig. 1) since the beginning of this research, and a total of 75 hours of observations have been recorded.

Data presented here were collected using a Remotely Operated Vehicle (ROV) equipped with a high resolution digital camera (Nikon D80 – 10 megapixels) and underwater strobe (Nikon SB 400) (Fig. 2). Besides the digital camera, the ROV was occasionally equipped with a Sony HD camcorder.
Fish species where identified to the lowest possible taxonomical level.

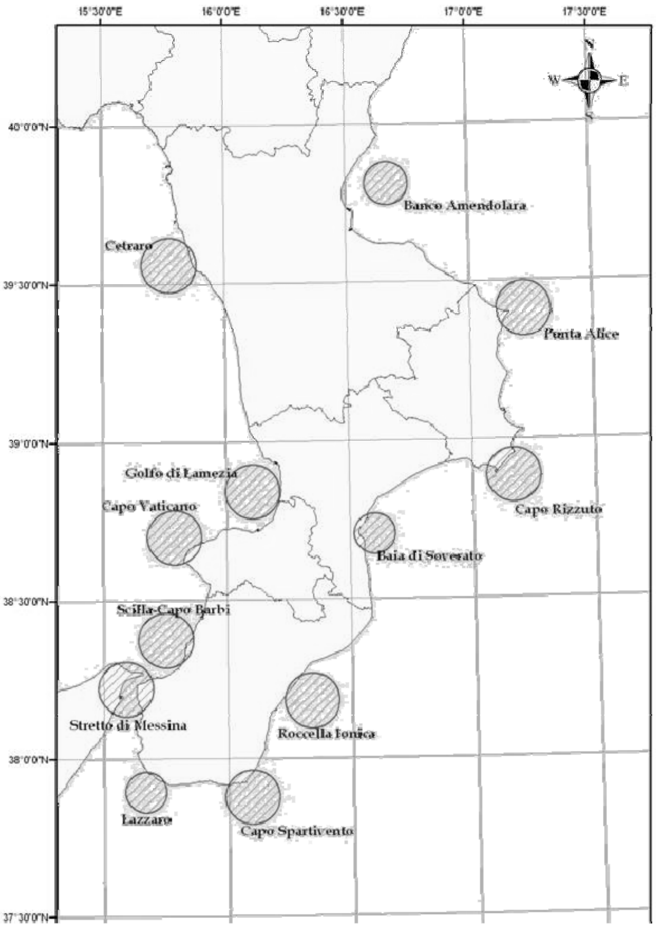

Fig. 1: Map of the 12 areas investigated

RESULTS

The identification of the fish species was accomplished by analyzing the video footage and the photographs collected by the ROV. A total of 34 fish species have been identified.

Table 1 lists the identified species and summarizes the depth range of each species.

The species encountered most often are *Anthias anthias*, *Serranus cabrilla*, *Callanthias ruber* and *Lappanella fasciata* (Fig. 2). Among the species we observed, we recorded the presence of *Gobius kolombatovici* (Fig. 3) for the first time in Italian waters.

Tab. 1: Depth range of the fish species encountered

Species	Depth range	Species	Depth range
Acantholabrus palloni	140-141	*Lepidorhombus sp.*	99-100
Aulopus filamentosus	150	*Lesuerigobius sp.*	128-130
Anthias anthias	30-140	*Muraena helena*	41-76
Apogon imberbis	35	*Oblada melanura*	40-42
Aspitrigla cuculus	129-130	*Phycis phycis*	126-127
Callanthias ruber	84-130	*Scorpaena scrofa*	84-84
Cepola macrophthalma	87-108	*Scorpena sp.*	69-123
Chromis chromis	30-77	Serranidae	68-106
Coris julis	38-98	*Serranus cabrilla*	27-144
Dentex dentex	32-42	*Serranus hepatus*	86-150
Diplodus puntazzo	49-50	*Serranus scriba*	105-108
Diplodus sp.	49-51	*Epiniphelus costae*	45
Diplodus vulgaris	50-93	*Sphyrena sp.*	38-43
Epiniphelus costae	45	*Spicara maena*	71-112
Gobidae	102-129	*Thorogobius ephippianus*	121-136
Gobius niger	80-120	*Thorogobius macrolepis*	120-137
Gobius geniporus	80-120	Triglidae	68-129
Gobius kolombatovici	50-70	*Zeus faber*	106-124
Lappanella fasciata	122-126		

Fig. 2: from left to right – *Anthias anthias, Callanthias rubber, Lappanella fasciata, Serranus cabrilla*

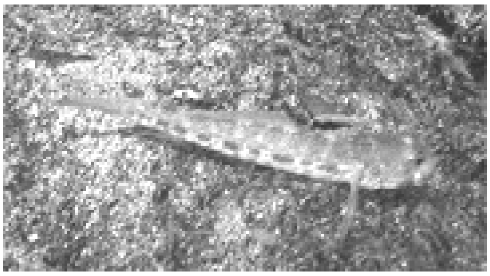

Fig. 3: *Gobius kolombatovici*

CONCLUSIONS

The fish assemblages in deep coralligenous habitat are composed mainly by the Serranidae *Anthias anthias*, present along the whole bathymetric range.

The presence of species belonging to the family Gobidae is underestimated due to the difficulty of identifying them form photographs and videos.

The ROV has revealed its great potential as tool for studying fish assemblages and behavior at depths out of the range of SCUBA divers (> 40 m). As a matter of fact we have been able to see in their natural environment several species never observed before.

It also has the advantage of making it possible to equip it with high-resolution digital cameras and camcorders to record data and navigation equipment to localize the exact position of data that are being recorded.

ACKNOWLEDGMENTS

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THE NORTHEN ADRIATIC SEA CORALLIGENOUS: HABITAT IN PELICULAR ENVIRONMENTAL CONDITIONS?

ABSTRACT

The Gulf of Venice is scattered with several hundreds of rocky outcrops, locally named in different manner, formed by a base rock (local sediments cemented by seeping methane) hosting the growth of stunning coralligenous and other calcareous bio-concretions, where filter feeders and calcareous algae represent most of the epibiota . They represented for a long time naturally protected areas in a sea over-exploited by fishery, sometimes using illegal methods and techniques. Up to a few years ago the northern Adriatic coralligenous was able to withstand much different and harder environmental conditions (highest water movement, or occasional environmental "disasters" as the oxygen crisis in 1977 and several "mucilaginous"), than the other coralligenous found in the Mediterranean. Now the vitality and the abundance of benthic assemblages seem to have decreased in the last few years along the Adriatic coasts – from Trieste to Chioggia – possibly due to the scarce plankton local availability At the same time even the primary production decreased together with the "blue fish" availability. In the last few years only, the beauties of the tegnùe have been discovered by the media, but luckily at least two areas (off Caorle and Chioggia) were declared "marine protected zones". Today underwater tourism is strongly fostered in the Chioggia area; but rumours among divers start to indicate the beginning of an overall environmental possible crisis, more evident in the epibiota

***KEY-WORDS*:** Northern Adriatic Sea; oceanographic character; coralligenous habitat; benthic biocenosis, synergic effects.

INTRODUCTION

The Northern Adriatic calcareous bioconcretions– locally named "tegnùe, presùre or grèbeni"–are growing and living in conditions somewhat different from other Mediterranean coralligenous (Casellato *et al.*, 2007; Casellato & Stefanon, 2008). They existence was known among fishermen since eighteen century, but were documented by underwater explorations only 40 years ago. These "patch reefs" (Newton & Stefanon 19752) are still not sufficiently studied and did not receive any consideration in Ballesteros's review (Ballesteros, 2006), possibly due to the lower visibility of papers published in local journals only. Their "base rocks", lying at depths between about 2 and 40 metres, located at different distances from the coast, are strongly related to the sediments permeability, and the gas related cementation follows its structural distribution. They are found in the form of slabs or layers up to a couple of decimetres thick and several square metres wide where the gas is expanding horizontally under a less permeable cover, or in form of column blocks up to a few metres high corresponding to vertical chimneys or cracks. Shapes and heights are variable from very small to about 6 metres high. Origin and age of the gas are still unknown, as well as the rocks age, because the C14 of the cementing methane can jeopardise the age determination (Stefanon & Zuppi, 2000).

RESULTS

Environmental parameters

The oceanographic conditions of the Gulf of Venice, where are the coralligenous bioconcretions, are rather peculiar and characterised by very strong energy (wind, waves, episodic surges and relevant, strong discharge currents) (Tab.1) (Zore-Armanda, 1968), and by high seasonal temperature variability, large fluviatile input from the Italian coast.

depth	cm / sec

M 12	38	50	63	75	88	125	160	**132**
m 14	33	45	56	67	78	111	143	**127**
m 16	30	39	49	59	69	99	125	**123**
m 18	26	35	43	52	61	87	112	**119**
m 20	23	30	38	45	53	76	98	**116**
m 22	20	26	33	40	46	66	87	**112**
m 24	17	23	29	34	40	57	74	**108**
m 26	15	20	25	30	35	50	60	**104**
m 28	13	18	21	26	30	43	55	**100**
m 30	11	16	18	22	27	37	48	**97**
times/year	**20**	**10**	**6**	**4**	**2**	**0.5**	**0.1**	**04/11/'66**

Tab.1: Values of horizontal velocities on the seabed versus water depth and time a year induced by significant waves in the Gulf of Venice

Furthermore the light availability is by far not constant as in most of the Mediterranean coralligenous environments, due to the limited water depth, combined with large but not constant planktonic blooms. Anyway, large food availability is provided for all the filter feeders (the Gulf of Venice and relevant lagoons host the largest Mediterranean shellfish farming and fishery) but the benthic biocenoses are strongly influenced by the chemical-physical parameters and behaviour of the waters, including some rare but terrible anoxia crises. The Coriolis effect associated to the current distributes only along shore the sedimentary budget discharged by the rivers of northern Italy (Po included), avoiding the siltation offshore and the suffocation of the coralligenous assemblages. The temperatures at the sea bed range between 5 and 22 C°; and salinities from 29 to 37 ppt (Soresi *et al.*,2004; Casellato *et al.*, 2005). At the same time even the primary production is decreasing, possibly induced by the decrease of the land discharged nutrients (Dr. Matassi, personal communication). This high variability of environmental parameters together with exceptional episodes as drastic oxygen crises (Stefanon & Boldrin, 1983) had sometime much more striking effects. The northern Adriatic coralligenous was able, anyway, for several thousand years to happily survive its difficult environment.

Anthropic pressure

At present the anthropic pressure, i.e. the strong increase of predatory, illegal fishery is badly damaging the most unprotected areas (Figs.1 and 2).

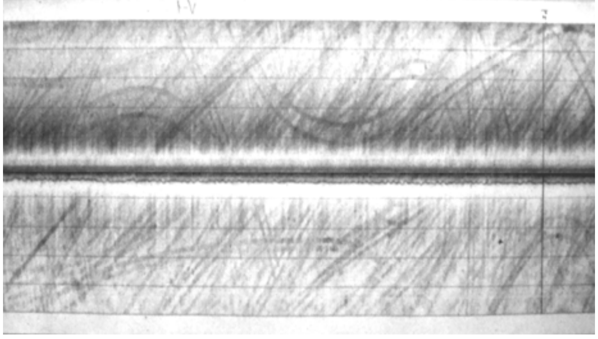

Fig. 1: Side Scan Sonar imagery of the sea bed 7 miles off Venice at 14 meters depth, evidencing the heavy impact of special towed gear used for fishing.

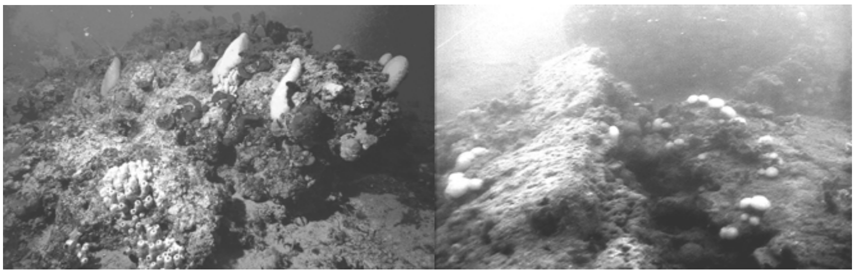

Fig.2: The epibiontal biocenoses of the Tegnùe are sometimes destroyed by “wiping gears” used by modern, illegal fishery practice. *Polyicitor adriaticus* (on the right), the most abundant ascidian completely displaced by the use of powerful fishing gears.

CONCLUSIONS

In the last few years only, the beauties of the tegnùe have been discovered by the media, but luckily at least two habitats (off Caorle & Chioggia) were declared “marine protected zones”. Today underwater tourism is strongly fostered in the Chioggia area; but rumours among divers start to indicate the beginning of an overall environmental possible crisis, more evident in the epibionta. We are now more and more convinced – as already suggested – that if the northern Adriatic coralligenous was able for several thousand years to happily survive its difficult environment, the present crisis maybe due to the increased anthropic pressure, i.e.the strong increase of predatory, illegal fishery and diving tourists.

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CORALLIGENOUS ASSEMBLAGES IN THE MARINE HABITATS ATLAS OF LIGURIA REGION (ITALY)

ABSTRACT

The importance of Coralligenous assemblages is widely recognized in the coastal environment. For this purpose Coralligenous is one of the habitats included in the Atlas of marine habitats of Liguria Region. Information on main Ligurian coastal habitats have been revised and an integration of bibliographical data with field investigation has enabled to produce a map, by means of GIS technology. The habitats were included in 24 different typologies and 83 colour maps in 1:10000 scale, were realised. Maps include also other information, as topography, water-waste pipelines, fish-farms, artificial reefs, marine protected areas. A synthetic description of the habitats, for each coastal segment, has also been provided in the text. In the last part information and considerations on management aspects of coastal marine habitats of Liguria have been given.

KEY-WORDS: Cartography, Coastal Management, Liguria, Coralligenous assemblages.

INTRODUCTION

The importance of circalittoral and infralittoral Coralligenous assemblages (Ballesteros, 2006; Giaccone, 2007) is widely recognized in the coastal environment. For this reason they must be known and protected by means of concrete actions, in the framework of an integrated management, to avoid their deterioration, due to the impact of human activities on the coast.

Mapping and description of Coralligenous assemblages was lacking for Liguria Region and Regional Administration needed recent and detailed data, to support coastal management actions. Therefore information on these communities and on other main Ligurian coastal habitats has been revised and an integration of bibliographical data with field investigation has enabled to produce a map, applying GIS technology.

MATERIALS AND METHODS

For the achievement of the atlas, an integration of different methods was carried out, according to recent methodology used during the last decades (Bianchi *et al.*, 2003). They are indicated in the following list. The asterisk shows methods used in particular to map Coralligenous assemblages:

- Bibliography analysis*;
- Standardisation of symbology*;
- Georeferencing of bibliographic data*;
- Selection, scanning and georeferencing of regional aerial photographies of Ligurian coast;
- Interpretation of aerial photographies and digital orthophoto;
- Field surveys by means of Side Scan Sonar, submersible videocamera and diving transects*;
- Integration of all data by means of GIS technology*;
- Elaboration of final maps*.
-

RESULTS

The integration of the different kinds of information enabled to realise the map of the Ligurian coastal bottoms included from surface to 50 m depth, for all the regional length (nearly 300 km). The habitats were coded in 24 different typologies (Diviacco & Coppo, 2006).

All the data were entered on specific regional GIS, enabling all the functions of analysis and implementation of the rich data-base associated. The Ligurian coast is represented in 83 colour maps in 1:10000 scale, that include also other information, as topography, water-waste pipelines, fish-farms, artificial reefs, marine protected areas.
A synthetic description of the habitats, for each coastal segment, was also provided.
In the last part of the atlas information and considerations on management aspects of coastal marine habitats of Liguria have been given.
As regards the hard bottom sciaphilic assemblages of the coastal zone, recorded in the depth range 0–50 m, they are distributed along the coast of the Region, but not in uniform way (Fig. 1). Savona Province presents lower values of area and coast length, while Genova Province has the most important values, thank, but not only, to the Portofino promontory. Moreover, between Genova town and Portofino promontory, within the *Posidonia oceanica* meadows, there are some sciaphilic hard bottom assemblages, not considered here.

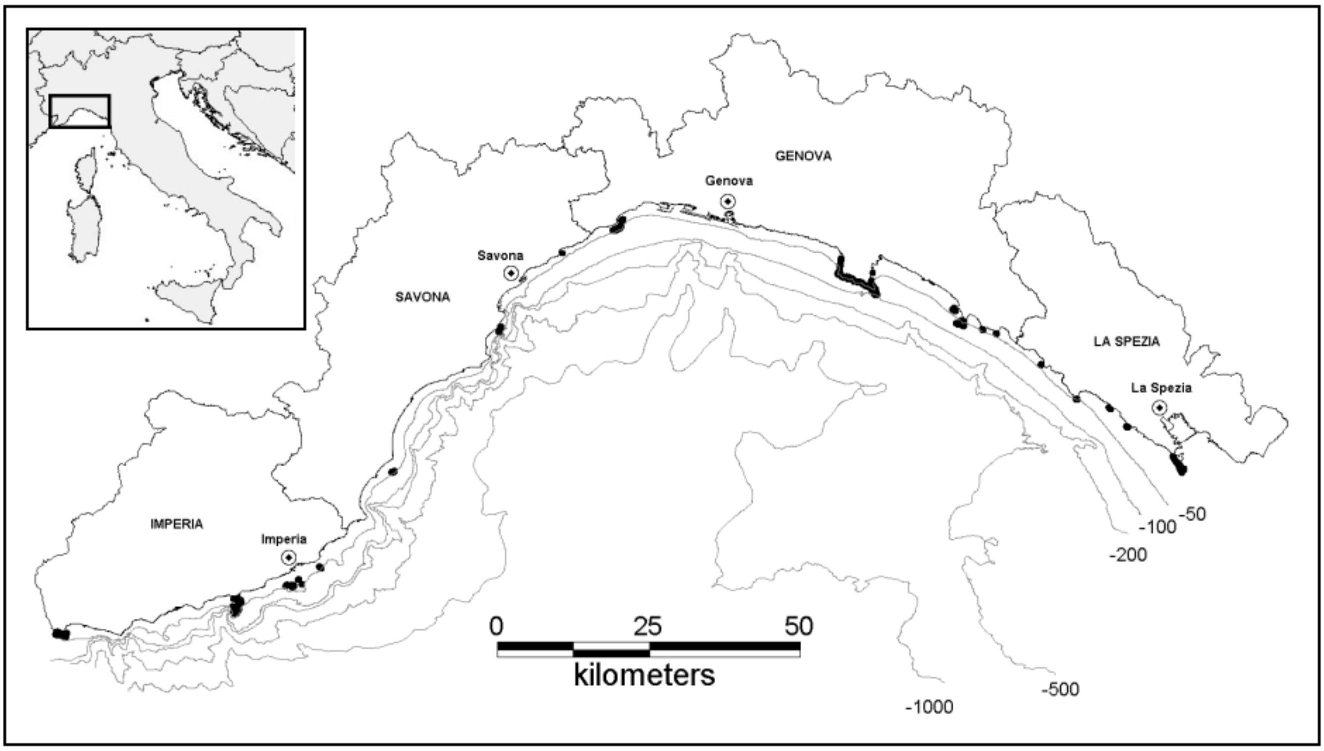

Fig. 1: Distribution of the main hard bottom sciaphilic assemblages (black areas) in the coastal benthos of Liguria.

The total area concerned is 188 ha wide (128 ha circalittoral and 60 ha infralittoral) and the coastline concerned is almost 20 km long, corresponding to 6.3% of the total regional coastline (Tab. 1). The situation in the four Provinces, in importance order, is so resumed. In Genova Province sciaphilic hard bottom assemblages are distributed in three main districts: Arenzano, Portofino Promontory and Sestri Levante - Punta Manara zone. In Imperia Province also three main areas can be recognized: Capo Mortola, Santo Stefano and Imperia. La Spezia Province has one important area round Tino and Tinetto Islands and some sites in corrispondance of promontories in Cinque Terre zone, mainly Punta Mesco. Savona Province, characterized by several beaches and predominance of sandy bottoms, presents areas of sciaphilic hard bottom assemblages mainly round two small islands of Gallinara and Bergeggi.

Tab. 1: Area and coastline length concerned to the presence of hard bottom sciaphilic assemblages in the coastal benthos of the four Liguria Provinces and of the whole Region (C=coralligenous; ASC=circalittoral sciaphilic algae; ASI=infralittoral sciaphilic algae).

	C-ASC area (ha)	C-ASC-ASI area (ha)	C-ASC coastline length (km)	C-ASC coastline length (%)	C-ASC-ASI coastline length (km)	C-ASC-ASI coastline length (%)
IMPERIA	54	70	3.0	5.00%	3.5	5.8
SAVONA	2	6	0.6	1.00%	1.6	2.1
GENOVA	56	84	8.3	8.00%	10.8	10.7
LA SPEZIA	16	28	2.2	3.00%	4.2	5.0
LIGURIA	128	188	14.1	4.00%	20.1	6.3

CONCLUSIONS

In Liguria Region there are many important sites with Coralligenous an other hard bottom sciaphilic assemblages. Some of them are protected by Marine Protected Areas (MPAs) and almost all are included in Sites of Community Importance (SCI) (Habitat Directive, 92/43/EEC). Conservation measures in sites included in MPAs are guaranteed by management plans, whereas they are not in force yet in SCI. Anyway Regional Administration of Liguria has passed technical rules within the Environmental Impact Assesment (EIA), for protection of marine habitats included in SCI.

Although in the last decades, and especially in the last years, many steps forward have been taken as regards knowledge of marine environment of Liguria, only a strategy of continual studies and monitoring is able to guarantee a correct management of marine resources. So it is really possible to control the disturbances listed by Ballesteros (2006) affecting coralligenous communities: large-scale events, degradation by waste water, degradation by fishing, degradation by the activity of divers and invasive species.

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LES GORGONACEA ET LES ALCYONANEA DES COTES DE L'EST ALGERRIEN : DIVERSITE ET ETAT D'EXPLOITATION DE *CORALLIUM RUBRUM*

RÉSUMÉ

*Sur les côtes de l'Est algérien, les Octocorallia sont représentés essentiellement par les Gorgonacea (*Eunicella singularis, E. cavolinii, Leptogorgia ceratophyta, Paramuricea clavata*) et les Alcyonacea (*Corallium rubrum*). Dans la tranche bathymétrique prospectée (0 - 50 m),* E. singularis *reste l'espèce la mieux représentée avec des densités moyennes de 1,33 ind./m^2 (Rocher Hauffmann) et de 2 ind./m^2 (Rocher la Kiane). La densité des autres Gorgonacea est toujours inférieure à 1,5 ind./m^2. Les Alcyonacea sont représentés par une seule espèce d'intérêt économique,* C. rubrum. *Sur les côtes algériennes, sa présence est signalée à Ténès, à Bejaïa, à Jijel, à Collo et dans les golfes de Skikda, d'Annaba et d'El-Kala. Ces deux dernières zones produisent annuellement environ 4 tonnes, soit 1/7 de la production méditerranéenne. Dans un souci de préservation, l'exploitation de* C. rubrum *dans les eaux sous juridiction nationale a été suspendue en 2001 dans l'attente des résultats de l'étude d'évaluation du stock corallien.*

MOTS CLÉS : Gorgonacea, Alcyonacea, *Corallium rubrum*, Algérie, Méditerranée.

INTRODUCTION

Sur les côtes de l'Est algérien, les fonds à coralligène sont très peu connus (Vaissière et Fredj, 1963 ; Derbal & Kara, 2005) comparés à d'autres régions de Méditerranée (Laubier, 1966 ; Gili & Ballesteros, 1991 ; Bitar & Kouli-Bitar, 1997 ; Ounais-Thevenin *et al.,* 1998). Nous présentons ici un inventaire préliminaire des Gorgonacea et des Alcyonacea avec un intérêt majeur pour le corail rouge *Corallium rubrum* en raison de son importance économique et patrimoniale en Méditerranée. Ce travail concerne, d'une part, une revue de l'exploitation de *C. rubrum* au cours de la période 1974 et 2000, et d'autre part des résultats de terrain.

MATERIELS ET METHODES

La zone d'inventaire est située à l'ouest du golfe d'Annaba. Deux secteurs très fréquentés par les plongeurs sportifs ont été échantillonnés par relevés visuels en juillet 2002: le rocher "Hauffmann" et la "Kiane (Fig.1). L'inventaire a été réalisé sur un fond rocheux et mixte (rochers et herbiers) dans la tranche bathymétrique 0 - 50 m. La densité spécifique moyenne a été estimée, tous les 10 m de profondeur, à partir de 3 quadras de 1 m^2.

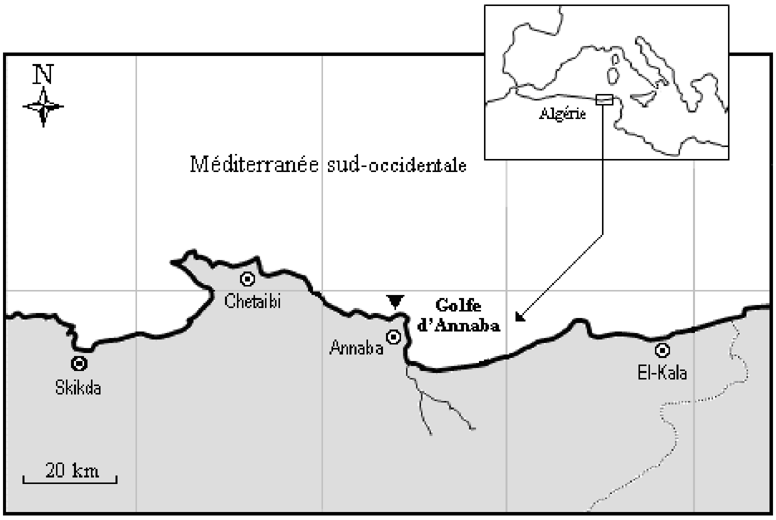

Fig.1: Zone d'inventaire (▼) des Gorgonacea et des Alcyonacea sur les côtes de l'Est algérien.

RESULTATS

Les Gorgonacea sont représentés par les espèces *Eunicella singularis*, *E. cavolinii*, *Lophogorgia ceratophyta* et *Paramuricea clavata.* Les Alcyonacea ne sont représentés que par le corail rouge *Corallium rubrum*. Les températures limites enregistrées au niveau de Hauffmann (H) et de la Kiane (K), sont comprises respectivement entre 16 et 23 °C (moy.: 19,1°C) et entre 17°C et 24°C (moy.: 19,6°C). Dans les deux zones, la population de gorgone la plus dense est celle représentée par *E. singularis* avec des densités moyennes respectives de 1,33 ind./m^2 (H) et de 2 ind./m^2 (K). La densité de *E. cavolinii* n'excède jamais 1 ind./m^2 dans les deux zones. Quant à la présence de *L. ceratophyta* et *P. clavata*, elle reste sporadique avec des densités moyennes inférieures à 0,2 ind./m^2 (Tab.1).

Tab. 1: Diversité et densités moyennes (ind./m^2) des Gorgonacea et des Alcyonacea en fonction de la profondeur dans les deux zones d'étude (H : rocher Hauffmann, K: rocher de la Kiane).

Espèces	Zone	Bathymétrie (m)						Densité moyenne (ind./m^2)
		0	10	20	30	40	50	
Eunicella singularis	H	**0**	1,33	2	1	1	1,33	**1,33**
	K	**0**	2,66	2,66	2	0,66	2	**2**
E. cavolinii	H	**0**	0,66	1,33	1	0,66	1,33	**1**
	K	**0**	1	0,33	0,66	0,33	1,33	**0,73**
Lophogorgia ceratophyta	H	**0**	0	0	0	0,33	0,33	**0,13**
	K	**0**	0	0	0	0	0,67	
Paramuricea clavata	H	**0**	0	0	0,33	0,66	0,33	**0,26**
	K	**0**	0	0	0	0	0,33	**0,06**
Corallium rubrum	H	**0**	0	0	0	0	0	**0**
	K	**0**	0	0	0	0,33	0,33	**0,13**
Température moyenne (°C)	H	**23**	**22**	**18**	**18**	**18**	**16**	**19,1 ± 2,7**
	K	**24**	**22**	**19**	**18**	**18**	**17**	**19,6 ± 2,7**

L'espèce *C. rubrum* n'apparaît qu'à partir de - 40 m avec une densité inférieure à 0,33 ind./m^2 au niveau de la Kiane. Aucun spécimen n'a été observé au niveau du rocher "Hauffmann". Sa présence est signalée à Ténès, à Bejaïa, à Jijel, à Collo, à Skikda, à Annaba et à El-Kala. Toutefois, les zones les plus productives restent situées entre Annaba et El-Kala où les quantités moyennes débarquées sont estimées respectivement à 4410,75 Kg (période:1992 - 2000) et à 3819,2 Kg (période: 1974 - 2000) (Fig. 2).

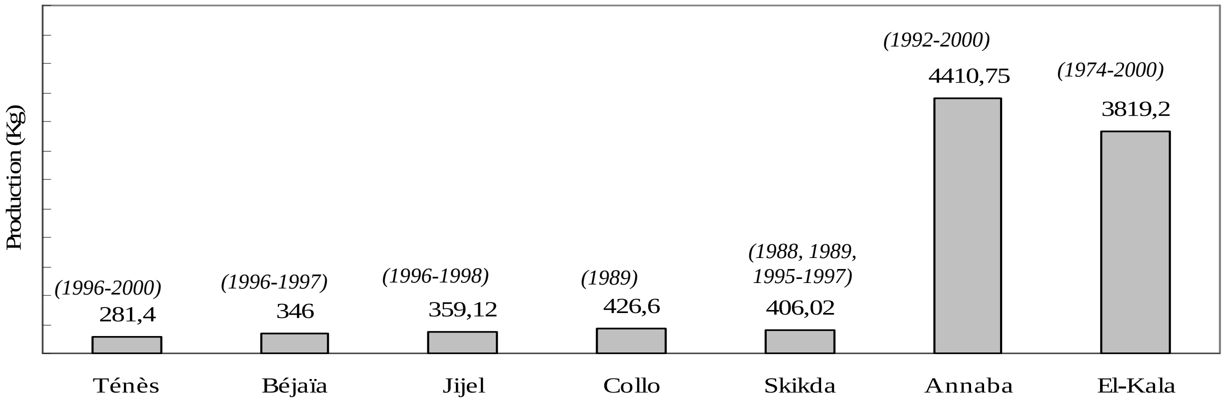

Fig.2: Quantités débarquées (en kg) de corail rouge *C. rubrum* le long des côtes algériennes entre 1974 et 2000. Les valeurs entre parenthèses représentent la période d'exploitation (source MPRH : Ministère de la Pêche et des Ressources Halieutiques).

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DESCRIPTION SUR LES COTES NORD DE LA TUNISIE, D'UN SITE COMPRENANT DES ENCORBELLEMENTS A *LITHOPHYLLUM LICHENOIDES* PHILIPPI AINSI QUE DES FORMATIONS A *LYTHOPHYLLUM DENTATUM* KÜTZING FOSLIE.

RÉSUMÉ

La littérature consacrée à la macroflore algale de Tunisie ne révèle, à l'heure actuelle, qu'un nombre restreint de travaux relatifs à l'observation, la description ou la localisation des bio-concrétionements. Dans ce contexte, nous reportons dans le présent travail la signalisation et la description d'un site présentant à la fois des encorbellements à Lithophyllum lichenoides *Philippi ainsi que des formations à* Lythophyllum dentatum *(Kützing) Foslie.*

INTRODUCTION

Les côtes tunisiennes, généralement sableuses et à l'abri des vents dominants, ne présentent pas les conditions favorables à l'installation et au développement de constructions à *Lithophyllum lichenoides* où à *Lythophyllum dentatum*. De ce fait, *L. lichenoides* n'est cité qu'entre Tabarka et Bizerte, sur le littoral nord (Ben Maiz, 1987) et *L. dentatum*, encore plus rare, ne figure, sur ces mêmes côtes, que dans un secteur encore plus restreint (Ben Maiz, 1987). L'observation d'un site comprenant des encorbellements bien développés à *L. lichenoides*, ainsi que des peuplements relativement étendus à *L. dentatum*, suscite de ce fait l'intérêt et mérite d'être signalée et décrite.

MATERIEL ET METHODES

La localisation des sites d'observation a été faite à partir d'images satellites relevées dans Google Earth. L'observation et la récolte des échantillons sur le terrain ainsi que les relevés *in situ* de tous les paramètres relatifs aux peuplements, ont été réalisés en apnée.

RESULTATS

Le site où ont été observés les peuplements à *L. dentatum* ainsi que les encorbellements à *L. lichenoides* se situe sur le littoral Nord, entre Bizerte et Tabarka, à proximité de la localité dite «Henchir l'Ahouichette » et située aux coordonnées de 37°17'22.35"N et 9°31'36.40"E. Sur l'ensemble de la région, la topographie est caractérisée par la présence de reliefs peu élevés, parallèles à la côte et parcourus de nombreux oueds. En conséquence le littoral, très découpé et exposé au Nord-Ouest, apparaît formé par une succession de caps et de promontoires rocheux entre lesquels s'individualisent des criques sableuses. Les fonds sont constitués par des tablettes rocheuses recouvertes partiellement de sable.

L'encorbellement à *Lithophyllum lichenoides* : Situé dans le fond d'une anse étroite et fortement battue par la houle, l'encorbellement (Fig. 1, A) se présente sous la forme d'une tablette d'environ 3m de longueur, pour une largeur de 80 cm et une hauteur de 25 cm à la base. Au contact de la façade rocheuse, l'encorbellement émet vers le haut et sur une vingtaine (20) de centimètres un épais bourrelet. A ce niveau, *L. Lichenoides* se développe normalement et semble vivant et en bonne santé. Par contre, au niveau de l'encorbellement, il est recouvert par une végétation dense à *Corralina elongata* et *Jania longifurca* (Fig. 1, B). Cette dernière observation fait état de la mort de *L. lichenoides* au niveau de l'encorbellement et d'un état de dégradation avancée de celui-ci.

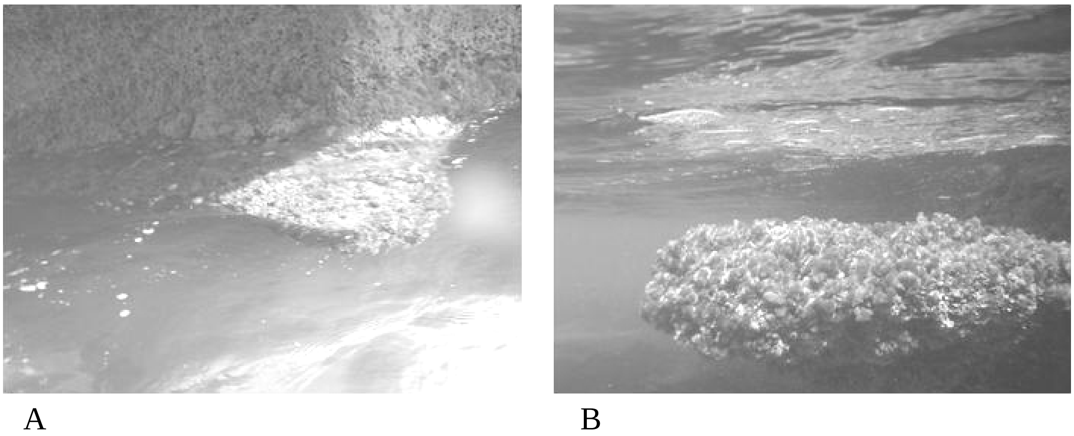

Fig 1 : Encorbellement à *L. lichenoide* : A = vue générale ; B couverture algale de l'encorbellement.

Les peuplements à *Lithophyllum dentatum* : Localisé sur les platiers rocheux à partir de 1 m de profondeur, *L. dentatum* constitue des peuplements denses couvrant jusqu'à 80 % du fond (Figure 2, A). Les populations sont formées d'individus d'âges différents et dont taille varie de 2 à 30 cm (Fig. 2, B). La plupart des individus sont fixés au substrat rocheux mais certains d'entre eux sont libres sur le fond apparentant ainsi la formation à du maërl.

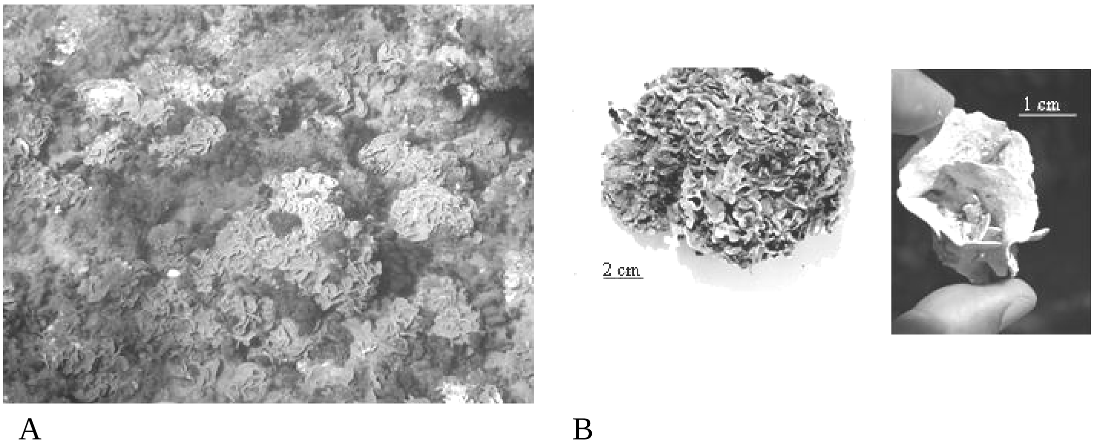

Fig.2 : *L. dentatum* : A = vue d'un peuplement ; B= individus de differentes tailles

DISCUSSION

Les encorbellements à *Lithophyllum lichenoides* de grandes tailles semblent relativement rares et ne sont cités qu'en Méditerranée Occidentale, en Espagne, en France, en Sicile et en Adriatique (Boudouresque *et al.*, 1990). La présence d'une telle bio-construction sur les côtes tunisiennes est donc reportée ici pour la première fois.

Par ailleurs, ces formations rares mettent un temps très long à s'édifier (Laborel *et al.*, 1983) et sont très vulnérables à la pollution des eaux (Boudouresque *et al.*, 1990, Kantin *et al.*, 2007, Thibaut & Mannoni, 2007). Ces traits leur valent de figurer sur le livre rouge Gérard Vuignier" des végétaux, peuplements et paysages marins menacés de Méditerranée, de même que sur la liste des espèces en danger ou menacée (annexes II du Protocole ASP/DB du CAR/ASP). L'état de l'encorbellement décrit suggère une dégradation avancée de celui-ci et appelle à des mesures urgentes pour recenser sur les côtes tunisiennes les formations analogues, ainsi des mesures pour leur conservation.

L. dentatum est cité en Irlande où il forme des peuplements à maerl. En Méditerranée il est sur les côtes nord-occidentale depuis l'Espagne jusqu'en Grèce, sur les côtes méridionales il est connu du Maroc (Dangeard, 1949), d'Algérie (Babbini & Bressan, 1997) et de Tunisie (Ben Maiz *et al*.,1987) où il est signalé une seule et unique fois. La présente signalisation confirme donc sa présence sur les côtes tunisiennes et souligne l'étendu de ses peuplements.

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CORALLIGENOUS ASSEMBLAGES IN THE NORTHERN ADRIATIC CONTINENTAL SHELF

ABSTRACT

*Numerous coralligenous rocky outcrops occur in the northern Adriatic Sea between 10 and 40 m in depth. Epibenthic assemblages were investigated on rocky outcrops scattered through an area of about 500 km^2 offshore of Chioggia and Venice. Spatial distribution and temporal variation of epibenthic assemblages were annually studied by photographic sampling from 2003 to 2006 on 12 sites randomly selected. The dominant reef-forming organisms are encrusting calcareous algae (*Lithophyllum stictaeforme, Lithothamnion minervae *and* Peyssonnelia polymorpha*), while the main bioeroders are boring sponges (*Cliona viridis, C. celata, C. thoosina, C. rhodensis, Piona vastifica*) and the endolithic bivalve Gastrochaena dubia. Assemblages showed variability both in space and time even though spatial heterogeneity was higher than temporal changes. Spatial-temporal variability of the epibenthic assemblages seemed to be related to geo-morphological features and to hydrological variables. The relative abundance of reef builders and bioeroders together with the most abundant species (massive sponge and social ascidians) appeared well differentiated between sites but showed slight temporal changes. Some taxa, such as encrusting sponges and algae, showed complex site-specific temporal trends.*

KEY-WORDS: coralligenous, subtidal communities, temporal variability, spatial patterns, Northern Adriatic Sea.

INTRODUCTION

Numerous coralligenous rocky outcrops occur in silty-sandy bottom of the northern Adriatic Sea between 10 and 40 metres in depth, ranging in size from few to thousands square metres, and raising between 1 and 4 metres from surrounding bottoms. These rocky outcrops are biogenic reef made predominantly by calcareous algae and characterized by a high biodiversity in term of epibenthic assemblages, mainly composed by filter feeders (sponges, colonial ascidians and cnidarians), endobionthic organisms and fish fauna (Casellato & Stefanon, 2008). Although these outcrops, locally named tegnùe, were discovered and documented in the 18th century (Olivi, 1792) their assemblages were analysed only in few locations (Gabriele *et al*., 1999; Soresi *et al*., 2004) and their spatial and temporal variability is little unknown. The aim of this study was to analysed regional distribution and temporal variation of the epibenthic assemblages in order to contribute to the knowledge of this peculiar coralligenous habitat.

MATERIALS AND METHODS

The study sites includes approximately 500 km^2 of the northern Adriatic continental shelf offshore of Chioggia and Venice (Lat. 45° 24' - 45° 04' N; Lon. 12° 23' - 12° 43' E) (Fig.1). Species reference collection was made using photographs and specimens collected on twenty six outcrops. Some new records for the northern Adriatic Sea have been reported.

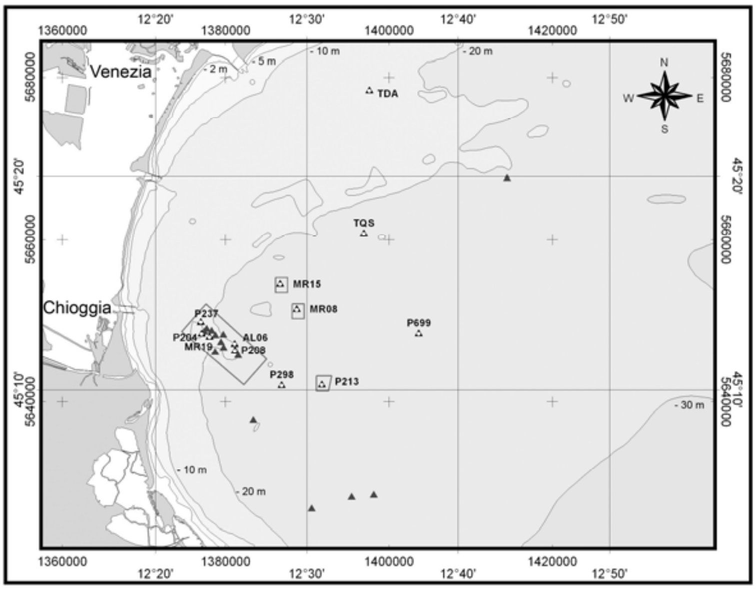


Fig. 1: Map of the twelve investigated outcrops scattered in the Northern Adriatic Sea.

Epibenthic assemblages on twelve randomly selected outcrops were annually investigated using a non-destructive photo-sampling method (Roberts *et al.*, 1994), samples were collected at each site in August from 2003 to 2006. Ten photos for each site and date were haphazardly selected from all those available and analyzed superimposing a grid of 100 equal sized squares. Abundance of sessile organisms was quantified in term of percentage cover estimation. The sand-silt-clay and organic content of sediment samples, collected near the outcrops, were analysed; since hydrographical data were not available, mean daily temperature (°C) and salinity (psu) near the bottom for each sampling site and for the whole study period, were obtained from the ASHELF oceanographic model (http://gnoo.bo.ingv.it/adricosm/).

RESULTS

Epibenthic assemblages showed a high spatial and temporal variability with complex distribution patterns. These results are confirmed by PERMANOVA analysis that detected significant differences among sites year by year (Year X Site p<0.001) and by PCO ordination plot. Cluster analysis, superimposed on the PCO plot, showed three main groups of epibenthic assemblages, which are quite stable year by year (Fig. 2). Patterns of similarity of the benthic assemblages showed a significant relationship with outcrops size (log10 transformed), distance from coast, depth, elevation and longitude. Some ecological groups like non calcareous algae and encrusting sponge showed complex site-specific temporal patterns, while other groups like boring sponges, calcareous algae, cnidarians, colonial ascidians and massive sponges had a limited temporal variability but differed between sites. In particular:

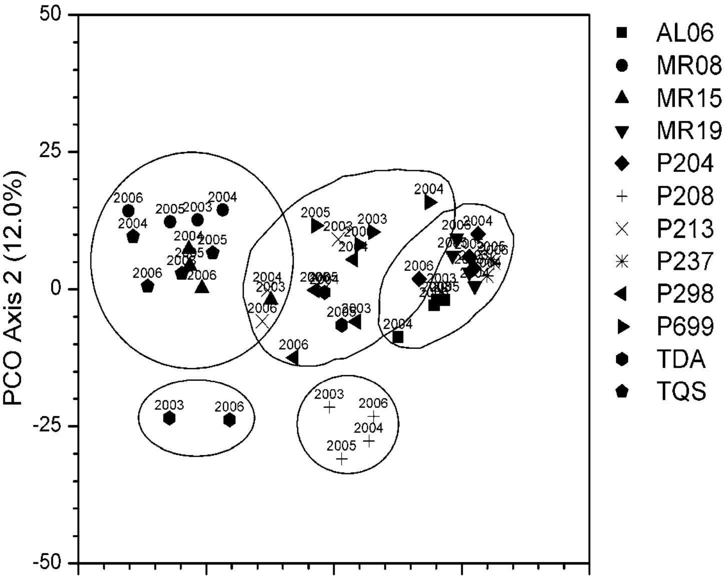
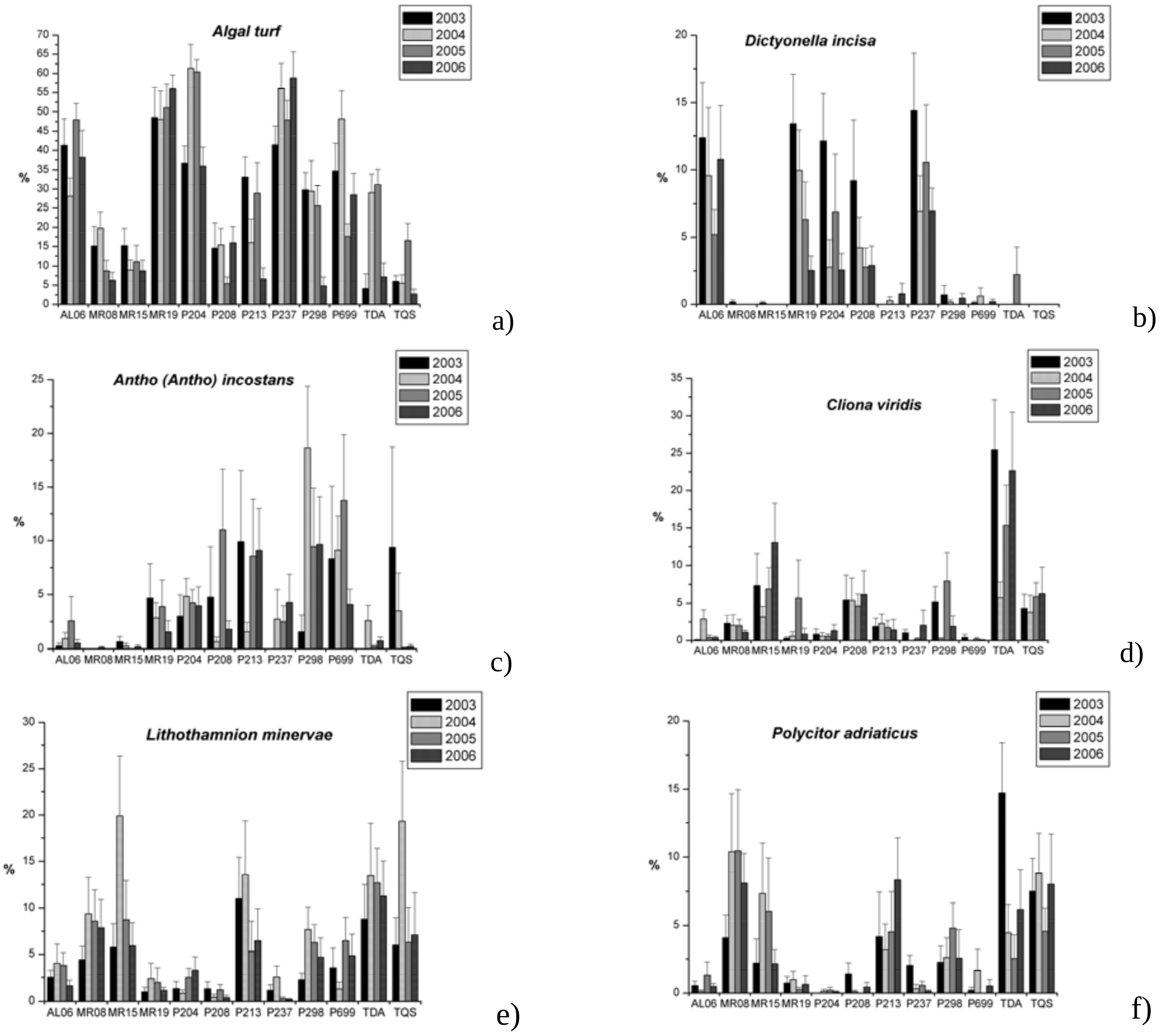


Fig. 2: PCO ordination plot based on epibenthic assemblages percent cover data.

- Algal turf showed differences both in time and space, abundance increased near the coast in the wider outcrops (Fig. 3-a).
- The most abundant encrusting sponges *Dictyonella incisa* and *Antho* (*Antho*) *incostans* differed between sites. The first sponge exhibited small change in time and appeared abundant in shallower and wider outcrops, the second showed a spatial-temporal heterogeneity increasing with depth (Fig. 3-b/c).
- The boring sponge *Cliona viridis* showed a site-specific distribution with a high abundance in shallow and small outcrops as the site TDA (Fig. 3-d).
- The calcareous algae *Lithothamnion minervae* appeared constant in time but differed between sites dominating the small and far locations (Fig. 3-e).
- The ascidian *Polycitor adriaticus* was characterized by a high spatial heterogeneity with higher abundance in the small outcrops far from the coast (Fig. 3-f).

DISCUSSION AND CONCLUSIONS

The present study showed that the structure of the epibenthic assemblages changed thorough years and sites even if spatial heterogeneity was higher than temporal changes, as clearly shown by the ordination plot. Spatial distribution of assemblages appeared strongly correlated with the morphological features and geographical location of the outcrops, while was less affected by the hydrological conditions. This work represents a contribution to the knowledge of biodiversity of this peculiar coralligenous habitats. It provides the bases for a better understanding of the ecological processes and could be used to develop conservation strategies including a sustainable tourism and management of fisheries.



a) b) c) d) e) f)

Fig. 3: Spatial and temporal trends of the most important and abundant species.

ACKNOWLEDGMENTS

We would like to acknowledge the taxonomists Marco Bertolino, Carlo Cerrano, Francesco Mastrototaro and Guido Bressan for their help and also the no profit association "Associazione Tegnùe" for the logistic support.

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THE "PINK MILE": BENTIHIC ASSEMBLAGES OF RHODOLITH AND MÄERL BEDS (CORALLINALES) OFF THE ISLAND OF ISCHIA (TYRRHENIAN SEA)

ABSTRACT

*In the framework of a study to evaluate the impact of sand extraction on benthic biota, various rhodolith (Corallinales) beds were surveyed in July 2004 on the soft bottoms off the islands of Ischia (Bay of Naples, Tyrrhenian Sea, Italy) from 50 to 80 m depth, including also the association of mäerl (*Phymatolithon calcareum *and* Lithothamnion corallioides*). The analysis of benthos in 13 samples, collected by means of a van Veen grab, led to the identification of 13 rhodolith species and 185 animal taxa represented mainly by polychaetes (88), molluscs (40),and amphipods (30). The highest species richness was recorded in two samples characterized by mäerl, while the highest variability and patchiness was observed in the 50 m depth samples.*

KEY-WORDS: benthic communities, Corallinales, mäerl, biodiversity, detritic bottoms.

INTRODUCTION

The soft bottom habitats characterized by conspicuous occurrence of rhodoliths (Rhodophyta, Corallinales) (rhodolith beds) host associated benthic communities with elevated structural and functional diversity and complexity (Barbera *et al*., 2003, Ramos-Esplà & Luque, 2004). Rhodolith accumulation in soft substrates can be considered as a "mobile" coralligenous formation. Among the Corallinales, the species *Phymatolithon calcareum* (Pallas) Adey & McKibbin and *Lithothamnion corallioides* (P. & H. Crouan) P. & H. Crouan, are the main constituents of a typical association, the mäerl (Bressan *et al*., 2001, Bressan & Babbini, 2003), and are actually protected species according to the Annex V of the EC Habitats Directive (92/43EEC). Notwithstanding the high ecological relevance of the rhodolith beds, the knowledge on the associated benthic communities to these formations are still relatively scarce in the Mediterranean (Barbera *et al*., 2003). These habitat generally occurs in the Mediterranean in relatively deep coastal biogenic detritic bottoms, with various degrees of fine sediment, or around shallow and deep rocky banks, and can be observed deeper than 100 m (Bressan *et al*., 2001). Generally the presence of rhodolith beds and of the mäerl association testify a balance and dynamic equilibrium between bottom current and wave action intensity, light and water transparency (both generally high), and sedimentation rate (generally low) (Bressan *et al.*, 2001). Therefore rhodolith and mäerl beds are biological indicators of peculiar conditions and show a relatively limited extension and patchy distribution.

In the framework of a study to characterise the benthic community of detritic and sandy soft bottoms to evaluate the impact of relict sand extraction for beach nourishment around the Phlaegrean islands of Ischia and Procida (Gulf of Naples, Italy), an extended area colonized by rhodoliths and *mäerl* has been discovered (Babbini *et al*., 2006, Massa-Gallucci *et al*., 2006). The aim of this contribution is to provide information on the features of these beds and on biodiversity and structure of the plant and animal assemblages associated.

MATERIALS AND METHODS

The investigated area is located off the town of Forio (south-western side of the island of Ischia), between 50 and 80 m depth. In this area, in July 2004, benthic samples have been taken with a van Veen grab. Results here reported represent the analysis of 7 stations (two grab replicates, about 15 l of sediment each, for each station), for a total of 13 grab samples distributed at 50 m (6 samples), 65 m (5) and 80 m (2) depth. In addition to the grab samples, a visual inspection was performed in the area with a ROV (Prometeo model). For each sample both algae and animals were identified whenever possible at species level; for the zoobenthos, Shannon diversity (H') and Pielou eveness (J) were calculated, a cluster analysis based on the Bray-Curtis similarity was performed on specie's abundance.

RESULTS

The visual inspection by ROV allowed to identify a *mäerl* association about 1 mile long between 50 and 65 m depth (the "pink mile") off Punta del Soccorso (Forio, Fig. 1) (Babbini *et al*., 2006).

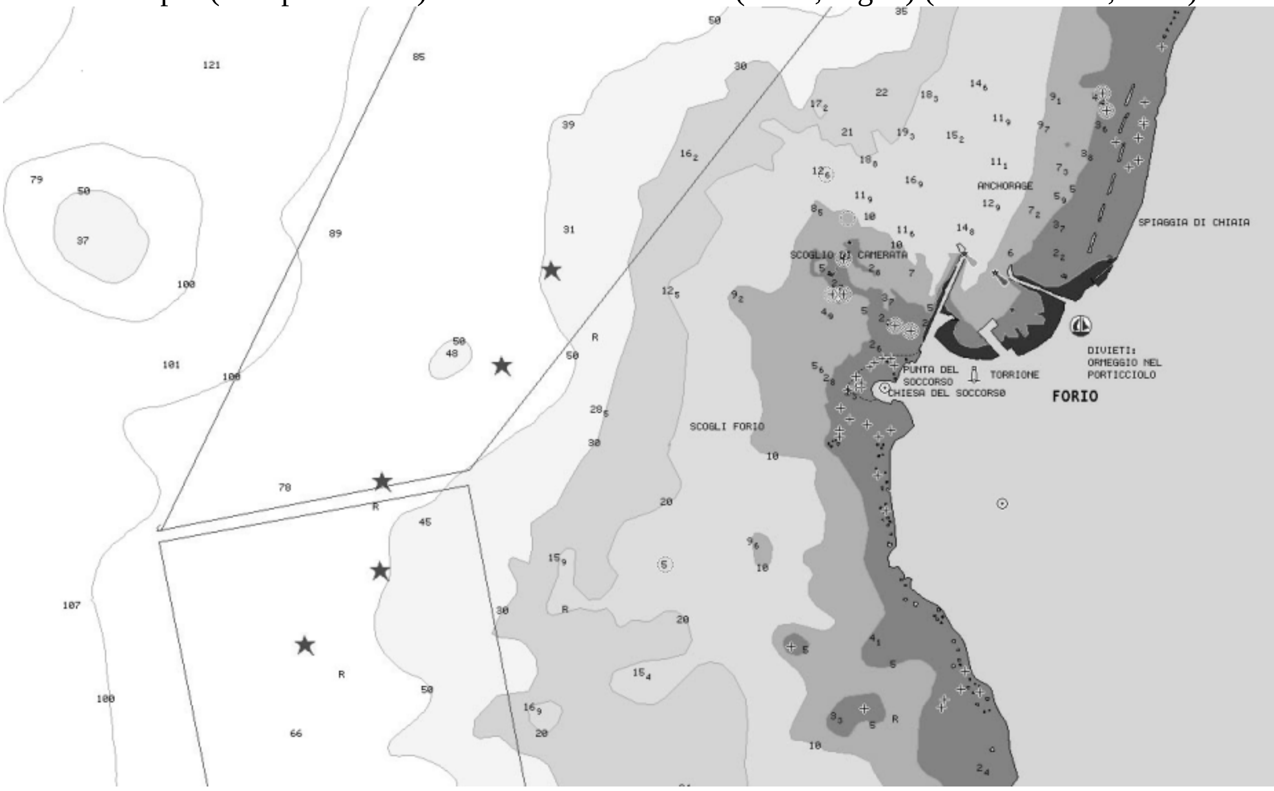
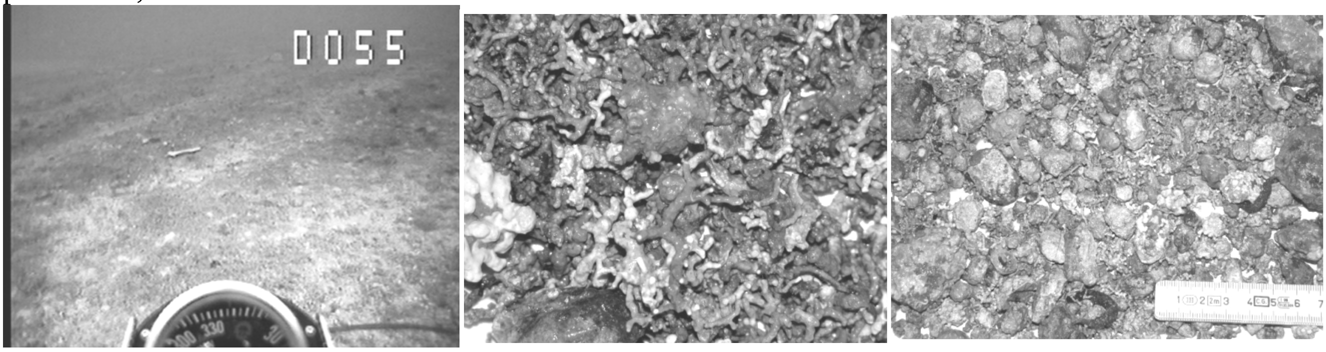


Fig. 1. Map of the investigated area (Punta del Soccorso in front of Forio, island of Ischia, Gulf of Naples) with the location of the "pink mile" (stars), the area characterized by the mäerl association, defined by ROV inspection and benthic sample analysis (between 40° 44.455 - 40° 43.875 N, and 13° 50.435 - 13° 50.008 E). The lines indicate the perimeter of the larger area included in the impact study.

The bottoms in this area is characterised by a biogenic coarse detritic sediments (Ferraro *et al*., 2003) and show large ripple marks, related to strong wave action and bottom currents, as confirmed also by previous geo-morphological survey (Budillon *et al*., 2003). The thalli of the Corallinales are located in the concavity of the ripples (Fig. 2a). Among the 13 samples here considered, 3 were collected inside the "pink mile" (FO65C2, SF50A1 and SF50A2, Fig. 2b). As a whole, a total of 13 species of Corallinales were identified representing all the known growth forms: prâlines, box works, free ramified thalli, epilithic and epizootic thalli (Babbini *et al*., 2006). Among the animals a total of 1036 invertebrate specimens belonging to185 taxa were collected: polychaetes (88 taxa), mollusk gastropods (18), mollusk bivalves (22), crustacean amphipods (30), echinoderms (14), sipunculids (8), crustacean isopods (5). The more abundant species were the sipunculids *A. mülleri* and *Phascolosoma granulatum*, the amphipods *Autonoe rubromaculatus, Caprella rapax* and *Harpinia truncata*, the polychaetes Cirratulidae gen. sp., *Nematonereis unicornis, Aponuphis brementi, A. bilineata, Lumbrineris gracilis, Eunice vittata, Glycera tesselata, Nephtys hombergii*, and the bivalve *Gouldia minima*. The majority of the species are typical of coastal detritic habitats, other species especially among crustacean amphipods and echinoderms occur also on hard bottoms (coralligenous), and are probably associated to epiphytes of the rhodoliths. Several interstitial species were also observed, especially among polychaetes. The abundance per sample ranged between 38 and 186 individuals, the number of species per sample ranged between 12 and 56, and both variables showed among the highest values in the samples characterized by the mäerl association. The diversity index H' ranged between 2.7 and 3.6, and the Pielou evenness J between 0.79 e 0.96, except two samples at 50 m depth characterized by dominance of the sipunculid *Aspidosiphon mülleri*, a species that inhabits dead shells. The cluster analysis showed three groups of samples (A, B and C) distributed according to depth: cluster A contains the two samples at 50 m depth dominated by *A. mülleri*; cluster C includes the remaining samples at 50 m depth, two of which characterized by the *mäerl* association, cluster B include samples at 65 m and 80 m depth (among which one with *mäerl*). Therefore, benthic community structure is more influenced by depth than by the occurrence of the mäerl. The lower similarity of samples at 50 m depth testify their higher variability and patchiness, due also to the occurrence of mäerl.



(a) **(b)** **(c)**

Fig. 2. a) ROV image of the bottom of the area characterised by the mäerl association (55 m depth), note the distribution of the Corallinales in the ripple mark's concavity. b) Thalli of mäerl in sample FO65C2 (65 m depth), and SF50A1 (50 m depth) c).

These first results confirm that rhodolith beds off the island of Ischia host a highly diversified benthic flora and fauna, especially when compared to the biodiversity recorded in other types of soft bottom habitats previously studied around the island of Ischia (Gambi *et al*., 2003). In rhodolith beds, in fact, taxa with different ecological requirements co-occur due to the mixed and heterogeneous biogenic sediments and to secondary hard substratum that rhodoliths provide for epibiont and motile organisms.

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MEDCHANGE PROJECT. EVOLUTION AND CONSERVATION OF MARINE BIODIVERSITY FACING GLOBAL CHANGE: THE CASE OF MEDITERRANEAN COMMUNITIES DOMINATED BY LONG-LIVED SPECIES.

ABSTRACT

The MEDCHANGE project aimed to anticipate and analyze the impact of climate change on coralligeneous communities dominated by gorgonian species. Overall this project allowed us to better understand the impact of climate change as well as to reveal the underlying biological and genetic factors involved in the resistance of populations exposed to severe disturbances such as those related to climate change. The project used a pluridisciplinary and integrative approaches. For more information visit the project's site web www.medchange.org.

KEY-WORDS: Climate change, North Western Mediterranean, community structure and dynamics, conservation biology

INTRODUCTION

Recent mass mortality events occurred in the Mediterranean coralligenous communities supposedly linked to global warming of the NW Mediterranean Sea (Perez *et al.*, 2000, Garrabou *et al.*, in press). This scenario poses serious questions about the consequences for the conservation of these communities under the likely increase of the perturbation regime. The project used an interdisciplinary study combining hydrology, high resolution cartography, genetics and ecophysiology based on the following five main goals (Fig. 1):

1) To acquire high-resolution data on the environmental context within the selected communities.
2) To set-up a new system to map at high-resolution the selected communities.
3) To study diversity dynamics on the selected communities by carrying out long-term data analysis, in situ diversity surveys and phylogeographic analyses.
4) To study resilience of gorgonian populations by demographic surveys, modeling population dynamics and analyzing the population genetic structure as well as their diversity.
5) To study the sensibility and the adaptation capacity of gorgonian populations using aquarium and field experimental approaches. Different markers potentially linked related to stress are being

used to determine the health status of populations including the study of bacterial communities associated to the gorgonians.

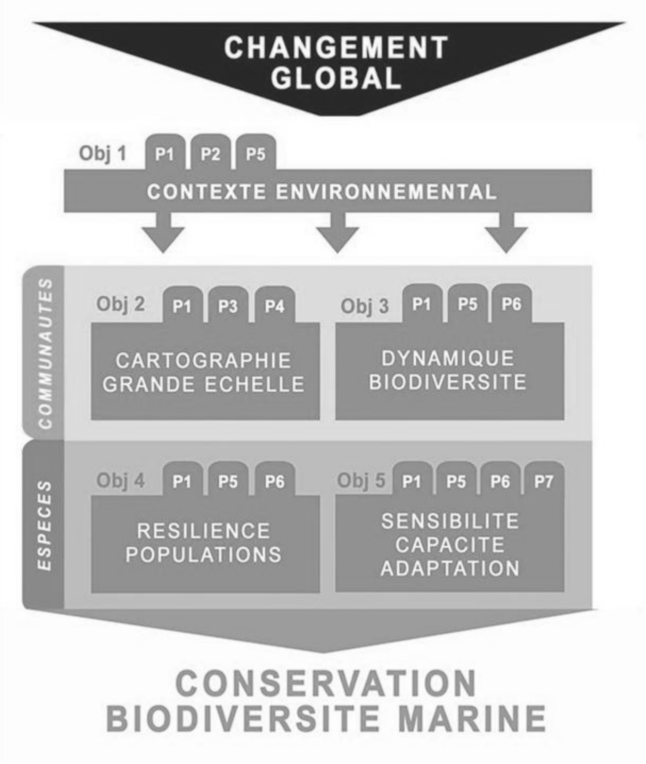

Figure 1. Organisation des objectifs du projet Medchange

MATERIAL AND METHODS

The project concerned the communities dominated by the presence of three gorgonians: the white (*Eunicella singularis*) and red (*Paramuricea clavata*) gorgonians and the red coral (*Corallium rubrum*). These are complex communities with high specific diversity as those of the Mediterranean coralligenous assemblages. These communities are emblematic of the under-water Mediterranean landscape. They have a very long life span (up to 80 years or more), a reduced growth (less then 1 cm in height by year) and a reduced recruitment. The recovering time of the populations and the communities must therefore be assessed with a time scale corresponding to decades, or maybe even centuries.

Four main zones have been studied: two on the continental NW Mediterranean coast (Catalonia and Provence coasts) and two on Mediterranean islands (Corsica and Balearic Islands). These areas are subject to contrasted temperature regimes and have undergone different degrees of disturbance during the recent thermal anomalies (mass mortality of 1999 and 2003).

In each study zone we have set up a temperature recordings between 5 and 40 m using autonomous recorders, carried surveys at population and community level and obtained samples for population genetics studies for the three gorgonian species as well as for the study of microbial communities associated to the red gorgonian *P. clavata.*

Selected zones and populations have been also used to analyze temperature trends (Catalonia and Provence coasts), test new cartographic methods in the Riou Archipelago (Marseilles, France) and to obtain samples for thermotolerance experiments in aquarium.

RESULTS

-The study of long-term temperature series showed a significant warming trend which has increased in the last 30 years when the temperature increased about 1°C.

-The analysis of high-resolution temperature series (hourly measurements) allowed for the very first time to characterize the temperature regimes in the study areas. The inter-annual study of temperature series allowed to detect specific patterns (mean and variability) for each site. These patterns show contrasted temperature conditions to which the populations could have been adapted to. Furthermore, the temperature series allowed to characterize the positive anomalies which were related to the occurrence of large-scale mortality events.

-New cartographic methods have been tested to survey changes in bathymetric distribution of gorgonian populations.

-Demographic data (about 30 gorgonian populations surveyed) obtained through *in situ* measurements and photogrammetric methods, have been used to develop population viability analysis (PVA) models to investigate the long-term consequences of mass mortality events. Furthermore, the evaluation of the impacts at a large spatial scale (the 4 study zones) in relation with temperature data provided useful descriptors and protocols to gradually expand the assessment of climate change impacts towards a Mediterranean-wide scale.

- Through the analysis of hundreds of high-resolution photographs we obtained baseline data on abundance on about 100 macrobenthic species dwelling in different study areas. These data will enable the detection of future changes in species abundance and community composition submitted to strong disturbances such as mass mortalities.

-Microsatellite loci were developed for the three gorgonian species to examine the genetic structuring at different spatial scales and to evaluate the species dispersal ability. These results can help to predict the population potential of recovery/extinction and the evolutionary trajectories of the associated communities.

-Several thermo-tolerance experiments have been carried out to help in the development of physiological, biochemical and molecular markers to better know the temperature defense and resistance mechanisms on the model gorgonian species. These experiments also provided data on the temperature thresholds of different gorgonian populations.

-The composition and dynamics of the natural microbial communities living in association with *P. clavata* have been analyzed to establish a baseline for diversity and abundance of associated bacteria. These study provided data on seasonal microbiota changes and will allow to test specific hypothesis about factors leading to pathogen development and disease during temperature anomalies.

CONCLUSIONS

The Medchange project provided, through detailed and multidisciplinary studies, precious data on the resistance, adaptation and evolution capacities of long-lived emblematic species of the Mediterranean confronted to temperature regime changes in littoral habitats. This knowledge should provide the proper scientific basis to anticipate marine biodiversity trajectories over mid- and long-term scales in view of predicted climate change scenario.

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CONTRIBUTION TO THE KNOWLEDGE OF CORRALIGENOUS COMMUNITIES IN THE NE AEGEAN SEA

ABSTRACT

Within the present work coralligenous communities from the NE Aegean Sea have been qualitatively investigated. Sampling methodology included visual census techniques by means of SCUBA diving, at depths of up to 45m. Typical coralligenous communities were found at the deeper sites, such as on bluff sea cliffs and rocky reefs, as well as at the entrance of submerged caves. The distribution pattern found in this area could be attributed both to the oceanographic features of the surveyed sites, as well as to the level of intensity of human activities (e.g. fishing and boat anchoring) that may constitute a limiting factor for these fragile communities to develop in shallow waters. Additional scientific research, detailed habitat mapping and adoption of measures for the protection of the coralligenous communities of the Aegean Sea are necessary in order to ensure their conservation and avoid further habitat loss.

KEY-WORDS**:** coralligenous communities, biodiversity, Aegean Sea.

INTRODUCTION

The Mediterranean coralligenous community (Laubier, 1966; Pérès, 1967) is characterized by such a rich biodiversity and high level of structural complexity that it can be compared to that of the coral reefs (Margalef, 1985; Bellan-Santini *et al*., 1994). Although this type of marine habitat has been extensively studied and described in the NW Mediterranean Sea (e.g. France – Pérès and Picard, 1951; Laubier, 1966; Spain – Gili & Ros, 1984; Italy – Giaccone, 1968), available scientific information regarding the rather oligotrophic eastern Mediterranean and the Hellenic Seas remains relatively limited and fragmented (e.g. Vafidis *et al*., 1997; Koukouras *et al*., 1998; Antoniadou & Chintiroglou, 2005). The notable lack of knowledge regarding reference state conditions of the coralligenous community in this region, along with the increasing anthropogenic pressures to the marine environment (e.g. habitat destruction, pollution, fishing, global warming) constitute a crucial threat for this unique biotope. Within this context, the purpose of the present work is to assess marine biodiversity and state conditions of coralligenous beds at the NE Aegean Sea.

MATERIELS AND METHODS

In the framework of a project regarding the potential establishment of a marine park at the NE Aegean Sea, hard substrate communities from three marine areas off the island of Lesvos (NE Aegean Sea) (Fig.1) were investigated. Marine biodiversity was studied by means of SCUBA diving through the use of visual census techniques (e.g. direct observation and photography), at depths of up to 45m. Identification of species was mainly concentrated in megabenthic organisms

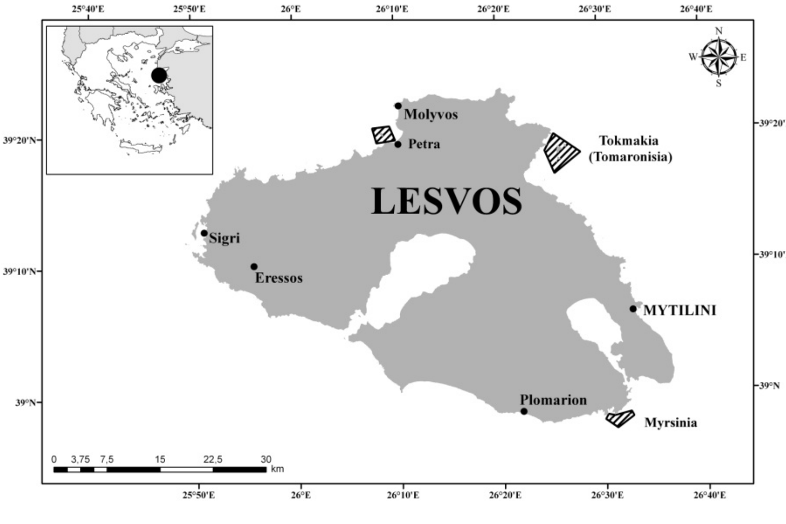

Fig. 1: Map of Lesvos Island where black stripes indicate the study areas.

and ichthyofauna.

RESULTS

From the surveyed marine areas, typical coralligenous communities were found on vertical walls and bluff cliffs (25-40m depth) at the Tokmakia area, as well as at the entrance, walls and ceiling of semi-obscure submerged caves (15-45m depth) at the Myrsinia area (Fig. 1). This type of benthic community was also found as enclave at the deepest shadowy surfaces of rocks and pinnacles (20-35m), or in cracks and crevices of all areas.

In total, more than 100 taxa of marine flora and fauna, from 11 taxonomic groups were identified. The most characteristic species, with regard to the frequency of encounter during the dives and the percentage of spatial coverage at the surveyed sites include: calcareous rhodophytes (e.g. Coralliniaceae and Peyssonneliaceae); sciaphilous chlorophytes (e.g. *Halimeda tuna* and *Palmophyllum crassum*); a big number of sponge species (e.g. *Agelas oroides*, *Aplysina aerophoba*, *Axinella* sp., *Chondrosia reniformis*, *Dysidea avara*, *Petrosia ficiformis*, *Phorbas* sp.); cnidarians (e.g. *Caryophyllia smithii*, *Cladocora caespitosa*, *Ballanophyllia europaea*, *Leptosammia pruvoti*, *Madracis pharensis*, *Parazoanthus axinellae* and facies of *Eunicella* gorgonians which reached a maximum density of 1-2 colonies per m^2 and a maximum height of 50 cm); polychaete worms (e.g. *Hermodice carunculata*, Sabellid and Serpulid species); mollusks (e.g. *Cratena peregrina*, *Discodoris atromaculata*, *Flabellina affinis*, *Octopus vulgaris* and *Spondylus gaederopus*); crustaceans (e.g. *Palinurus elephas*); bryozoans (*Hornera sp.* sp., and *Smittina cervicornis*); echinoderms (e.g. *Centrostephanus longispinus*, *Hacelia attenuata* and *Stylocidaris affinis*); tunicates (*Halocynthia papillosa* and *Microcosmus* sp.) and fish (e.g. *Anthias anthias*, *Boops boops*, *Chromis chromis*, *Conger conger*, *Coris julis*, *Diplodus vulgaris*, *Epinephelus marginatus*, *Muraena helena*, *Sciaena umbra*, *Scorpaena sp*., *Spicara sp*.).

It is important to highlight that in many marine sites; there was an obvious impoverishment of structural diversity due to the presence of the invasive species of green algae *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman and Boudouresque, which formed extensive mats that covered hard surfaces (e.g. calcareous red algae). In addition, biological degradation, traces and leftovers of destroyed fishing gear (e.g. nets) and lost anchors were found scattered throughout the seabed of the different marine sites, or even entangled with the branches of gorgonians (e.g. at the Tokmakia area).

DISCUSSION AND CONCLUSIONS

The results of the present work support the opinion of previous authors (e.g. Chintiroglou *et al*., 2005) that the coralligenous communities of the Aegean Sea constitute biodiversity ‘hot-spots’. The distribution pattern of the coralligenous communities of the NE Aegean Sea could be attributed both to the oceanographic features of the surveyed sites (e.g. bathymetry, seascape, water temperature, level of turbidity and currents’ strength), as well as to the intensity of human activities (e.g. uncontrolled fishing and boat anchoring). The destroyed fishing gear and left anchors reveal the existence of a critical threat for these vulnerable biotopes. The confinement of this habitat at deep sites with increased inclination, ‘sheltered’ from the potential impacts of the above mentioned human activities, indicates that these may constitute a limiting factor for that fragile community to develop in shallower waters (Bavestrello *et al*., 1997; Ballesteros, 2003). At the same time, the ever-growing aquatic tourism and recreational SCUBA diving activities, could have additional detrimental effects, as long as they remain unregulated (Milazzo *et al*., 2002; Dalias *et al*., 2007). Apart from the mechanical damage caused by anchoring or trawling, the potential negative effects that recreational SCUBA diving may have on hard substrate communities have been described by several authors (e.g. Garrabou *et al*, 1998, Lloret *et al*, 2006). Moreover, the rapid alteration of natural benthic communities due to the expansion of the invasive chlorophyte *Caulerpa racemosa* var. *cylindracea*

(Occhipinti-Ambrogi & Savini, 2003), may constitute an additional critical threat, that needs to be investigated. Overall, further scientific research, detailed habitat mapping and measures for the protection of the coralligenous communities of the Hellenic seas are considered necessary, in order to safeguard their conservation and avoid extended habitat loss caused by potential anthropogenic or environmental pressures.

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A REVIEW OF CORALLIGENOUS ALGAL ASSEMBLAGES IN TURKISH COASTS OF MEDITERRANEAN SEA

ABSTRACT

Coralligenous algae are very common along marine coasts, especially in tropic regions. In Turkey, 9 coralline macroalgal genera (Corallina, Amphiroa, Lithophyllum, Titanoderma, Haliptilon, Jania, Hydrolithon, Pneophyllum, Neogoniolithon) have been recorded on the Mediterranean coastline.

But in recent years there have been changes in the Mediterranean Sea ecosystem as a result of disturbing fishing methods, anchoring, interferences by scuba diving, invasion of alien species, pollution and global warming.

In this respect, the aim of this study is to make an overview of Turkish literature on coralligenous macroalgae in macroalgal studies and to offer the possibility to the Mediterranean researchers to access Turkish national publications.

KEY-WORDS: Coralligenous algae, taxonomy, Turkish Coasts, Mediterranean Sea

INTRODUCTION

The ‘Coralligenous’ is a complex of biocenosis rich in biodiversity and mostly formed by calcareous algae. Unique calcerous formations are produced by the accumulation of encrusting algae growing in dim light conditions that is sufficient for photosynthesis of sciaphilic algae, at relatively low and constant temperature and constant salinity, weak hydro-dynamism and in clean waters. Although more extensive in the circalittoral zone, coralligenous habitats can also develop in the infralittoral zone (Gibson *et al.,* 2006).

This review provides an overview of results obtained by the main studies dealing with macroalgal species that contain coralline algae species in Turkish Coasts of Mediterranean Sea.

ALGOLOGICAL STUDIES IN TURKEY

The Aegean Sea has a rich biological productivity and its shores include many areas suitable for algal growth. In Turkey there have been many investigations on the floristic composition of the Aegean and Mediterranean Sea (Gibson *et al.,* 2006).

According to Sukatar (2001), Fritsch made the first studies on the systematics of marine algae of Turkey in 1899 and Öztığ (1957; 1959; 1961; 1962) and Karamanoğlu (1964) and Güven & Öztığ (1971) followed these. These studies were furthered by Zeybek (1966; 1969; 1976), Sukatar (1981), Sukatar *et al.* (1986), Güner *et al.* (1984; 1985), Dural (1986; 1990), Dural *et al*. (1997). Aysel *et al.* (2005; 2006) stated that Apaydın *et al.* (2002), Aysel (1997a; b), Aysel & Gezerler- Şıpal (1996), Aysel *et al.* (1998; 2002; 2003; 2005a; b), Cirik (1986; 1991), Cirik & Öztürk (1991), Ertan *et al.* (1998), Everest *et al.* (1997), Okudan & Aysel (2005), Öztürk (1988; 1993; 1996 a; b), Öztürk & Güner (1986), Taşkın *et al.* (2000a; b 2001), Turna *et al.* (2000a; b; 2002; 2003), Yağcı & Turna (2002) have also performed floristic studies on Mediterranean coasts of Turkey.

Recently, the presence and the distribution of macroalgae and seagrasses were studied in the upper littoral zones of Bozcaada Island (Aegean Sea, Çanakkale), Hatay, Mersin, Adana (Fig. 1) and the taxa were presented as floristic lists by Aysel et al. in 2005 and 2006 (Tab. 1).

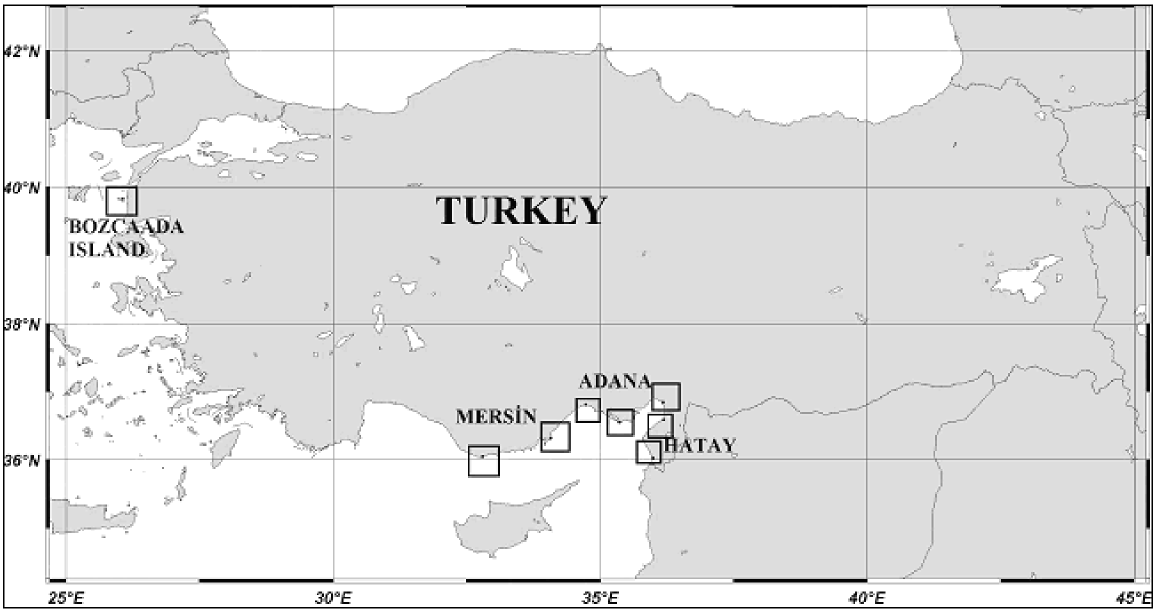

Fig 1: Distribution areas of coralline algae in Turkish Coasts of Mediterranean

Tab 1: Coralline algae taxa distributed in Turkish Coasts of Mediterranean (Aysel *et al.*, 2005 and 2006)

Species	**Bozcaada**	**Mersin**	**Adana**	**Hatay**
Choreonema thuretii (Bornet) Schmit	+	+	+	+
Corallina elongata Ellis and Solander	+	+	+	+
C. panizzoi Schnetter and V. Richter	+	+	+	+
C. pinnatifolia (Manza) Dawson			+	
Amphiroa cryptarthrodia Zanardini	+		+	+
A. rigida Lamouroux	+	+	+	+
A. beauvoisii Lamouroux	+	+	+	
Lithophyllum cystoseirae (Hauck) Heydrich	+	+	+	+
L. incrustans Philippi		+	+	+
L. tortuosum (Esper) Foslie		+	+	+
Lithophyllum f. *tortuosum*		+	+	+
Lithophyllum f. *undulosum* (Bory de SaintVincent) Okudan & Aysel		+		
L. lobatum M. Lemoine			+	
L. stictaeforme (J.E. Areschoug) Hauck	+			
L. byssoides (Lamarck) Foslie	+			
Titanoderma corallina (P.L.Crouan&Crouan) Woelkerling,Chamberlain&C. Silva	+			
T. pustulatum (Lamouroux) Nägeli	+	+	+	+
Haliptilon squamatum (Linnaeus) Johansen, Irvine & Webster	+	+		
H. virgatum (Zanardini) Garbary & Johansen	+	+	+	+
H. roseum (Lamarck) Garbary & Johansen	+		+	
H. roseum var. *roseum*	+		+	

Jania longifurca Zanardini	+	+	+	+
J. rubens (Linne) Lamouroux	+	+	+	+
J. rubens var. *rubens*	+	+	+	+
J. rubens var. *corniculata* (Linnaeus) Yendo	+	+	+	+
Hydrolithon farinosum (Lamouroux) D. Penrose & Chamberlain	+		+	+
Hydrolithon var. *farinosum*	+	+	+	+
Pneophyllum confervicola (Kützing) M. Chamberlain	+			
Neogoniolithon brassica florida (Harvey) Setchell & Mason		+		

197 species of Florideophyceae class in Bozcaada, 194 species in Mersin, 195 species in Adana and 192 in Hatay were recorded. Beside this they determined the algae which are tolerant to drastic ecological conditions (Nemalion, Laurencia, Bangia and most of the members of Corallinales and Cystoseira, Halopteris, Valonia and Cladophora) grow in the northern coasts of Bozcaada Island that are exposed to strong waves. On the contrary, southern regions contain more refuged regions that phycological richness increases in the upper infralittoral zones.

CONCLUSION

As reef producers, the coralligenous communities form rich biodiversity around them. In addition, while crustose corallines play an important role in the construction and consolidation of coral reefs; erect corallines produce calcium carbonate sand and become an important constituent of marine limestones.

Unfortunately, global warming, anchoring, dredging, trawling, beach regeneration (move sediments), alien species that compete with native species, discharges of wastewater, eutrophication and marine accidents (oil spills, etc.) affect macroalgal species (particularly Cryptonemiales and Corallinaceae) negatively.

For these reasons work plans are necessary to be done to protect these coralligenous species.

Researches on coralline algae in Turkey were about their taxonomies therefore studies on distributions and ecology of coralline algae must be improved.

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THE BIODIVERSITY OF MACROBENTHOS WITHIN THE CORALLIGENOUS COMMUNITY DOMINATED BY THE RED GORGONIAN *PARAMURICEA CLAVATA* IN THE CENTRAL PART OF THE EASTERN ADRIATIC SEA (CROATIA): PRELIMINARY RESULTS

ABSTRACT

The coralligenous is considered to be a "hot spot" of biodiversity in the Mediterranean and Paramuricea cl*avata assemblage is regarded as one of its most representative facies. The aim of this study was to determine macrobenthic species composition of the coralligenous community dominated by the red gorgonian* Paramuricea clavata *(Anthozoa, Octocorallia) and to assess its spatial variability. Preliminary results are available for 4 sites located in the central part of the Eastern Adriatic Sea. A total of 173 taxa were identified to date: 82 bryozoans, 11 anthozoans, 45 polychaetes, 2 tunicates, 21 sponges and 12 macroalgae, including invasive red algae Womerslleyella setacea.*

KEY-WORDS: macrobenthos, biodiversity, coralligenous, the Adriatic Sea, Croatia

INTRODUCTION

There are potentially more species thriving in coralligenous than in any other community in the Mediterranean Sea (Ballesteros, 2006). Despite its value, the coralligenous in the Eastern Adriatic Sea remains poorly studied and there is scarcity of baseline data that would enable detection of future changes due to various disturbances such as, among others, the invasion of alien algal species (Piazzi & Balata, in press). Therefore, the aim of this study was to determine macrobenthic species composition of the assemblage dominated by the red gorgonian *Paramuricea clavata* (Risso, 1826), a species that represents one of the characteristic elements of the coralligenous communities (Pérès & Gamulin Brida, 1973), as well as to assess spatial variability of this assemblage.

MATERIALS AND METHODS

Four 25 x 25 cm random quadrats were scrapped off per site by SCUBA divers, on the vertical walls in the bathymetric range from 30 to 37 m, which represented the upper part of the *Paramuricea clavata* distributional range at the selected sites. Samples were collected in individual plastic bags and fixed in 4% formalin for later sorting and identification in the laboratory. Preliminary results are available for 4 sites located in the central part of the Eastern Adriatic Sea: the east (HT) and the southwest (RG) part of the Island Biševo and Islands Mali Obručan (MO) and Rašip Veli (RV) in the Kornati archipelago. Elevated hydrodynamism is observed at all of the sampling sites. Macrobenthos was identified at species level, or at the lowest taxonomic level possible, using standard taxonomic references. The abundance of the main macroalgae was estimated as the surface occupied by the vertical projection of each taxon and expressed as percentage of sampling area. Multivariate patterns were visualized using non-metric Multidimensional Scaling based on the Bray-Curtis similarity matrix calculated from presence/absence data and analysis of similarities (one–way ANOSIM) was applied to test differences among different sites. SIMPER was used to identify taxa that contribute most to the observed dissimilarity between groups. Computations were made using the PRIMER 6 package (Clarke & Gorley, 2006).

RESULTS

A total of 173 taxa were identified to date: 82 bryozoans, 11 anthozoans, 45 polychaetes, 2 tunicates, 21 sponges and 12 macroalgae. At the sampling site Mali Obručan 94 taxa were recorded and 106 at Rašip Veli respectively. At the Island of Biševo 100 taxa were recorded in the east part and 95 taxa in the southwest part. Bryozoans contributed the most to the observed species richness at all sites, followed by polychaetes (Fig. 1). The most dominant bryozoans were erect species *Smittina cervicornis* and *Schizotheca serratimargo* as well as encrusting species *Schizomavella cornuta*. Anthozoans noted during this study such as *Monomyces pygmaea*, *Paracyathus pulchellus* and *Ceratotrochus magnaghii* were rarely recorded in the Eastern Adriatic Sea. Serpulides were the most dominant polychaetes. The most frequent sponges were *Axinella damicornis, Acanthella acuta, Agelas oroides, Ircinia dendroides, Cacospongia scalaris, Erylus euastrum, Reniera fulva, Petrosia ficiformis, Crambe crambe, Sarcotragus spinosus* and *Cliona schmidti.* Sponges were less represented in the samples from the Island of Biševo (Fig.1).

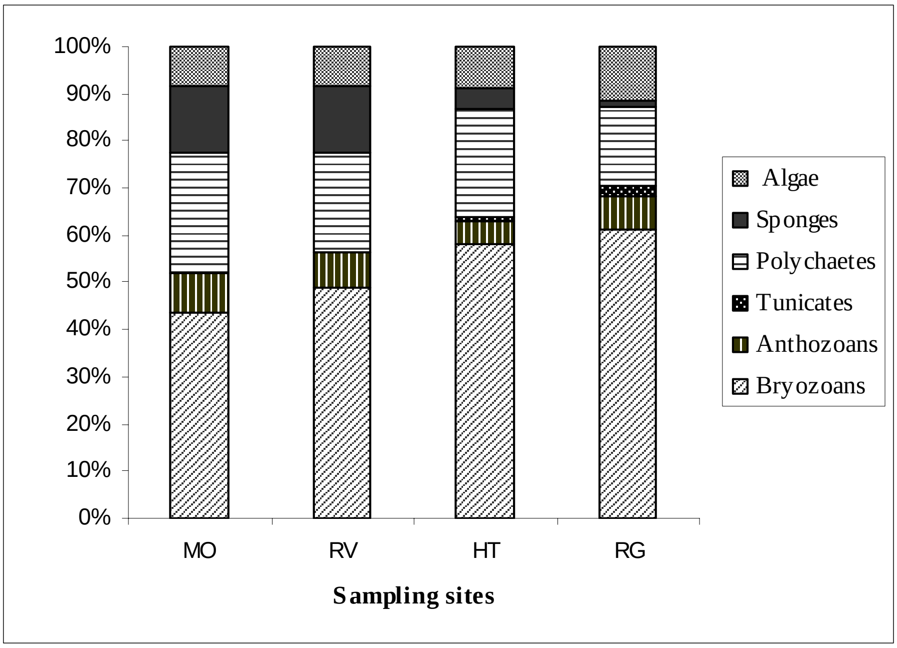

Fig.1: Taxa contribution to species richness of *Paramuricea clavata* assemblage at four sampling sites in the central part of the Eastern Adriatic Sea

The cover of the main macroalgae indicated greater abundance of encrusting red algae at the sites in the Kornati archipelago and greater abundance of green algae (*Flabelia petiolata*, *Codium difforme*) at the sites of the Island Biševo (Tab. 1). Invasive turf-forming filamentous red algae *Womersleyella setacea* was recorded at all sites. It was the least abundant (in terms of percentage cover) at the site MO (0.37 ± 0.47 SD) and the most abundant at the site RG (6.3 ± 12.1 SD)

	Mean abundances (SD)			
	Kornati archipelago		Biševo Island	
Codium difforme	0.1	(0.4)	12.1	(13.7)
Corallinacea indet.	9.6	(7.0)	1.0	(1.4)
Flabellia petiolata	2.4	(3.7)	17.3	(23.0)
Halimeda tuna	< 0.1	(0.1)	0.5	(1.0)
Lithophyllum stictaeforme	12.8	(7.9)	13.1	(10.2)
Peyssonnelia polymorpha	15.0	(10.1)	9.7	(5.9)
Peyssonnelia rubra	< 0.1	(0.1)	0.1	(0.3)
Peyssonnelia squamaria	8.2	(12.7)	2.4	(1.9)
Rodriguezella strafforelloi	0.4	(0.4)	0.5	(0.4)
Valonia macrophysa	0.1	(0.2)	< 0.1	(0.0)
Womersleyella setacea	3.7	(5.4)	5.7	(9.5)

Tab 1. Mean abundances (percentage cover) and standard deviations of the most conspicuous algae found in the *Paramuricea clavata* assemblage in the Kornati archipelago and the Island of Biševo

Non-metric MDS revealed separation of two groups: the Kornati archipelago and the Island of Biševo (Fig. 2).

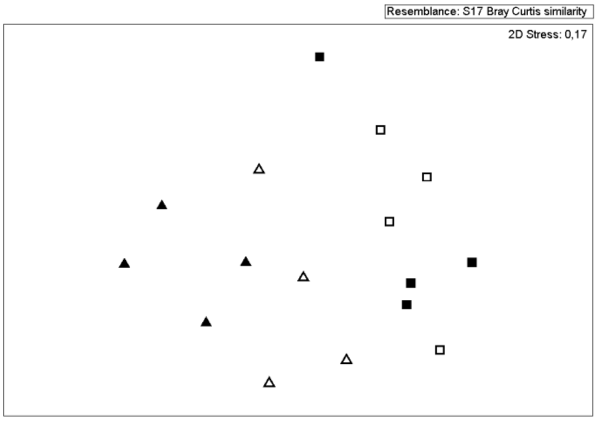

Fig. 2. Non-metric MDS based on the Bray-Curtis similarity matrix calculated from presence/absence data.Triangles = Kornati archipelago; black triangles = Mali Obrucan (MO), white triangles = Rasip Veli (RV). Squares = the Island Biševo; black squares = the east part (HT), white squares=the southwest part (RG)

One-way ANOSIM confirmed the observed discrimination at the level of locations as significant (global R = 0.59, p = 0.001) while difference at the level of sites was not significant. SIMPER analysis indicated 61 taxa that contributed to 60% of the observed dissimilarity of groups. Amongst the first five contributors (individual contributions between 1.27 and 1.54%) were polychaetes *Vermiliopsis infundibulum* and *Pomatoceros triqueter* and anthozoan *Leptopsammia pruvoti* that were more frequent in the Kornati Archipelago while bryozoan *Annectocyma sp*. and green alga *Codium difforme* were more frequent at the Island of Biševo.

DISCUSSION AND CONCLUSIONS

From the taxonomic groups examined, bryozoans made the greatest contribution to the overall species richness, accounting to 39% of the bryozoan taxa recorded on vertical walls in the Eastern part of the Adriatic Sea (Novosel, 2007). Based on species composition, variability was revealed at the level of locations 10s of km apart, emphasizing high heterogeneity of the coralligenous where environmental parameters can vary significantly (Ballesteros, 2006). Differences at the level of sites few km apart were not revealed. Although the invasive algae *Womersleyella setacea* is recorded at all of the sampling sites, its cover is still relatively low, especially at the site Mali Obručan in the Kornati archipelago. The results presented are preliminary; therefore more research of the above mentioned topics is needed. However, the acquired data will be useful for detecting future changes in species composition of this valuable habitat.

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BIOCONSTRUCTIONAL FEATURES OF THE TEMPERATE CORAL CLADOCORA CAESPITOSA (ANTHOZOA, SCLERACTINIA) IN VELIKO JEZERO (MLJET NATIONAL PARK, ADRIATIC SEA)

ABSTRACT

The Mediterranean endemic Cladocora caespitosa *(Linnaeus, 1767) is a colonial scleractinian coral belonging to the family Faviidae and the only zooxanthellate coral from Mediterranean whose colonies may fuse in reef-like structures similar to those in tropical seas. This coral is known as one of the major carbonate producers in the Mediterranean Sea. The* C. caespitosa *bank in Veliko jezero covers an area more than 650 m2, spreads at a depth from 6 to 18 meters, and is thus the largest bank of* C. caespitosa *found to date. The mean linear growth rate of the coral* C. caespitosa*, range from 1.75 to 5.64 mm·year-1 and this results is similar to the typical tropical reef-building corals.*

KEYWORDS: Anthozoa, Coral, *Cladocora caespitosa*, Coral bank, Adriatic Sea, Mediterranean Sea.

INTRODUCTION

One of the major carbonate producers in the Mediterranean Sea is the zooxanthellate and constructional colonial scleractinian coral *Cladocora caespitosa* (Linnaeus, 1767) (Peirano *et al*. 2001). The *C. caespitosa* bank in Veliko jezero (Mljet National Park) covers an area more than 650 m^2 and spreads at a depth from 6 to 18 meters (Fig. 1A, B; 2D) (Kružić, 2002; Kružić & Benković, 2008). The strong sea currents, which occur as a result of tidal exchange in the channel, appear to favor the growth of the bank. Because of the environmental conditions in Veliko jezero, which cause a mass production of particulate organic matter (POM), colonies of *C. caespitosa* have enough food to form sizeable banks.

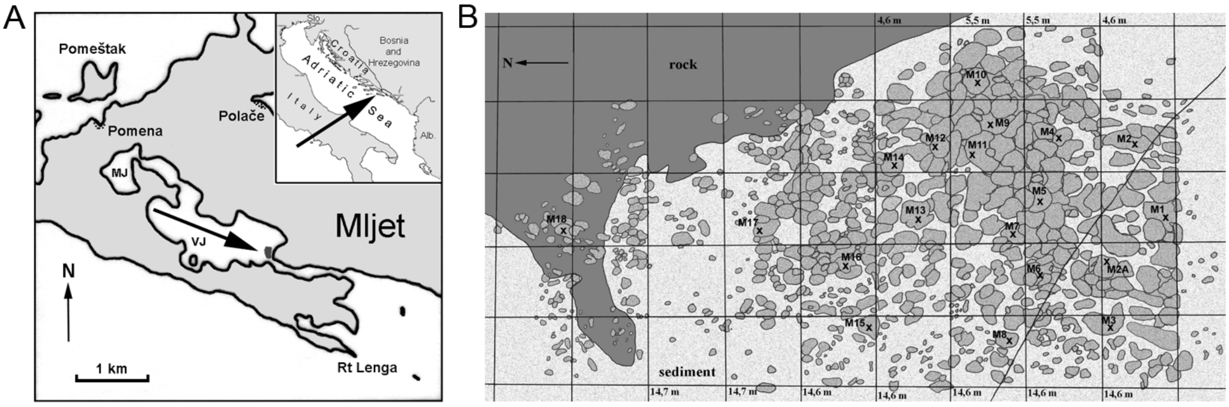


Fig. 1. Map of the National Park Mljet with location of the *Cladocora cae*spitosa bank (arrows) studied in this investigation (A). Map of the *Cladocora caespitosa* bank in Veliko jezero (Mljet National Park) (B) One quadrat is 5 x 5 m.

MATERIALS AND METHODS

The coral bank of *C. caespitosa* was investigated by Scuba-diving from 1998 to 2006. Transect lines marked at 5 m intervals were used to make 25 m^2 frames and all coral colonies inside the frame were counted and outlined. Moving the frame, the whole coral bank was mapped. Up to 500 corallites from the coral colonies were collected from five stations on each bank. For the estimation of corallites growth on the banks, corallites were cleaned of polyp tissue by soaking in a 25% peroxide solution and then X-radiographed with a medical mammograph unit (Siemens mammomat 300) at 30 kv - 25 mAs. The scanned X-ray images of the corallites were analyzed with *Coral XDS* image-analyzing software (Peirano et *al*. 1999). Software measure HD (high-density in winter period) and LD (low density in summer period) bands on the corallites which represents one year of corallite growth (Fig 2C). Having separate corallites, coral *C. caespitosa* provides clear results of density banding. Statistical analysis and statistical graphics were performed using Statistica 7.1 for Windows.

RESULTS

The bottom sea currents at the Mljet bank, because of tidal exchange, ranged up to 0.83 m·sec^{-1} during low tide and up to 1.03 m·sec^{-1} during high tide. The linear growth rate of the coral *C. caespitosa*, range from 1.75 (station M12) to 5.64 mm·year^{-1} (station M5) and this results is similar to the typical tropical reef-building corals (Fig. 2A; Tab. 1).

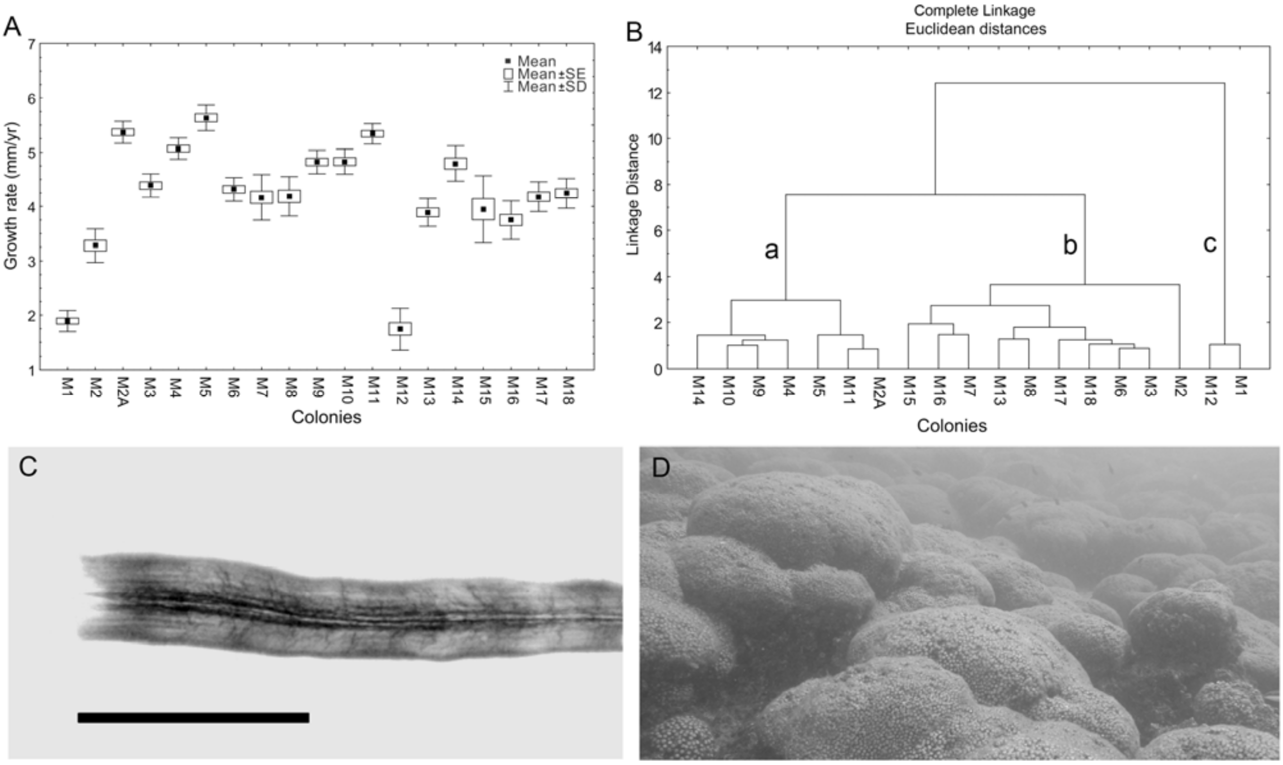
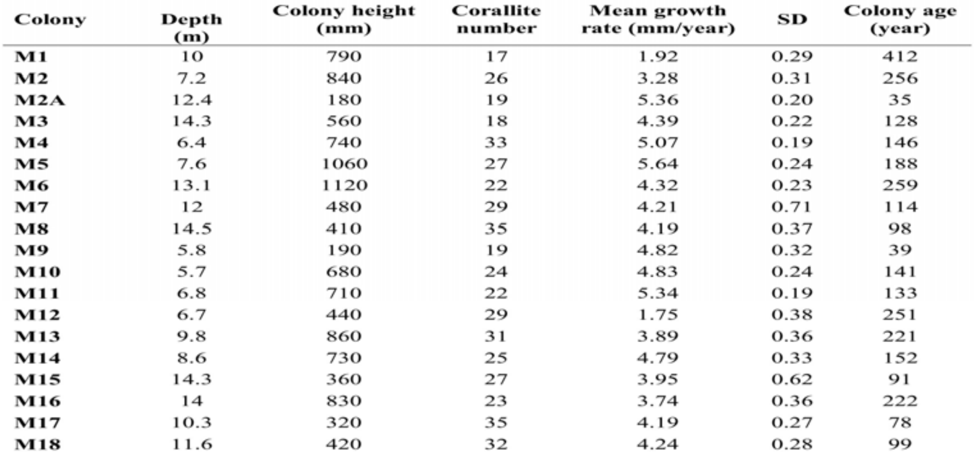


Fig. 2: Mean values of corallite growth rate from investigated colonies (A); results of cluster analysis of corallite growth rate (B); Positive X-rayed image of a corallite of *C. caespitosa* with visible dark (high density) and white (low density) banding. (Bar = 2 cm) (C); *C. caespitosa* bank in Veliko jezero (National Park Mljet) (D).

Significant differences were found between investigated stations at the Mljet bank (ANOVA $p<0.001$; Tukey post hoc test $p<0.05$). Recent sclerochronological analysis on *C. caespitosa* confirmed that the timing of band formation mainly corresponds with seasonal sea temperature. The strong sea currents near the bank appear to favor the growth of the bank. The Cluster analysis showed three groups of colonies; a - medium influence of sea bottom currents; b - low influence of sea bottom currents; c - high influence of sea bottom currents (Fig. 2B).

Tab. 1: Sampling colonies with depth range, colony height, examined corallite number, mean growth rate and estimated colony age.



Colony	Depth (m)	Colony height (mm)	Corallite number	Mean growth rate (mm/year)	SD	Colony age (year)
M1	10	790	17	1.92	0.29	412
M2	7.2	840	26	3.28	0.31	256
M2A	12.4	180	19	5.36	0.20	35
M3	14.3	560	18	4.39	0.22	128
M4	6.4	740	33	5.07	0.19	146
M5	7.6	1060	27	5.64	0.24	188
M6	13.1	1120	22	4.32	0.23	259
M7	12	480	29	4.21	0.71	114
M8	14.5	410	35	4.19	0.37	98
M9	5.8	190	19	4.82	0.32	39
M10	5.7	680	24	4.83	0.24	141
M11	6.8	710	22	5.34	0.19	133
M12	6.7	440	29	1.75	0.38	251
M13	9.8	860	31	3.89	0.36	221
M14	8.6	730	25	4.79	0.33	152
M15	14.3	360	27	3.95	0.62	91
M16	14	830	23	3.74	0.36	222
M17	10.3	320	35	4.19	0.27	78
M18	11.6	420	32	4.24	0.28	99

As these coral masses keep on growing, they incorporate smaller satellite colonies originating in sexual reproduction (settling of the coral larvae) or asexually by fragmentation of the coral colonies. A similar way of coral bank accretion was discussed by Schiller (1993) and Peirano *et al*. (1998). The special environmental conditions in Veliko jezero (Mljet National Park) caused by geomorphological conditions, weak connection with the open sea and strong currents occurring as a result of tidal exchange, are likely to favor the growth of the *C. caespitosa* bank. The absence of physical disturbance in Veliko jezero like storms and waves also helped these coral masses to keep on growing. Because of the environmental conditions in Veliko jezero, which cause a mass production of particulate organic matter (POM), colonies of *C. caespitosa* have enough food to form sizeable banks. Today the major threat to the coral bank in Veliko jezero, apart from the global warming, is the alien invasive green algae *Caulerpa racemosa* (Forsskal) J. Agardh., that grow near the coral bank, threatening to overgrow the colonies.

ACKNOWLEDGMENTS

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POPULATIONS STRUCTURE OF RED CORAL (*CORALLIUM RUBRUM* LINNAEUS, 1758) IN THE AREA OF THE DUGI OTOK ISLAND (EASTERN ADRIACTIC SEA)

ABSTRACT

*The aim of this preliminary study was to quantify the abundance of red coral (*Corallium rubrum *Linnaeus, 1758) in the coralligenous from four sites in the area of the Dugi Otok Island at depths from 30 to 60 m. Two of the studied populations were located in a protected area (Telašćica Nature Park). Highly branched colonies were observed at all four sites during the study. Comparing the population structure of investigated sites in the area of the Dugi Otok Island, significant differences were detected between no protected sites and the sites in the Telašćica Nature Park. Basal diameter, maximum height and branch numbers were significantly higher in populations from Telašćica Nature Park. Depth was also found to have a significantly positive effect on maximum height. The largest colonies were found deeper and exceeded 30 cm height.*

KEY-WORDS: Anthozoa, Red coral, *Corallium rubrum*, Adriatic Sea, Mediterranean Sea.

INTRODUCTION

The condition of red coral populations in the eastern Adriatic Sea was insufficiently studied. Although large scale mortality events (mostly by thermal anomalies) have been documented, harvesting is the major source of disturbance in red coral populations in the Adriatic Sea. Amongst the anthozoans, red coral (*Corallium rubrum* Linnaeus, 1758) is exploited commercially in almost all Mediterranean countries and its stocks have strongly declined in most areas, mainly in shallow waters. Red coral is typically associated with the animal dominated communities growing in dim light conditions that characterize the smaller cavities, vertical cliffs and overhangs. Demographic studies have been a valuable tool to determine the state of octocoral populations (Santangelo *et al.*, 2004; 2007). In red coral the size/age structure has been found to be shifted towards young individuals by lacking older and larger ones (Santangelo *et al.*, 2004). Luckily, there are some places where red coral populations are still untouched.

MATERIALS AND METHODS

The research presented here was carried out in the central part of the eastern coast of the Adriatic Sea. In the past the sea around Dugi Otok Island has not been a subject of extensive scientific research and only scarce information on the marine benthos has been available (Kružić, 2007). The southern part of Dugi Otok Island is protected area (Telašćica Nature Park). Four locations around the Dugi Otok Island were selected; two in the Telašćica Nature Park (DO 1 and DO 2) and two near the Iž Island (IZ 1 and IZ 2) (Fig. 1; Tab. 1.). Samples were collected by SCUBA diving on rocky bottom between 30 and 60 m depth. At all four stations red coral grows on semidark overhangs or in crevices forming small and disperse patches. A 25 cm x 25 cm quadrat was used to count colony density. The biometry of red coral was studied more by photographic sampling than collecting. Collected specimens were first preserved in 4% formalin and later transferred to 70% ethanol. Statistical analysis and statistical graphics were performed using Statistica 7.1 for Windows. All collected samples of red coral from the investigated stations are deposited in the research collection at the Department of Zoology, Faculty of Natural Sciences in Zagreb.

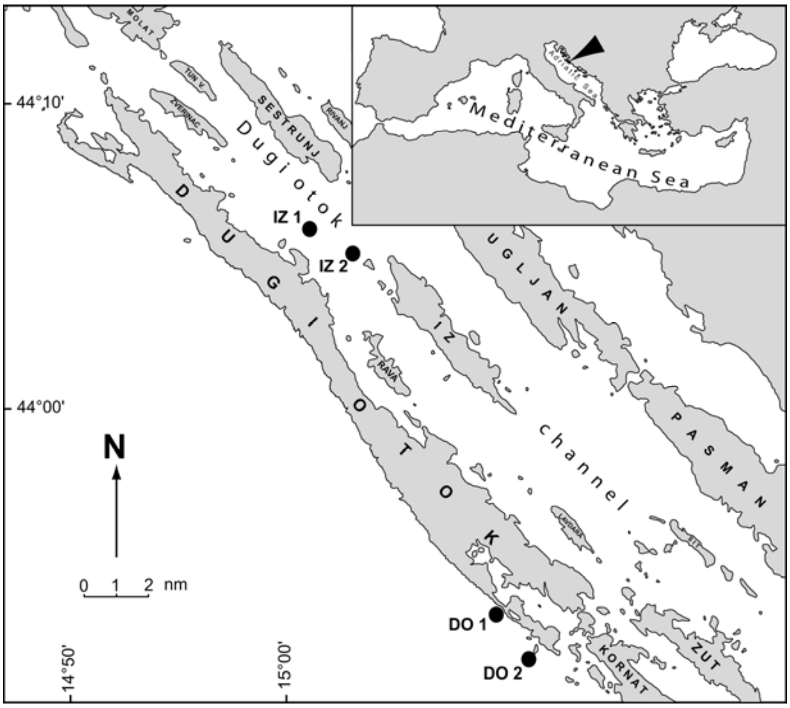

Fig. 1: Map of the Dugi Otok Island showing the location of the sites studied.

RESULTS

The sea temperature measured at depths of investigated stations near Dugi Otok ranged from 11.7 °C in winter to 12.4 °C in summer and near Iž Island from 12.9 °C in winter to 15.3 °C in summer. Highly branched colonies were observed at all four sites during the study (Tab. 2.). The population abundance from the studied sites ranged from 5.83 to 18.62 colonies per m2. Comparing the population structure of investigated sites in the area of the Dugi Otok Island, significant differences (ANOVA, $p<0.001$) were detected between no protected sites (Iž Island) and the sites in the Telašćica Nature Park (Fig. 2A, B, C.). Basal diameter, maximum height and branch numbers were significantly higher in populations from Telašćica Nature Park. Depth was also found to have a significantly positive effect on maximum height. The largest colonies were found deeper and exceeded 30 cm height. The basal diameter from the studied sites ranged from 6.62 to 17.46 mm. A sign of predation has been observed in studied colonies of *C. rubrum*, mostly by gastropod *Pseudosimnia carnea* (Poiret, 1789).

Tab. 1: Sampling stations with coordinates and depth range.

Sampling areas	Coordinates	Depth range (m)
Dugi Otok Island (DO 1)	43°52`58"N 15°09´57" E	56-60
Dugi Otok Island (DO 2)	43°51`56"N 15°10´50" E	57-59
Iz Island (IZ 1)	44°06`05"N 15°00´21" E	30-32
Iz Island (IZ 2)	44°05`01"N 15°02´56" E	36-38

Tab. 2: Differences in branch numbers of different orders among investigated red coral populations.

Sampling areas	Mean branch number ± SD			
	Primary	Secondary	Tertiary	Quartiary
Dugi Otok Island (DO 1)	3.8 ± 2.1	4.7 ± 3.1	2.8 ± 1.7	1.2 ± 1.6
Dugi Otok Island (DO 2)	3.5 ± 2.5	5.1 ± 3.9	2.3 ± 1.9	0.9 ± 1.1
Iz Island (IZ 1)	2.6 ± 1.9	2.7 ± 1.9	1.7 ± 1.0	0.3 ± 0.7
Iz Island (IZ 2)	2.8 ± 2.4	3.1 ± 2.4	1.8 ± 1.9	0.1 ± 0.6

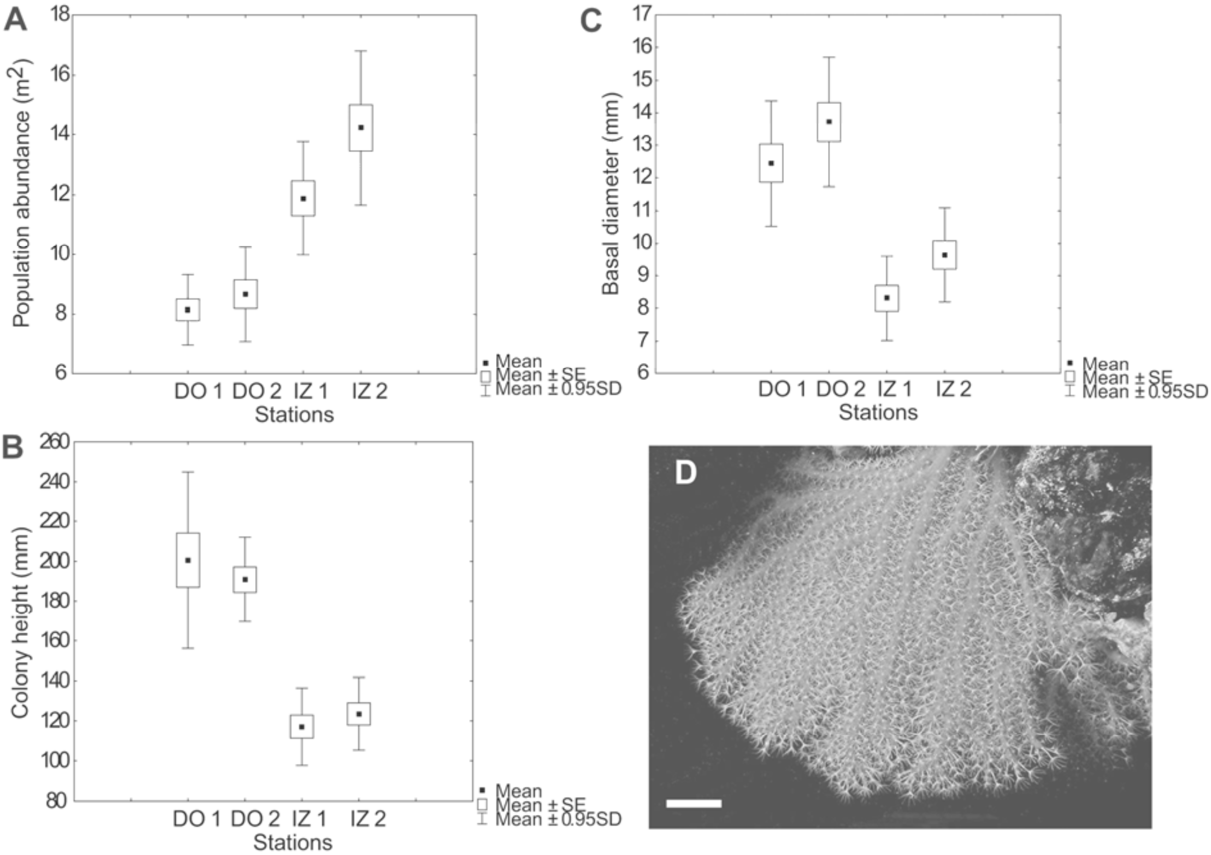

Fig. 2: Mean values of population abundance (A), colony height (B) and basal diameter (C) of the red coral populations from the investigated stations. D. Red coral colony from the station DO 2 (Bar = 2 cm).

CONCLUSIONS

The objective of this preliminary research was to increase knowledge on the population structure of red coral in the Adriatic Sea and to use these data to evaluate the efficiency of current management strategies of this endangered species. The red coral populations near the Iž Island grow in much shallower water than they do in the Telašćica Nature Park. The deeper populations from investigated sites in the Telašćica Nature Park showed higher biometrical values, but lower population abundance. These preliminary results may help to better understand the significant differences in the vertical distribution of red coral in different regions of the Mediterranean.

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THE BIOCONSTRUCTIONAL BRYOZOAN *PENTAPORA FASCIALIS* (PALLAS, 1766)

ABSTRACT

The erect, robust-carbonate bryozoan Pentapora fascialis (Cheilostomata) is a conspicuous subtidal species colonising hard rock substrates, boulder areas and also other living species from 1 m depth down to 60 m or more. It is responsible of biogenic structures made by groups of carbonate colonies that can form extensive "micro-reef" constructions up to 7 m across that provide living space for other species. Colonies of P. fascialis have been collected from environments with contrasting seasonalities in different NW Mediterranean localities. An overview on morphological, distributional, molecular, mineralogical and geochemical analyses is reported, as well as considerations on the role of the species as carbonate producer.

KEY-WORDS: carbonate bryozoan, *Pentapora fascialis*, bioconstructional role, NW Mediterranean

INTRODUCTION

The bryozoan *Pentapora fascialis* develops erect foliose structure, 20–30 cm in diameter, occasionally up to 80 cm (Cocito *et al.*, 1998; Novosel *et al.*, 2004). The colonies can develop into large reef-like constructions that provide living space for other species, thereby increasing the diversity of habitats where they occur. It expands along the western coast of Britain as far north as the Hebrides, southwards into the Western Mediterranean, with records in the Adriatic and Ionian seas and along the coast of Tunisia (Hayward & Ryland, 1999; Mustapha *et al.*, 2002). *P. fascialis* is a distinguishing species of the 'facies with large branching Bryozoa' among the biocenoses of the coastal detritic bottoms of the circalittoral zone and occurs within different *facies* of the coralligenous. Moreover, the species has an important role as benthic carbonate producer (Cocito & Ferdeghini, 2001; Lombardi *et al.*, 2008). Considering the wide distribution of the species and its importance as bioconstructor organism, an overview on the distributional, morphological, mineralogical, geochemical and molecular aspects is reported.

MATERIALS AND METHODS

The campaigns were carried out from 2001 to 2003 in 15 localities along the western coast of Italy, from the Ligurian Sea to the Sicily Channel, and 2 localities in the north eastern Adriatic (Croatia). Both in situ measurements, using transect lines and counting in replicate quadrats (1 m^2), and sample collection were made at each location. Since 2003, morphological (optical microscope, SEM, FESEM), distributional, mineralogical (x-ray diffractometry) and geochemical aspects (thin section, element mapping) of *P. fascialis* have been investigated. Molecular analyses are currently underway.

RESULTS

MORPHOLOGY AND DISTRIBUTION. Colonies of *P. fascialis* were usually characterized by two morphologies: foliaceous laminae and dichotomic branches (Fig. 1). Also zooids with different morphology and function, which are commonly found within *P. fascialis* colonies, had different features in foliaceous laminae and dichotomic branches. Pending molecular analysis will clarify the level of genetic differentiation between the two colony morphologies. Colonies with foliaceous laminae reached large size (> 20 cm, up to 80 cm of diameter) and frequently occurred on hard bedrocks and rock/boulder seabed habitat types. Dichotomic branched colonies grew epizooically and the main substrate for attachment of colonies was provided by the branches of gorgonians and by sponges. Colony density resulted > 2 colonies/m^2 in 8 out of 17 localities investigated, up to a maximum of 7.8 ± 0.5 colonies/m^2 at Tino Island (Ligurian Sea). The shallowest record (1 m) was found at Ždralova (Adriatic Sea). Along the Italian coasts superficial colonies were found at 11 m in the Ligurian Sea (Tino Island) and Tyrrhenian Sea (Capo Tegge), the deepest colonies occurred down to 60 m depth (Formiche Islands and Capo Barbi) in the Tyrrhenian Sea.

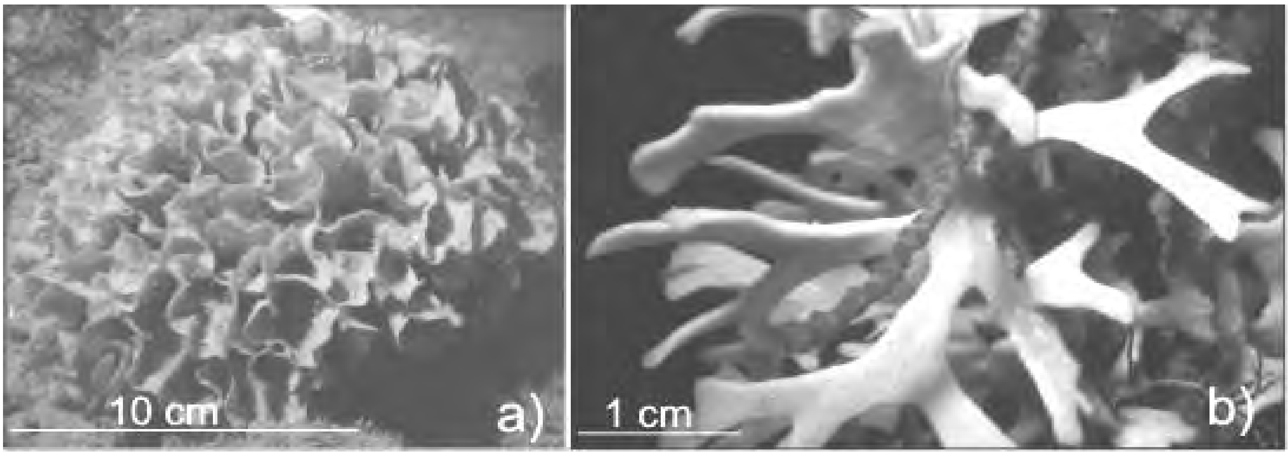

Fig. 1: a) *P. fascialis* colony bearing foliaceous laminae; b) *P. fascialis* colony with dichotomic branches.

MINERALOGY, GEOCHEMISTRY AND CARBONATE PRODUCTION. *P. fascialis* produced a bimineralic skeleton, i.e. a mixture of aragonite and calcite. On average colonies from all localities analysed had wt.% 73 aragonite and wt.% 27 calcite with a certain degree of variability. The aragonite content was mainly found within the zooid frontal wall. Mapping of minor elements and morphological analysis allowed to recognize two distinct layers within the frontal wall. Vertical section of the frontal shield showed an inner thin layer that transitioned into an outer thicker one. Distribution of minor elements revealed that both layers were composed by calcium but the content of magnesium increased from the outer to the inner layer. *P. fascialis* carbonate standing stock was remarkably high at Grmac and Ždralova (Croatia) where colonies grew in proximity of underwater freshwater springs, whereas at distance from the springs values were comparable (559-1,240 g/m^2 $CaCO_3$) with a few Italian localities.

DISCUSSION AND CONCLUSIONS

The investigation on the large-scale distribution and growth habits of *P. fascialis* along the western coasts of Italy and in the peculiar setting of the karstic underwater area in the north-eastern Adriatic Sea (Novosel *et al*., 2004) revealed that colonies, occurring at a depth range of 1 to 60 m, are an important part of the sessile carbonate benthos. Most of the bryozoan colonies were found in current swept areas, particularly at capes, shoals and banks. Small colonies bearing slender, dichotomous branches and growing epizooically may represent an adaptive response to conditions where colonies live in a multidirectional flow. Large colonies with expanded thick laminae may be a response to the increased capacity to withstand flow stress, allowing colonies to take advantage of strong laminar currents. In accordance with previous reports, we found the most frequent size class to be 10 to 20 cm in colony diameter, and biggest colonies (up to 80 cm) growing on hard bedrocks and rocky bottoms. Mineralogy of *P. fascialis* confirmed the bimineralic composition of colonies with a certain degree of variability. The difference in wt.% aragonite could be attributable to the different thermal regimes, giving support to the hypothesis that aragonite deposition is function of seawater temperature (Lombardi *et al*., 2006). *P. fascialis* has been confirmed to be one of the most important carbonate framework builder of the temperate sublittoral benthic species (Cocito & Ferdeghini, 2001), with carbonate standing stock ranging between 240 – 1,255 g $CaCO_3 \cdot m^{-2}$. Difference in seasonalities among localities could influence annual growth rate and thus differently contribute to variations in carbonate production of the bioconstructional bryozoan.

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ASSESSING THE EFFECT OF DIVERS ON BRYOZOAN SPECIES

ABSTRACT

Coralligenous community presents a high diversity in the Mediterranean where it forms the main biogenic construction made by skeletons of animals and calcareous algae. Recreational divers may unintentionally produce abrasive impacts in this key community, breaking the skeletons of benthic algae and invertebrates. Many of these species are particularly vulnerable to mechanic impacts due to its elevated fragility and to extremely low turnover rates, which causes a very slow recovery after any loss of biomass.

The bryozoan species Myriapora truncata *and* Pentapora fascialis *are very sensitive to this kind of impact. Therefore, in order to evaluate the effect of recreational diving on these species, we compared, during two years, three locations regularly used by diving centres with three unfrequented locations. Additionally, we sampled at two different times: before and after the main diving season. We used uunderwater photography to obtain an appropriate number of samples of an adequate size in a suitable diving time.*

After analyzing 3056 images differences were found in the number of colonies, occupied surface and in the exposition and aggregation level at locations under different diving pressure. Moreover, differences were also observed between the two sampling times (before and after the diving season) throughout the two sampling years.

KEY-WORDS: scuba diving impact, underwater photography, *Myriapora truncata*, *Pentapora fascialis,* coralligenous

INTRODUCTION

Coralligenous assemblages are characterized by richness, biomass and production, with comparable values to tropical reef assemblages, so that it can be considered one of the most important and characteristic assemblages of the Mediterranean Sea (Bianchi, 2001). Despite its complexity, the coralligenous system is considered fragile, as its persistence is related to the maintenance of peculiar biotic and abiotic factors (Hong, 1983) and because contain many sessile, long-live organism with fragile skeletons and slow growth rates (Laborel, 1961; Ros *et al*., 1985). This high diversity of organisms and colourfulness of these habitats make them more attractiveness for divers (Lloret *et al.*, 2006).

Divers can easily damage marine organisms through physical contact with their hands, body, equipment and fins (Talge, 1990, 1992; Rouphael & Inglis, 1995; Rouphael & Inglis, 1997; Tratalos & Austin, 2001; Zackai & Chadwick-Furman, 2002; Pulfrich *et al*., 2003; Uyarra & Côté, 2007) causing breakage, fragmentation or abrasion effect on tissue (Tilmant & Schmahl, 1981; Tilmant 1987, Hawkins & Roberts, 1992, 1993; Garrabou *et al.*, 1998; Calvisi *et al.*, 2003 ;Coma *et al.*, 2004).

Many of these species are particularly vulnerable to mechanic impacts, due to its elevated physical fragility and to an extremely low turnover rate (Zabala & Ballesteros ,1989; Ballesteros, 1992; Coma, 1994), which causes a very slow recovery after any loss of biomass (Sala *et al*., 1996).

This work focuses in two bryozoan species, *Myriapora truncata* and *Pentapora fascialis,* that are very sensitive to this kind of impact.

MATERIEL AND METHODS

The present study was carried out in Sierra Helada Natural Park, off the Mediterranean coast of south-east Spain(Fig.1). The surveys were conducted by SCUBA divers before and after of peak diving activity (June and October), during two years (2006 and 2007). Six sampling localities were established inside the marine park limit: two impacted locations were placed where most of the diving activity is concentrated and the others two locations in unusual diving areas were considered control locations. At each locality six metal screws marked the centre of each permanent circular plot of 4 meters diameter (covering 50.26 m2). All bryozoans colonies which were in the permanents plots were photographed. After analyzing 3056 photography with Image-J software, we calculated for each colony in each sampled site: occupied surface, diameter, level of aggregation and level of exposition (Figs. 2 and 3). Data were analyzed by ANOVA. Our design for the main experiment involved four factors, and corresponded to a split-plot or repeated-measures design.

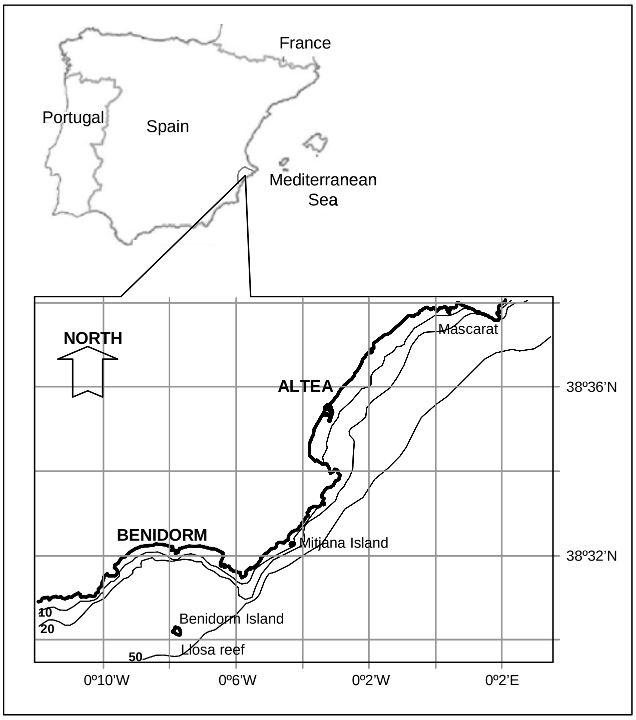

Fig 1.: Location of study area

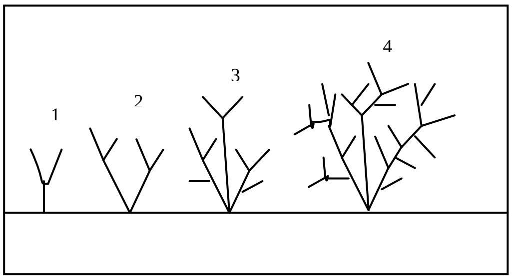

Fig 2.: Level agregation of briozoans colonies

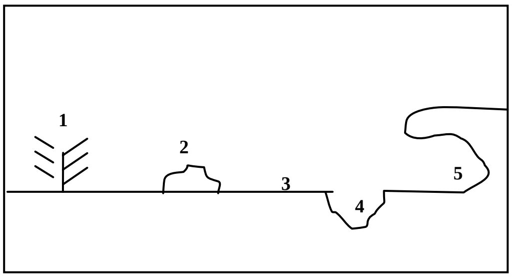

Fig 3.: Level exposition of briozoans colonies

RESULTS & DISCUSSION

Pentapora fascialis

We found a higher number of colonies, with higher surface and diameter in the undived sites than dived sites (Fig. 4). The two only level expositions in unfrequented localities were 1 and 2, where the colonies are more exposed. In impacted localities, after summer, those parameters decreased or even the colonies disappeared.

The colonies in impacted localities were found in exposition levels 4 and 5, more shelter sites, and in the control sites were found only in levels 1 and 2, more exposed.

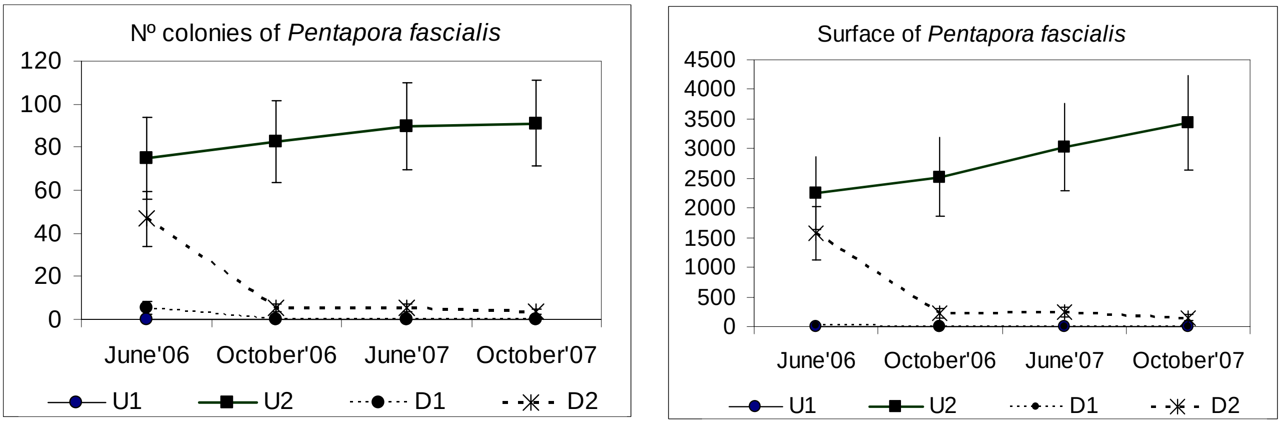

Fig 4.: Mean density (nºcolonies/replicate) and surface (cm2/replicate) of *Myriapora truncata* colonies at unfrequented (U1, U23) and dived (D1, D2) localities.Bars indicate the standar error.

Myriapora truncata

Density and surface of colonies was higher at unfrequented diving localities than in frequented localities. Also, those variables decreased after the diving season in the diving sites and increased in the unfrequented sites (Fig. 5).

The colonies in unfrequented sites were distributed in all positions and for dived sites were found, mainly, in levels 4 and 5. The fragile colonies in impacted localities may be in this cryptic position because in exposed places they are more exposed at physic impact.

In control localities, were found more colonies in 2, 3 and 4 level of aggregation instead 1 and 2 were the most frequently levels aggregation at frequented diving localities.

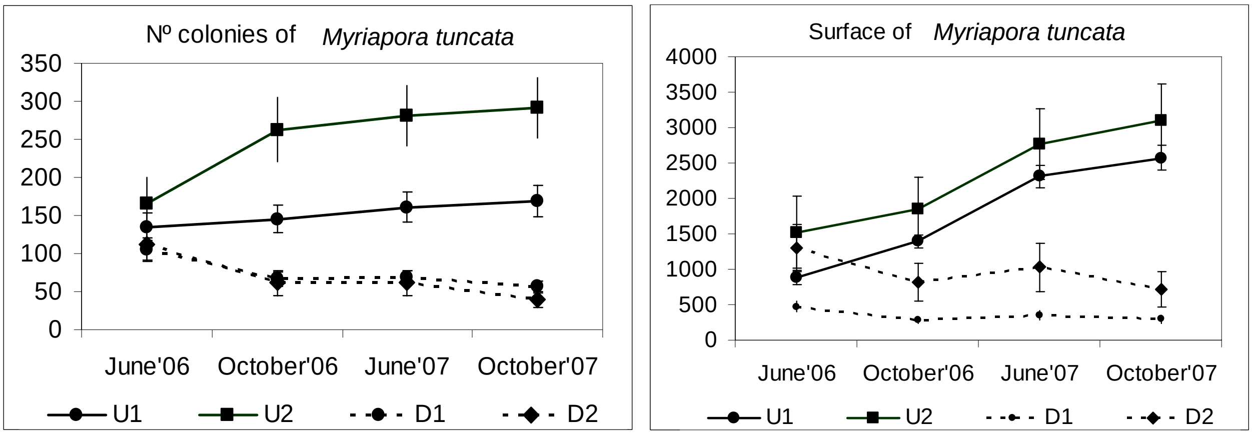

Fig 5.: Mean density (nºcolonies/replicate) and surface (cm2/replicate) of *Myriapora truncata* colonies at unfrequented (U1, U2) and dived (D1, D2) localities.Bars indicate the standar error.

CONCLUSION

Scuba diving produces a negative effect on the bryozoan community. Density and surface of colonies are reduced by the practise of diving and normal development at mature states more complex is impeded too. Constant pulses of impact on the bryozoans community may produce abrasion and breakage of tissues, which hinder a growth to more complex forms.

Moreover, the colonies in this frequented diving sites occupied more cryptic and less exposed locations. Filter feeding organism ideally prefer occupy site where the water flow is major, more exposition places, as occurred in less frequented sites where the risk to be broken is minor. Despite in the more frequented sites, those locations more exposed is more vulnerably at mechanic impact of divers and for this reason their occurrence in those sites more exposed is minor in those sites.

For all exposed, we proposed the use of *Myriapora truncate* and *Pentapora fascialis* as indicator useful and easy measurable for monitoring the scuba diving impact with a non destructive sampling method.

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A MEDITERRANEAN CORAL SPECIES IN THE DARDANELLES (MARMARA SAE – TURQUEY)

ABSTRACT

In this research, the Mediterranean coral species Cladocora caespitosa *(thin tube coral) was studied. This is the first report on this species in the Dardanelles (Marmara Sea-Turkey). In August 2008, we found the existence of the scleractinian coral* Cladocora caespitosa *in the Dardanelles (Marmara Sea, Turkey) as large groups between the Posidonia oceanica beds in seven metres under water. To be sure the occurence of the species in the field, we used Manta-tow technique first for searching the area. After this study, we found several communities of* Cladocora caespitosa. *Only three populations of* C. caespitosa *were macro-photographed with an underwater video camera by using scuba equipment and the coordinate that the species exists was taken by GPS (Global Positioning System).*

KEY-WORDS: Turkey, *Cladocora caespitosa*, Dardanelles, Scleractinian, Scuba

INTRODCUTION

The species *Cladocora caespitosa* is an only scleractinian coral of the Mediterranean Sea and occurs throughout the Mediterranean (Zibrowius, 1980). It has an existence also in the Aegean Sea.

Kingdom: Animalia
Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia
Family: Caryophylliidae
Genus: Cladocora
Taxon: Cladocora caespitosa (Linnaeus, 1758)

Cladocora caespitosa Linnaeus,1758 is an zooxantellate coral of the Mediterranean Sea, abundant both in the geological past and in recent times (Peirano *et al*, 1998). This occurence of the species is dated back to the late Pliocene. it is usually found in smaller colonies of a few hundred polyps. In some areas of the Mediterranean, they can spread to the significant zones. *Cladocora caespitosa* is mostly found in the areas which take a good sun light, but some colonies can also be lived in deep water.

MATERIEL AND METHODS

Several populations of the species *Cladocora caespitosa* were found in the Dardanelles, the coast of Dardanos Campus. To find the populations, the coast of Dardanos was searched using Manta-tow technique by boat. The coordinate that the species exists was recorded by a scientist on the boat. The first coordinates were 40º4'16" North and 26º21'68" East. The population was located in seven metres. By using scuba, the diver had pictured each three colonies and had taken video recording in the area.

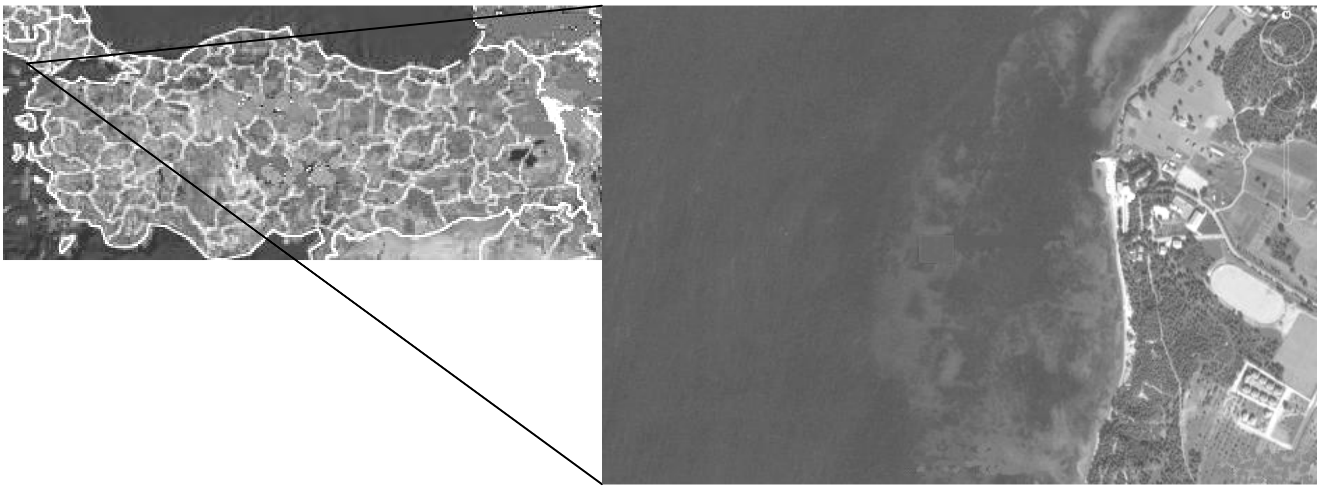

Fig 1. Red spot is showing the existence of *Cladocora caespitosa* in the Dardanelles, Turkey. The area is placed in front of the coast of Çanakkale Onsekiz Mart University Dardanos Campus.

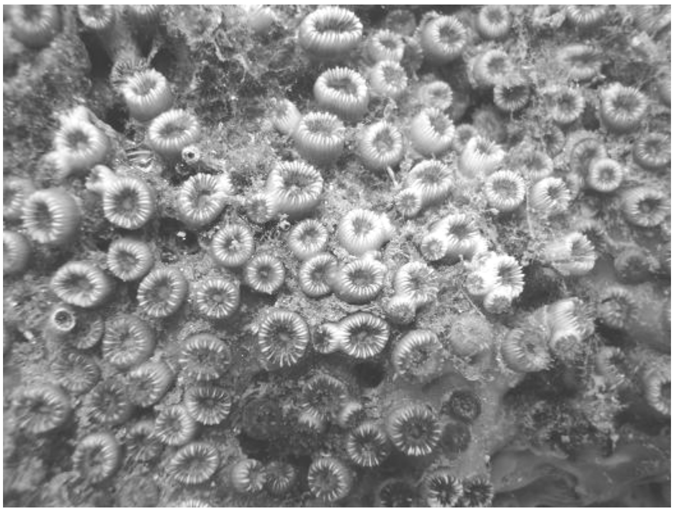

Fig 2. Photo of *Cladocora caespitosa* taken from 7 metres in the Dardanelles (First photo taken from the Dardanelles-Marmara Sea,Turkey)

RESULTS

In the Scientific References, especially in the Turkish Journals and Scientific Books, there is no record about the existence of this species in the Dardanelles,(Marmara Sea), although there are some informations that the species is existed in the Mediterranean and the northern Aegean Sea, Gökçeada Island (Öztürk 2004). In another scientific study, the species *C.caespitosa* was found in the northern Aegean Sea,(İzmir-Turkey),in 1.5 metres (Çınar, 2003). This study shows that the spreading area of *Clodocora ceaspitosa* has globally increased from the Mediterranean Sea to the Dardanelles, the Marmara Sea. We found the species also in the Dardanelles which is in very important situation as a strait system.

DISCUSSION AND CONCLUSIONS

Cladocora caespitosa is an important coral species providing evidence about the past climatic changes. Because of this property, studying on this species is needed and is very considerable for learning the past climatic datas of the Dardanelles.

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PRELIMINARY DATA ON RED CORAL *CORALLIUM RUBRUM* (LINNEO, 1758) POPULATION OF SARDINIAN SEA (WESTERN MEDITERRANEAN)

ABSTRACT

Corallium rubrum *(Linneo, 1758) (Gorgonacea: Octocorallia) is a precious octocoral that has been harvested for a long time in the Mediterranean and neighbouring Atlantic coasts. Nowadays the knowledge of this resource in Sardinia is very scanty. The aim of the present work is to give a preliminary description of the red coral population picked up within a depth range from 93 to 107 m. A total of 2351 samples (total weight of 204.7 kg) were collected in 2007 and 2008 by professional coral fishermen.*

No statistical differences between the biometric parameters (diameter, height and weight) of the two studied years (chi square test; P>>0.05) were observed. The basal diameter of the examined colonies ranges from 4.8 to 24.1 mm in 2007 and from 4.1 to 19.8 mm in 2008. The mean height obtained was 16.17±4.22 cm in 2007 and 15.63±4.23 cm in 2008, while the mean weight was of 41.48±40.58 g in 2007 and 39.73±35.02 g in 2008. Also the estimated mean age of colonies for the two years doesn't show any differences (28.59±7.87 years in 2007 and 27.33±6.62 years in 2008).

KEY-WORDS: Exploitation, Scuba diving, Management, Western Mediterranean

INTRODUCTION

Renewable resources have always been exploited by fishermen. These resources suffer the increasing number of human-induced disturbances over the last decades (Bostford *et al.*, 1997; Harvell *et al.*, 1999; Jackson *et al.*, 2001). Among these disturbances the overfishing is known to reduce size and abundance of resources (Dayton et *al.*, 1995; Jennings & Kaiser, 1998).

The red coral, *Corallium rubrum* (Linnaeus, 1758), is one of the most vulnerable resources in the Mediterranean Sea. This vulnerability is because *C. rubrum* is long lived, has a slow growth, a low fecundity and a late sexual maturity (Grigg, 1989). For these peculiarities red coral has sustained the effects of an immoderate exploitation. Nonetheless this resource is still considered abundant in the northwestern Mediterranean Sea (Torrents *et al.*, 2004).

First notes about harvesting of red coral in Sardinia date back to XI century (Doneddu & Fiori, 2003), however nowadays there isn't enough knowledge about the condition of this resource. The aim of this study is to give a preliminary result about the population structure of red coral in northern Sardinian sea (Western Mediterranean).

MATERIALS AND METHODS

The studied population is located along the Western Sardinian coast, in the Sardinian sea (Western Mediterranean) between Su Pallosu (OR) and Alghero (SS) (40°08.828'N, 8°19.598'E; 40°29.371'N, 8°15.379'E) (Fig. 1).

Samples were collected from July to October 2007 (26 scuba dives), and in May 2008 (9 scuba dives). The survey took place within a depth range from 93 m to 107 m.

All colonies were picked up by professional coral fishermen following the regional set of rules enacted in 2006 (DPR 16/V 22/05/06). According to the regulations, colonies were taken only by pick, performing a choice of commercial size.

On each entire colony biometric parameters were measured as in Garcìa-Rodrìguez and Massò study (1986): basal diameter (2 cm from the base, ± 0.01 mm); colony height (from the basis to the tip of the longest branch); colony weight (after drying of the colony and elimination of eventual rock portions, ± 0.01 g).

The estimation of the age of the colonies from basal diameter for each year according to Marschal et al., 2004 was made.

To compare the frequency distributions of biometric parameters and the estimations of the age obtained between the two different years, the chi square test was used (Zar, 1999).

RESULTS

The basal diameter of the examined colonies ranges from 4.8 to 24.1 mm in 2007 (mean value: 10.01±2.75 mm) and from 4.1 to 19.8 mm in 2008 (mean value: 9.56±2.32 cm). Frequency distribution of this parameter shows a similar modal value in the two years: between 9-10 mm in 2007 and between 8-9 mm in 2008 (Fig. 2). The height too shows similar values in the two analyzed years, with mean values of 16.17±4.22 cm in 2007 and 15.63±4.23 cm in 2008 (Tab. 1). The maximum frequency occurs between 15-16 cm in 2007 and between 14-15 cm in 2008. The weight of colonies shows the higher variability among measured parameters, ranging from 4.51 g to 465.3 g in 2007 and from 3.35 g to 515.29 g. The maximum amount of samples is observed in the class of 15-20 g in 2007 and 20-25 g in 2008 (Tab.1). Only few colonies with weight over 460 g were collected. No statistical differences between the biometric parameters of 2007 and 2008 were observed (chi square test; P>>0.05).

The minimum age estimated is 12 years (basal diameter of 4.1 mm) whereas the maximum age is of 69 years (basal diameter of 24.1 mm).The estimated mean age of colonies is very similar in the two analyzed years: 29±8 years in 2007 and 27±7 years in 2008. As expected, no statistical differences were observed (chi square test; P>>0.05).

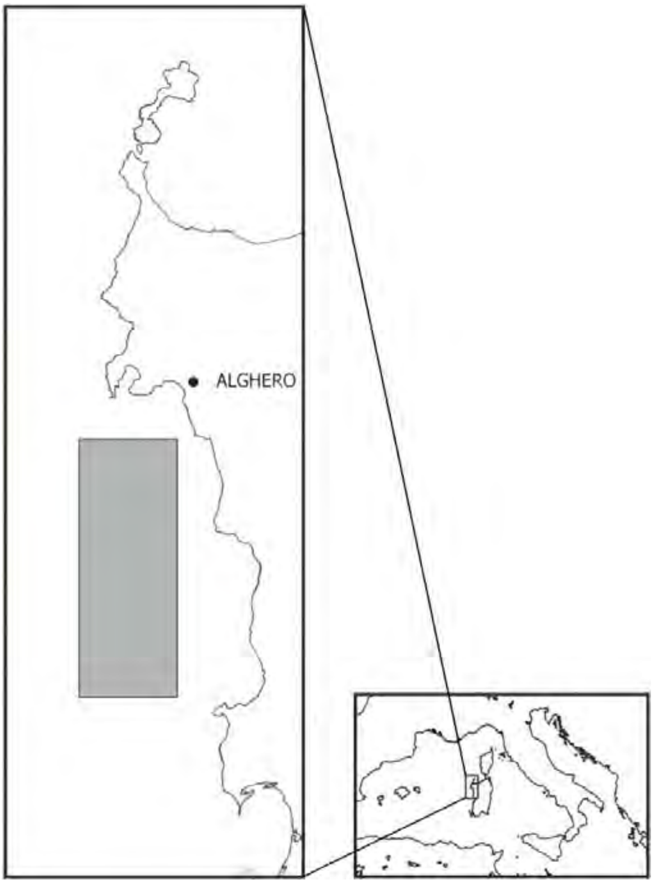

Fig. 1: Geographical position of the study area. The grey rectangle shows the survey site

Tab. 1: Minimum (min), maximum (max), mean value (m) and standard deviation (sd) of diameter (d), height (h) and weight (w) for *Corallium rubrum* in 2007 and 2008

2007	min	max	m	sd
d	4.80	24.10	10.01	2.75
h	4.60	36.88	16.17	4.22
w	4.51	465.30	41.48	40.58
2008	min	max	m	sd
d	4.10	19.80	9.56	2.32
h	6.46	34.12	15.63	4.23
w	3.35	515.29	39.73	35.02

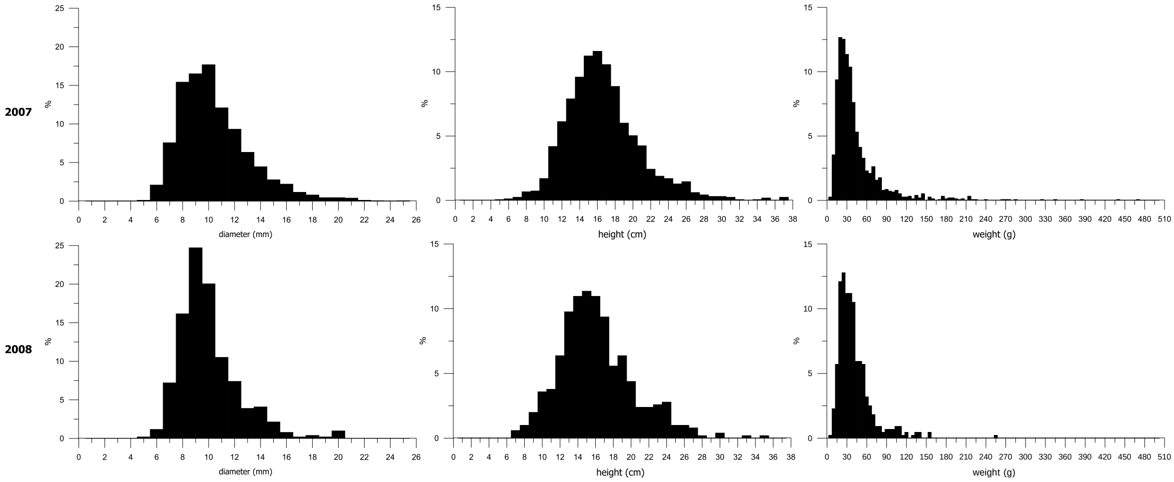

Fig. 2- Frequency distributions of diameter, height and weight for *Corallium rubrum* in 2007 and 2008

CONCLUSION

These results represent the first description of the population structure of red coral in the North Western Sardinia.

The studied population appears well represented in the two considered years, showing the same pattern distribution of the biometric parameters observed in Garcìa-Rodrìguez and Massò, 1986 for the Spanish waters. The biggest variability is observed for colonies weight where the bulk of individuals weighted not more than 120/130 g but heaviest individuals were caught, mainly in 2007. No relevant change is found on the structure of *C. rubrum* population in the two analysed years.

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DECADAL MONITORING OF CORRALIGENOUS AND BIOCONSTRUCTION ORGANISMS IN THE EASTERN LIGURIAN SEA (NW MEDITERRAEAN)

ABSTRACT

Since 1991, the activities of the laboratory of benthic ecology of the ENEA Marine Research Centre of La Spezia (Italy) are centred in the Eastern Ligurian Sea (NW Mediterranean) and focused on coralligenous assemblages and bioconstructional organisms. Changes of coralligenous assemblages and long-lived species have been monitored by means of short (annual) to medium (decadal) scale studies. Two bioconstructional species, the bryozoan Pentapora fascialis *(Pallas) and the coral* Cladocora caespitosa *(Linnaeus), which form some of the most relevant carbonate frameworks in the Mediterranean Sea, are particularly abundant in the area. The study area includes two locations, recently established as protected areas: the 'Cinque Terre' MPA and the Regional Natural Park in the Gulf of La Spezia.* *Since 1999, both coralligenous assemblages and bioconstructional organisms have experienced the repetition of mortality events. The gorgonian* Paramuricea clavata *(Risso) was the most affected species showing a dramatic reduction of colony density. Also the huge colonies and beds of* C. caespitosa *exhibited reduction in size or, sometimes, total death. The bryozoan* P. fascialis *displayed necrosis and decrease of colony average size. These effects could be related to high summer temperatures and the invasion of alien species such as* Caulerpa racemosa *(Forsskål) J. Agardh* var. cylindracea *(Sonder) Verlaque, Huisman et Boudouresque. The species acts detracting substrata previously colonised by coralligenous assemblages or suffocating the colonies of bioconstructional organisms.*

KEY-WORDS: Coralligenous, bioconstructions, mortality, invasive species, Ligurian Sea

INTRODUCTION

Long-term monitoring and analysis of decadal time series are crucial in the present and future assessment of coastal ecosystems (Pernetta, 1994). Since 1991, the activities of the laboratory of benthic ecology of the ENEA Marine Research Centre of La Spezia (Italy) are focused on coralligenous assemblages and bioconstructional organisms. Here we report the main results on health status and major changes, mainly related to climate change, of target long-lived species and coralligenous assemblages in the Eastern Ligurian Sea (NW Mediterranean).

MATERIAL AND METHODS

The rocky bottoms and the shoals of the "Cinque Terre" Marine National Park and the Regional Natural Park in the Gulf of La Spezia in the Eastern Ligurian Sea (NW Mediterranean) were investigated through SCUBA diving since 1991 before being established as marine protected areas. Three main long-lived species were monitored: the gorgonian *Paramuricea clavata* (Risso) colonising Punta Mesco and La Spezia islands (Cocito *et al.*, 2002), the bryozoan *Pentapora fascialis* (Pallas) which forms relevant bioconstructions at Tino Island (Cocito & Ferdeghini, 2001) and the scleractinian *Cladocora caespitosa* (Linnaeus) abundant in the area where it forms extensive 'beds' of colonies. Non-destructive methods (photographic sampling) and discrete colony sampling allowed to estimate growth rates, carbonate production, and to sort out mortality events related both to climate anomalies and invasive species.

RESULTS

Two mass mortality events (1999 and 2003) strongly affected coralligenous assemblages and particularly *Paramuricea clavata* populations both in the Gulf of La Spezia (Cupido *et al.*, 2008) and Punta Mesco from 17 to 25 m depth. Today, in some sites of La Spezia area (Dante's shoal) the gorgonian is disappeared, whereas in other sites (Tinetto Island and other rocky shoals) the population size structure is changed and a slow recover of colony density, particularly due to recruits, is recorded. Damaged colonies resulted a suitable substratum for the establishment of different epibionts, particularly bryozoans, that previously throve the rocky substratum beneath the gorgonian canopy (Cupido *et al.*, 2007). At Punta Mesco, where the largest population of *P. clavata* was present (Peirano & Sassarini, 1991; Bianchi *et al*., 2001), gorgonian *facies* were deeply affected by mortality down to 25 m of depth and sub-horizontal bottoms are now covered by dense meadows of the green alga *Caulerpa racemosa* var. *cylindracea*.

Episodes of mortality affected the dense *Pentapora fascialis* population in the Gulf of La Spezia. Partial mortality was mainly due to overgrowth by algae and to siltation, particularly at the end of the summer seasons. An episode of total mortality was suffered by shallow colonies caused by an exceptionally severe winter storm (December 1993) (Cocito *et al*., 1998). Decrease of colony average size, hence of carbonate production, was noticed during the monitoring period.

The zooxantellate coral *Cladocora caespitosa* is present with dense colony aggregations (beds) in the Gulf of La Spezia and with huge colonies at Bonassola (West of Punta Mesco) and Punta Montenero (Cinque Terre) (Peirano *et al.*, 1998). Sclerochronological analyses revealed a positive trend in annual coral growth rates related to climate warming (Peirano *et al*., 2004). Coral populations were affected by mortality due to temperature anomalies recorded since 1997 (Rodolfo-Metalpa *et al.*, 2000) that caused partial or total mortality of colonies. In this last decades *C. caespitosa* colonies living in the area suffered also mortality due to the spreading of the invasive alga *Caulerpa racemosa* var. *cylindracea* that colonized coastal bottoms in the Eastern Liguria since the year 2000 (Piazzi *et al.*, 2005).

Conclusion

The decadal studies on coralligenous assemblages and biocostructional species evidenced that: a) long-lived species are valid ‘proxy’ to evaluate population dynamics and response to environmental modifications; b) monitoring activities should cover an adequate sampling area (in our case at least 40-50 km) and marine protected areas (MPAs); c) various geomorphologies (islands, shoals, etc.) should be included in monitoring areas to differentiate modifications due to global causes (global warming) or local effects (invasive species) both at species or population level.

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THE FUTURE OF MEDITERRANEAN SCLERACTINIAN CORALS IN A WARMING MEDITERRANEAN SEA

ABSTRACT

The resistance of symbiotic scleractinian corals living in the NW Mediterranean Sea to global warming was investigated through field observations and laboratory experiments. Coral mortality events in the Ligurian Sea (NW Mediterranean) were observed on 1999, 2003 and 2005, at the end of particularly warm summers. The correlation between elevated temperature and mortality events was tested during laboratory experiments using two corals, Oculina patagonica *and* Cladocora caespitosa. O. patagonica *seemed more resistant to elevated temperatures, because of a rapid physiological acclimation. However, when elevated temperatures were sustained over a long period, both species showed signs of tissue degradation followed by the death as observed in situ. Mediterranean corals are living near their upper thermal limits during summer. Since global warming seems more rapid than the corals potential adaptation, they might be threatened of extinction.*

INTRODUCTION

Since the last decade, the Mediterranean Sea experiences the effects of global warming, with a 0.3 - 0.7 °C increase in seawater temperature (Bethoux *et al.*, 1990; Walther *et al.*, 2002). Concurrently, mortality events of sessile benthic species such as sponges, gorgonian and corals are becoming more and more frequent (e.g. Cerrano *et al.*, 2000). Summer 2005 was one of the warmest seasons ever recorded (NASA's Goddart Institute for Space Studies), with mortality events, suggesting that elevated temperature is a potential causative agent of the events. However, a relationship between temperature stress and coral mortality was not clearly demonstrated. We report here mortality rates of two Mediterranean corals measured during two summer hot spots, and we provide experimental evidences that high temperature is the cause of the mortality of these two corals (Rodolfo-Metalpa *et al.*, 2006).

MATERIAL AND METHODS

Mortality effects on colonies of *C. caespitosa* were investigated using SCUBA diving in summers 1999 (Punta Bianca, Fiascherino, Bonassola, Prelo, Fig. 1) and 2005 (Villefranche, and Monaco, Fig. 1) at 7-15 m depth. The invading coral *O. patagonica* was also monitored during the summer of 2005 in Albissola and Monaco. Biometric parameters of the colonies and their % of the damaged surface per colony were measured along 30 m^2 belt transects. During summer 2005, seawater temperatures were hourly measured in Albissola and Monaco using Onset HOBO® water temperature pro data loggers. Methodological details are in Rodolfo-Metalpa *et al.*, (2005).

Fig. 1. The six study sites along the coast of the Ligurian Sea.

To assess the effect of elevated temperature on corals, we also simulated in aquaria the temperature regime measured *in situ* during the warm summer of 2005 (Rodolfo-Metalpa *et al*., 2006). The two coral species were therefore exposed for 7 weeks to elevated temperatures (24, 26, 28°C and 20°C as control). Photosynthetic efficiency (F_v/F_m) and zooxanthellae contents were periodically measured (see details in Rodolfo-Metalpa *et al.,* 2006).

RESULTS

In situ measurements

In summer 2005, at Albissola, Monaco and Villefranche, temperatures of 24-26°C persisted from early July to the end of August. Approximately on the 10th of August, after ca. 4 weeks of elevated temperatures, *C. caespitosa* in Monaco and Villefranche showed the first signs of mortality. Respectively 30 and 20% of their total surface area died after the month of August. The 4 sites investigated in 1999 showed also similar mortality rates (Fig. 2). Mortality pattern was described by Rodolfo-Metalpa *et al.,* (2000; 2005; 2008).

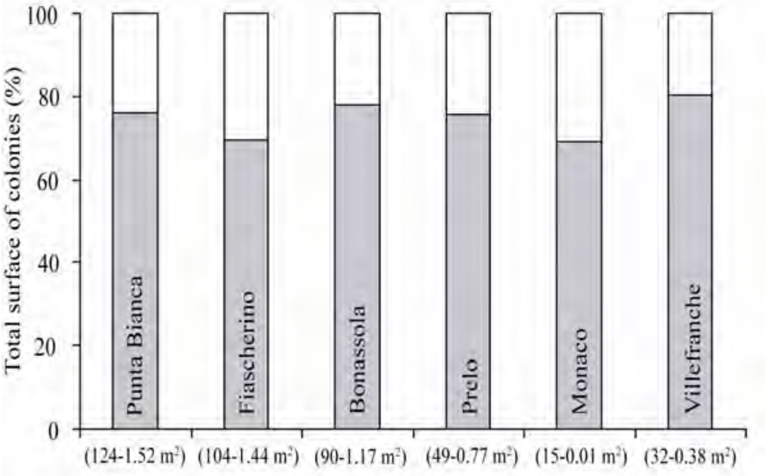

Fig. 2: Percentages of live (white bar) and dead (gray bar) surface areas of all *Cladocora caespitosa* colonies measured in summer of 1999 (Punta Bianca, Fiascherino, Bonassola and Prelo) and in summer 2005 (Monaco and Villefranche). Surface area of colonies (sum of dead and live patches) and number of colonies are in brackets.

O. patagonica showed the first signs of stress on the 20th of August 2005, after 4-5 weeks at 24-26 °C. 32 % (total surface = 0.06 m^2) and 2.2% (total surface = 6.2 m^2) of the colony surfaces were damaged at Monaco and Albissola, respectively.

Experiment in aquaria

C. caespitosa F_v/F_m was gradually reduced by 20 and 40 % at 24°C, 26°C and 28°C (Fig. 3a). At the end of the experiment, almost all samples maintained above 24°C died. A 70% decrease in zooxanthellae density was concomitant with the tissue loss (data not showed).

O. patagonica showed a significant and rapid F_v/F_m decrease (ca. 30 %), either at the “normal” summer temperature (24°C) or higher temperatures (Fig 3b). The drastic decrease was followed by a 30% drop in zooxanthellae density at all the high temperatures. However, elevated temperatures caused tissue loss only in few samples that recovered from the stress.

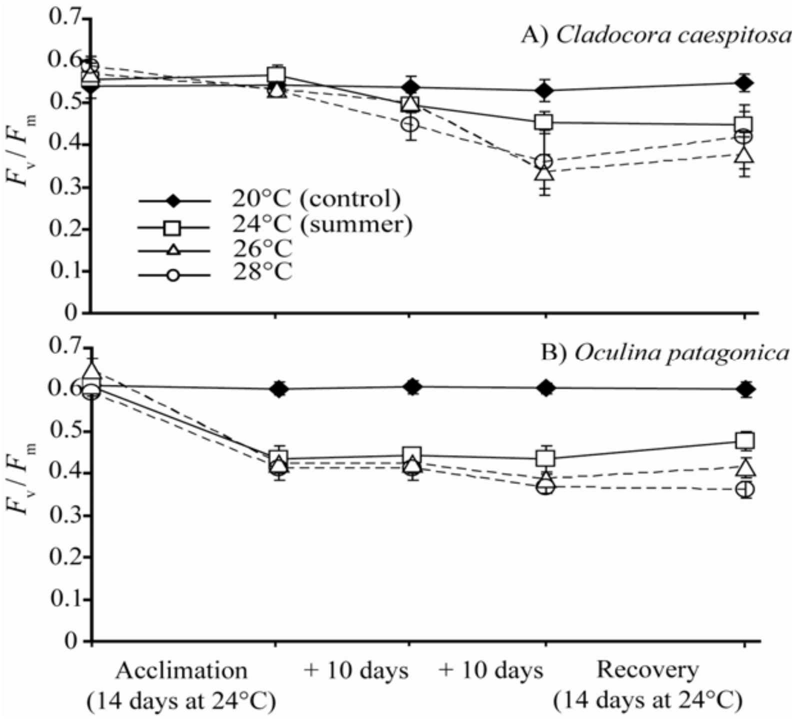

Fig. 3: Photosynthetic efficiency (F_v / F_m) measured on the two dark-adapted corals. Mean values ± SE, n = 10.

CONCLUSION

We provided evidences that prolonged exposure (5-7 w) to normal summer temperature (24°C) or above is the cause of the mortality events of the two Mediterranean corals. Whereas *O. patagonica* showed high resistance to high temperatures, *C. caespitosa* seemed to live close to its thermal limit during the summer period and suffered during long and warm summers. The consequences of global warming will certainly be lethal for this coral if this “tropicalization process” of the Mediterranean Sea continues (Bianchi, 2007).

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Proceedings of the 1st Mediterranean Symposium on the Coralligenous and other calcareous bio-concretions of the Mediterranean Sea
(Tabarka, 15-16 January 2009)

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ESTIMATION OF CORALLIGENOUS ASSEMBLAGES' ECOLOGICAL STATE AROUND EMBIEZ ARCHIPELAGO (VAR, FRANCE)

ABSTRACT:
As part of monitoring program around Embiez archipelago we characterized four coralligenous sites which were affected by different degrees of anthropic impacts (fishing, scuba diving, dive hunting). We studied gorgonian communities and no erect species (algae, sponges and bryozoans) from -30 meters of depth, so as to retain bathymetric gradients. The results obtained highlight a connection between the size, breakage of gorgonians and presence of the bryozoan Pentapora fascialis *and economical activities practised on sites. No erect communities seem rather specified sites.*

KEY-WORDS: Coralligenous assemblages, ecological state, Embiez, economical activity impacts.

INTRODUCTION

This study was realized in order to positioning a monitoring of coralligenous communities around Embiez archipelago. Although many studies were realized about coralligenous assemblages (see Ballesteros, 2006), there is no standardized method to estimate its ecological state. As regards that, we studied coralligenous assemblages on four sites around Embiez archipelago using different methods. The aims of this study were to characterize coralligenous assemblages' ecological state and to evaluate anthropic impacts affecting its communities.

MATERIALS AND METHODS

Four sites around Embiez archipelago were studied in 2008 (Fig. 1). All of them had the same substratum type, comparable slopes and depths but were affected by different degrees of anthropic impacts. At each site, three replicates 3 m x 1 m transects were placed in the horizontal and vertical surfaces and the percentage cover and the rate of necrosis of gorgonians (*Paramuricea clavata* and *Eunicella cavolinii*) were recorded. Bryozoan *Pentapora fascialis* (diver indicator frequenting; Sala *et al.* 1996) was recorded too. Within each transect, nine replicate 0,3 m x 0,2 m photo quadrats were taken in order to measure the percentage cover of each no erect taxa and the biological diversity (Shannon Wiener Index). Photo quadrats were analysed using method developed by Dethier et *al*. (1993). The results were analysed using Principal Component Analysis (PCA) thanks R-cran progam (R-Development-Core-Team, 2007).

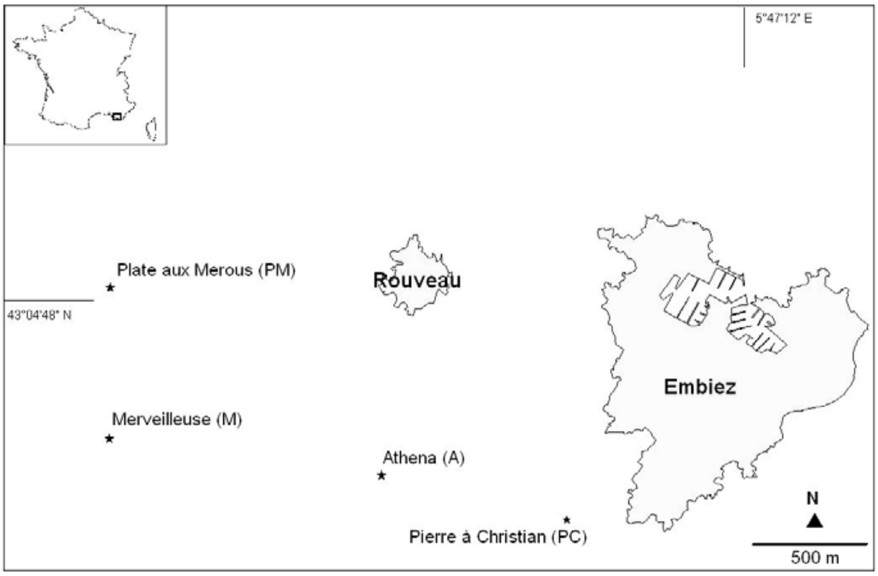

Fig.1: Map of the Embiez archipelago showing the location of the sites studied.

RESULTS

PCA ordination based on environmental variables (density, size classes, cover of necrosis and percentage of breaking of *P. clavata* and *E. cavolinii*, degree of exposure and percentage of breaking of *P. fascialis*, percentage of cover of Rhodophyta, Phaeophycea, Chlorophyta, Sponges and encrusting Bryozoans) clearly characterized the sites, with Axis 1 and Axis 2 collectively explaining 90% of the variation. PC1 appeared related to the size and breakage gorgonians and bryozoan *P. fascialis*, and PC2 to Athena's characteristic (fig.2).

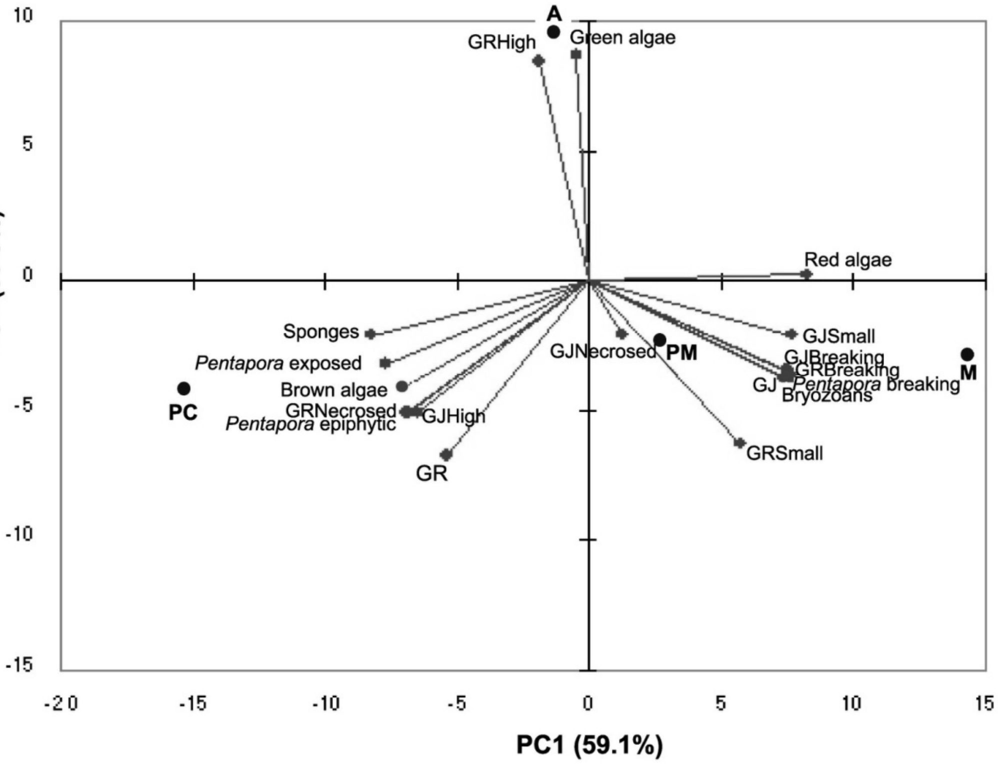

Fig.2: The results of PCA ordination of the environmental variables on four sites separating in three groups in connection with economical activities (site codes are as given in Fig.1).

The sites appeared constituted three groups: (1) Merveilleuse and Plate aux mérous strongly used for economical activities (fishing, scuba diving, dive hunting), (2) Pierre à Christian where these activities are not very marked, (3) Athena which no diving and hunting and very few fishing activities. Diversity index's study reinforce this grouping since Shannon index allows us to highlight two site groups and Pielou index shows a link between a diversity gradient and site working (Fig.3).

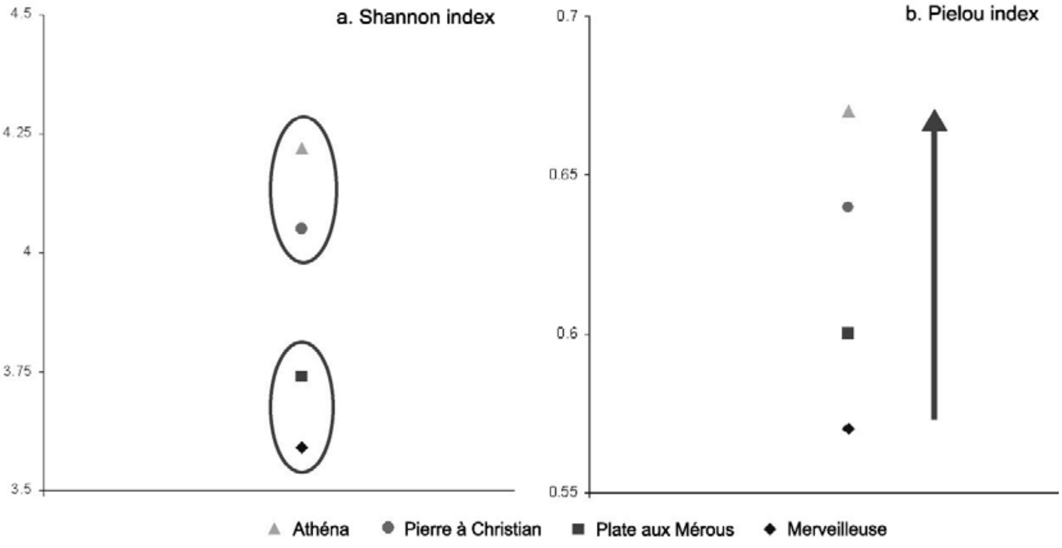

Fig.3: Diversity index calculated from genus on the four sites ; a : Shannon index seems related sites to two groups ; b : Pielou index shows a diversity gradient.

CONCLUSION

This study allows us to characterize, estimate coralligenous assemblages' ecological state and positioning a monitoring on four sites around Embiez archipelago.

The use of gorgonians and bryozoans to assess economical activity impacts on coralligenous sites seems to be justified. On the other hand the use of alga, sponge and encrusting bryozoan compositions seems rather characterized sites.

No erect communities (particularly sponges and bryozoans) are sometimes difficult to characterize using photo quadrats as they are mainly composed of ecological categories differentiated with difficulty (e.g. genus and/or species).

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SOME OBSERVATIONS ON THE STRUCTURE AND DISTRIBUTION OF GORGONIAN ASSEMBLAGES IN THE EASTERN MEDITERRANEAN SEA

ABSTRACT

Knowledge on distribution of coralligenous communities with gorgonian facies (Anthozoa: Gorgonacea) is still rather poor in the Eastern Mediterranean Sea. This is mainly due to their considerably deeper distribution than their Western basin counterparts. In the framework of "Nautilos" Project (2005-2008) several combined Submersible and ROV surveys were conducted to systematically locate gorgonian facies and visually assess their basic structure and distribution. Gorgonian assemblages were recorded from 10 study sites within a depth range of 30-120m. Shallow gorgonian assemblages were an exception, with most found at depths greater than 50m. In general, Eunicella cavolinii *and* Paramuricea clavata *were found to be the most common species, while* Leptogorgia sarmentosa, Eunicella singularis *and* Corallium rubrum *were extremely rare findings. Considering the susceptibility of these habitats to various anthropogenic impacts, this is an important first attempt to map their spatial distribution and give a general description of their composition and present ecological state.*

KEY-WORDS: coralligenous communities, visual assessment, fishing pressure

INTRODUCTION

Gorgonian corals (Anthozoa, Gorgonacea) are a typical facies of Mediterranean coralligenous communities (Peres & Picard, 1964), building up complex habitats of high ecological and aesthetic value (Boudouresque, 2004; Giaccone, 2007). Despite the increasing scientific concern on their ecological importance and conservation status, their presence and distribution in the Eastern Mediterranean basin is poorly studied (Ballesteros, 2003 but see Laborel, 1961; Chintiroglou *et al.*, 1989; Skoufas *et al.*, 2000). In the framework of the HCMR's "Nautilos Project" (2005-2008), aiming at identifying biological and geological hot spots in the Greek Seas, several gorgonian assemblages were detected. This is a first systematic attempt to record their spatial and bathymetric distribution as well as to describe their basic composition and present ecological state.

MATERIALS AND METHODS

The survey was initially based on unofficial records (mainly from fishermen) mentioning the presence of "corals" at several coastal and offshore sites. In total, 22 submersible and Remotely Operated Vehicle (ROV) dives were conducted in depths between 30-250 m to verify these reports and identify which species they actually concerned. "Thetis" (Comex type REMORA 2000), a manned submersible equipped with an acrylic dome passenger area, allowed a general wide angle view of the benthic communities, while the use of ROV (DSSI Max Rover and Comex Super Achilles) permitted closer inspection for the identification of conspicuous species. Underwater vehicle positioning was determined using on board depth meters and a Trackpoint USBL positioning system coupled to the support vessel's navigation computer and GPS (underwater position +/- 10 m). During all surveys, video footage and digital photographs were recorded and later analysed to identify species present that were not recognised or spotted in situ.

RESULTS

Dense facies of various gorgonian species were recorded at 10 sites of the Aegean, Ionian and Cretan Seas (Fig.1).

Eunicella cavolinii, Koch and *Paramuricea clavata,* Risso were found to be the most widespread species, in either monospecific or mixed gorgonian assemblages, at depths between 30-120 m (Fig. 2).

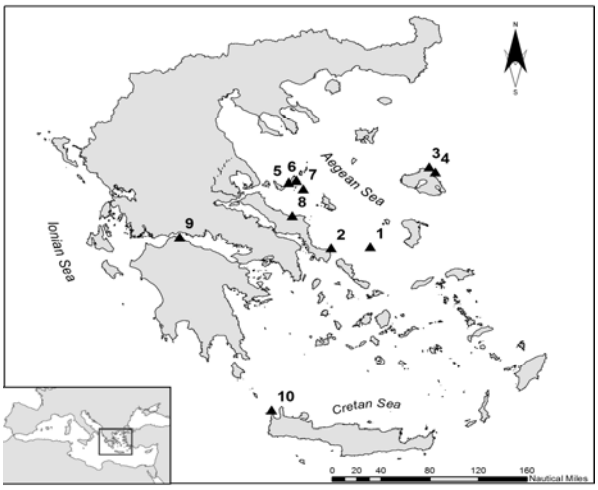

Fig.1: Map of Greece showing the location of the sites studied.

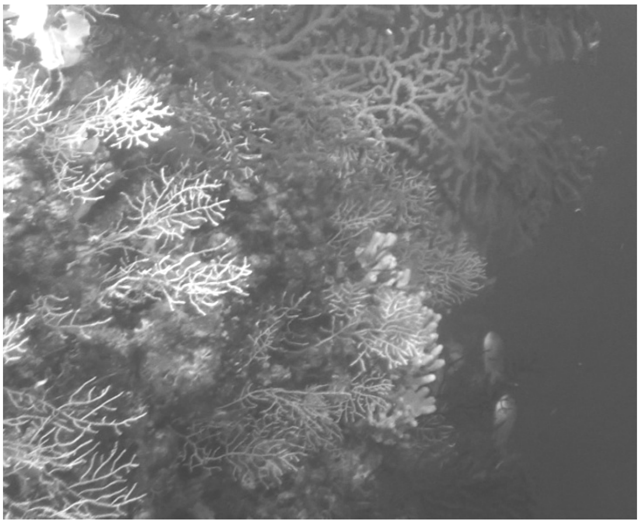

Fig. 2. Typical aspect of a rocky cliff at Site 7, with *E. cavolinii* and *P. clavata facies*.

Eunicella singularis, Esper and the red coral *Corallium rubrum,* Linnaeus, were detected only once (Aegean Sea, Site 3 and 8 respectively) in rather low abundances. *Leptogorgia sarmentosa,* Esper, was the rarest encounter, with only one specimen found throughout the study area (Ionian Sea, Site 9). Tab. 1 summarizes sites surveyed, gorgonian species present and their vertical distribution. Due to the inherent restrictions of rapid visual assessment studies, only dominant and conspicuous species were identified down to the lowest taxonomic level. All sites surveyed presented the typical aspect of Mediterranean coralligenous communities, with abundant sciaphilic red algae (mainly Corallinales and Peyssonneliaceae) and sponges (*Axinella* sp., *Aplysina* sp., *Agelas oroides*). Other common invertebrates were the Bryozoans *Pentapora fascialis, Smittina cervicornis* and *Sertella septetrionalis*, the Echinoderms *Peltaster placenta*, *Centrostephanus longispinus* and *Antedon mediterranea,* and the Anthozoans *Leptopsammia pruvoti*, *Gerardia savaglia*, *Parazoanthus axinellae* and *Parerythropodium coralloides.* Only fish species of minor or no commercial value were abundant (mainly *Anthias anthias*, *Serranus cabrilla*, *Coris julis*, *Scorpaena sp.* and *Muraena helena*). No conspicuous alien species were observed.

Tab 1. Sites with Gorgonian Assemblages, Structural Species and recorded depth range.

Diving Sites	**Structural Species**	**Depth range (m)**
Site 1 (Kalogeri isl., Aegean Sea)	*E. cavolinii*	50-120
Site 2 (S. Evia, Aegean Sea)	*E. cavolinii, P. clavata*	42-80
Site 3 (N. Lesvos, Aegean Sea)	*E. cavolinii, E. singularis, P. clavata*	45-50
Site 4 (N. Lesvos, Aegean Sea)	*P. clavata*	44-50
Site 5 (N. Sporades, Aegean Sea)	*E. cavolinii*	48-68
Site 6 (N. Sporades, Aegean Sea)	*E. cavolinii, P. clavata*	40-80
Site 7 (N. Sporades, Aegean Sea)	*E. cavolinii, P. clavata*	34-65
Site 8 (E. Evia, Aegean Sea)	*E. cavolinii, P. clavata, C. rubrum*	60-65
Site 9 (Lambiri coast, Ionian Sea)	*E. cavolinii, L. sarmentosa*	30-60
Site 10 (Gramvoussa isl., Cretan Sea)	*P. clavata*	85-105

Frequent findings of ghost nets and long lines indicated artisanal and recreational fishing activities at almost all sites inspected. However, gorgonian assemblages were generally found to be in good ecological condition, with minor partial necrosis or other signs of stress. A major exception to this pattern was observed at Site 5, where direct fishing impacts were detected. Here, the relative absence of fragile calcareous species (e.g. *Pentapora fascialis*, *Filograna implexa*), dominance of massive and encrusting forms (mainly sponges and red algae) and scattered presence of small *E. cavolinii* colonies, exhibited irrefutable signs of degradation. Moreover, ghost nets and long lines were ubiquitous, causing coenenchyme loss when in direct contact with gorgonian parts.

DISCUSSION AND CONCLUSIONS

Very little is known about coralligenous ecosystems and much less about gorgonian assemblages in the Eastern Mediterranean basin. According to Ballesteros (2003), this may be related to the greater depth where they develop in this area and to the lack of traditional marine research institutes. Our findings seem to support the former hypothesis. Indeed, although shallow (<20m) facies of gorgonians have occasionally been reported in Greece (e.g. Skoufas *et al*., 2000; Salomidi *et al*., 2006), they seem to be exceptions: out of the ten sites investigated here, gorgonians were found shallower than 40m at only two of them, and at rather sparse densities. The mean distribution depth was 60 m for *Paramuricea clavata* and 59 m for *Eunicella cavolinii*. Such depths (which are beyond normal scientific SCUBA diving limits), render *in situ* studies even more difficult and expensive to undertake than normal, since the use of state-of-the-art technology is requisite. The deeper distribution of coralligenous assemblages has naturally restricted direct human access so recreational scuba diving seems not to pose a serious threat, as has been frequently the case elsewhere (review by Ballesteros, 2003). Artisanal and recreational fishing impacts were detected during this study, although other potential threats (turbidity by nearby trawlers, pollution, climatic changes) are, as yet, unknown. The effect of red coral exploitation on the viability of its populations is largely unassessed. To date, the “out of sight, out of mind” rule has applied to these invaluable ecosystems. There is an increasing awareness of their presence, importance and sensitivity to anthropogenic impacts (UNEP, 2007) which needs to lead to suitable legislation to ensure sustainable management, both within National and International frameworks.

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DIVERSITY, DENSITY AND MORPHOMETRY OF A *ERRINA ASPERA* FACIES IN THE MESSINA STRAIT

ABSTRACT

Errina aspera *is the only calcareous skeleton hydrozoan of Mediterranean, the presence of which is restricted to the Strait of Messina. The rareness makes this species the only Mediterranean hydrozoan mentioned in the IUCN red list. Because of its rareness and of the environmental conditions in which it lives (deep waters with strong currents), information about this species are incomplete and approximate. During the sampling activities for the project "Monitoring the marine biodiversity along Calabrian coasts", affiliated in the framework of "Census of marine life", high resolution photographs data about the massive assemblages of* E. aspera *were collected.*

The aim of this work is to describe the Errina aspera *facies present in the middle of the Strait of Messina. A R.O.V. equipped with a high definition camera and two parallel lasers pointers provided us with 30 pictures to elaborate qualitative and quantitative data. Information concerning species composition of the assemblage (random point count methodology), density (n° of colonies/m^2) and macroscopic morphometric measurements (height and width) have been calculated using CPCe software.*

KEY-WORDS: *Errina aspera*, ROV, Messina Strait

INTRODUCTION

Errina aspera is the only calcified skeleton hydrozoan of Mediterranean Sea, the presence of which is restricted to the Strait of Messina. (Bouillon *et al.*, 2004). Because of its rareness and of the environmental conditions in which it lives (deep waters with strong currents), there are few information about this species (Giacobbe, 2001). In this study we attempted to improve the knowledge about *E.aspera* giving density, morphology and assemblage composition information, extrapolated from the analysis of high resolution georeferenced photos collected by means of a ROV photo camera (Fig. 1).

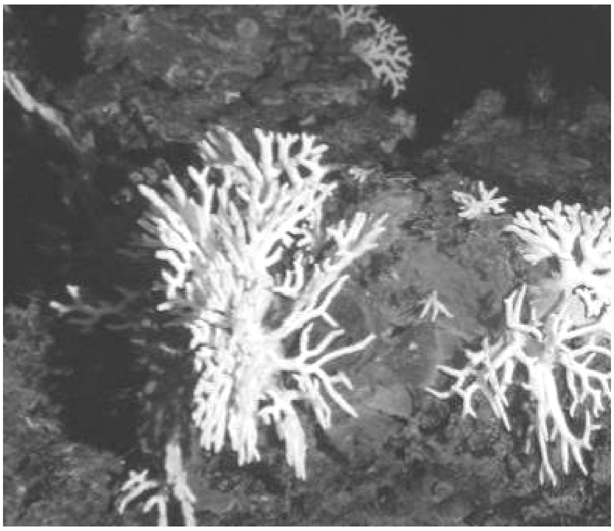

Fig.1: *Errina aspera*

MATERIALS AND METHODS

During a research campaign held by ISPRA (ex ICRAM), aimed to study marine biodiversity, along the Calabrian coast, a ROV survey was conducted near the ridge that connects Sicily and Calabria. This site is particularly interesting due to the presence of the hydrozoan *Errina aspera*.

Data were collected by means of the ROV digital photo camera, equipped with two laser pointers 10 cm apart. 51 photos were selected, both in HR and NEF format, and analyzed. All of them were snapped at a depth between 95 and 110m. Images were analyzed using CPCe software (version 5.1), available from the National Coral Reef Institute, NOVA University (Kohler & Gill, 2006), using as reference measure the distance of 10 cm between the two leds that are visible like two red points in each picture

Data analysis was done with the aims listed below:

- analysis of the taxonomic composition of the population;
- density of the colonies;
- measurement of the morphometry parameters of the colonies.

Due to the low numbers of observations only descriptive statistical analysis were done.

RESULTS

Percentage of benthic cover was calculate for 30 photos. According with the ROV's route (Fig. 2) the analysis of data shows a separation of 4 groups (Fig 3).

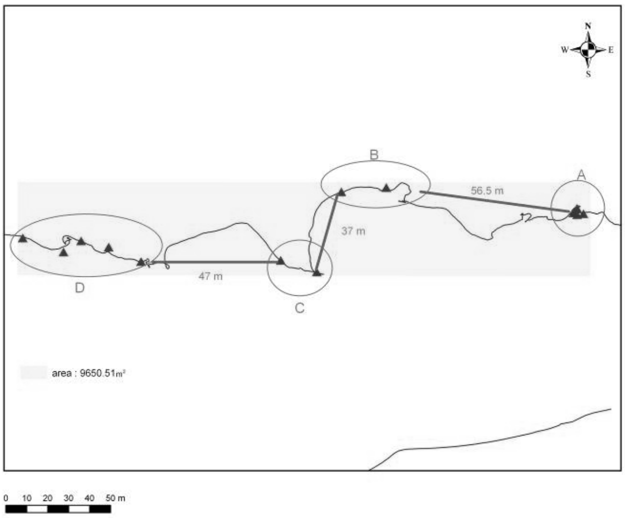

Fig 2 ROV route and 4 group of images

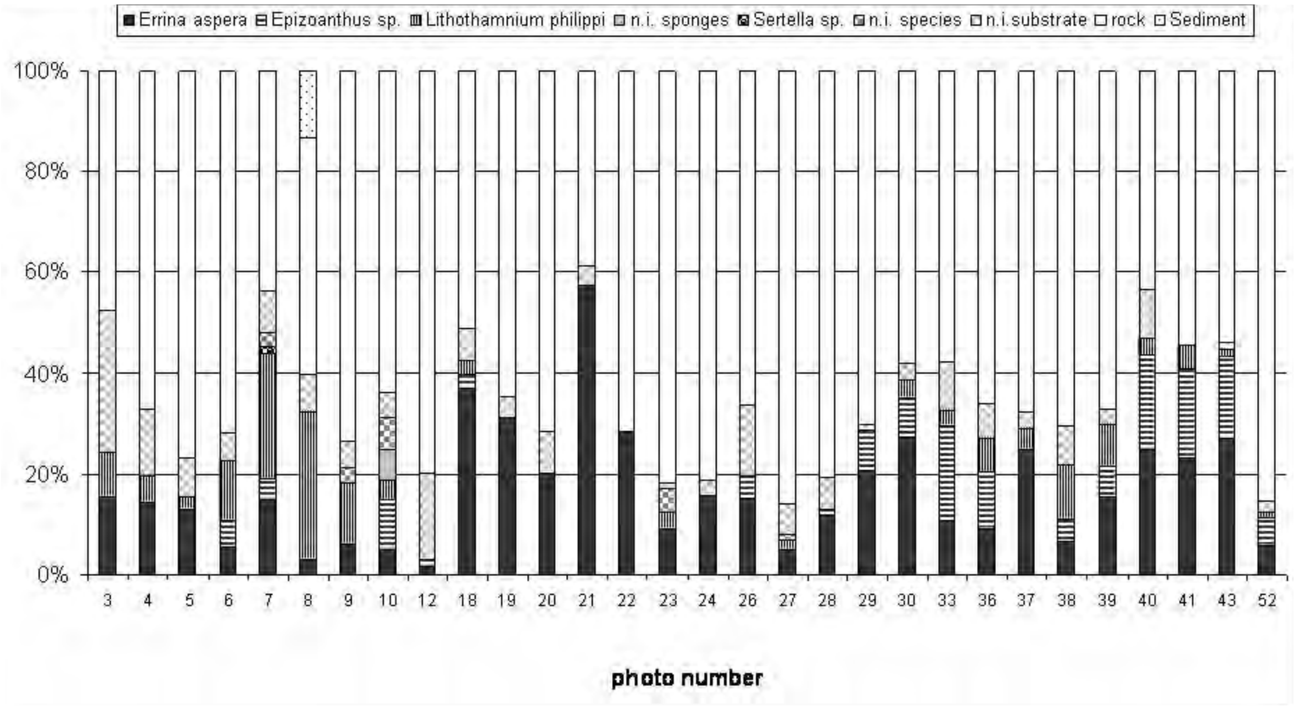

Fig.3: Benthic cover (%) in each photo. 4 different group are shown

The groups A and D show respectively high abundance of red encrusting alga *Lithotammion philippi* (A) and the anthozoa *Epizoanthus* sp. (D). B is the only group with a dominance of *E. aspera*. In the Group C are joined the deepest photos, but information are not enough to link this group to ecological aspect. Diversity index (exp(H')) calcutated for the different groups shows a low diversity where *E. aspera* is dominant. (Exp(H'): A: 2,9; B:1,2; C:2.0; D: 2,5).

Four types of colony of *E.aspera* have been identified by visual analysis of photos: small (< 5 cm h), widely branched by two axis fan-shaped; large (≥ 5cm h) widely branched by two axis fan-shaped; large (≥ 10cm h) widely branched by three axis ball-shaped; large (≥ 5cm h) not very branched by three axis stags' antlers- shaped. The last two types are rare, so only the first two typologies have been measured. 60 colonies were measured: 5 colonies for 3 photos in each area as identified above. Morphometrics information are showed in Tab1.

28 photos were selected to estimate the colonies density. Colonies have been counted considering both the small and the large type, as well their sum (Tab. 1 and Tab. 2).

Tab.1: Morphometric data of *E. aspera*

	HEIGHT	WIDTH
MINIMUM	1,20	1,21
MAXIMUM	13,60	15,60
MEAN	4,65	5,95
MEDIAN	3,85	5,15
MODE	7,8	5,7
SD	2,96	3,20
SE	0,38	0,41

Tab.2: *E. Aspera* density colony

	SMALL	LARGE	TOTAL
COLONY/M^2	66	24	90
SD	33,7	11,8	38,9
SE	6,36	2,22	7,35
CV	0,50	0,50	0,43

CONCLUSIONS

The density of 90 colonies of *E. aspera* in $1m^2$, confirms that this species represents a type of soffusive rarity (Bouillon *et al*.,2004).

The innovative aspect of this study is due to the utilization of advanced technologies that allowed us to collect high resolution georeferenced photos of this species.

Due to the importance and rarity of this species it could be desirable to do further studies repeating and extending sampling to the neighboring areas.

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UNE REVUE DES METHODES D'ETUDE DES PROCESSUS DYNAMIQUES AU SEIN DES BIOCONCRETIONNEMENTS MARINS

RESUME

L'édification des bioconcrétionnements en milieu marin découle de schémas dynamiques généraux comparables, tant dans les zones tropicales que dans les zones tempérées. Certaines méthodes d'étude de ces processus, mises au point en milieu récifal, ont été appliquées en Méditerranée. Les particularités structurales et dynamiques des biohermes méditerranéens limitent leur utilisation et nécessitent la mise au point de nouvelles techniques. Compte tenu de ces particularités, la compréhension des mécanismes de bioérosion et de bioconstruction passent par une approche multidisciplinaire à différentes échelles spatiales (du niveau sub-métrique au secteur littoral) et temporelles (de l'année à l'échelle géologique). L'appréhension des mécanismes et des vitesses de lithification doit notamment faire l'objet d'une attention particulièrement.

MOTS-CLEFS: Bioconcrétionnement, Bioérosion, Bioconstruction, Processus dynamiques.

INTRODUCTION

De nombreuses espèces marines calcifiées peuvent former des bioconcrétionnements, les structures les plus emblématiques étant les récifs coralliens des mers tropicales. En Méditerranée, différents biohermes se rencontrent de la surface de la mer à la limite du talus continental (Laborel, 1987) et présentent un fort intérêt patrimonial (Ballesteros, 2006). La connaissance de leur fonctionnement est essentielle pour la définition de mesures de gestion adaptées. Dans ce travail, nous proposons une synthèse des méthodes appliquées à son étude. Sur la base de cette synthèse, nous dégageons les perspectives techniques à mettre en œuvre dans l'avenir.

METHODOLOGIE

Deux processus dynamiques, opposés mais simultanés, sont à l'origine de l'existence des concrétionnements : (i) la bioconstruction et (ii) l'érosion biologique et physique (érosion mécanique). Le colmatage des structures (bioclastes et apports terrigènes) et les phénomènes de diagénèse complètent ces mécanismes et mènent à la formation de biolithes (Hong, 1980). Ce schéma commun à l'ensemble des biohermes permet d'appliquer des principes méthodologiques similaires pour l'étude des mécanismes dynamiques. Cette synthèse s'appuie donc sur les techniques utilisées en zone tropicale (milieu récifal) et tempérée (coralligène et encorbellement à *Lithophyllum byssoides*).

RESULTATS

L'édification des bioconcrétionnements est un phénomène long s'étendant sur plusieurs centaines d'années (Laborel *et al.*, 1994 ; Sartoretto, 1996). Leur destruction est due à des organismes érodeurs et perforants, dont l'action est lente en zone tempérée (Sartoretto 1996). La modification des conditions environnementales liée aux activités humaines, peut accélérer ces mécanismes (Hong, 1980 ; Orsono Velazquez, 2005). Le suivi des paramètres environnementaux influents (pièges à sédiments et mesures des nutriments dans l'eau) est donc un préalable à l'étude de la dynamique des biohermes (Chazotte 1994 ; Sartoretto, 1996). Compte tenu de leurs particularités, les processus dynamiques des bioconstructions ont été étudiés à des échelles de temps (de l'année à l'échelle géologique) et d'espace (échelle sub-métrique à celle d'un secteur littoral) différentes. Le tableau 1 présente les approches méthodologiques mises en œuvre pour différents types de bioconcrétionnements. Il regroupe des techniques de cartographie des structures (méthodes acoustiques) et de leur suivi à plus petite échelle (suivi 3D) (Bythell *et al.*, 2001). Les vitesses de croissance des bioconstructeurs sont évaluées par des suivis photos, des marquages (colorants) et des techniques de sclérochronologie et de datation par radioisotopes (Chazotte, 1994; Harriott, 1999; Sartoretto 1996; Garrabou & Ballesteros, 2000). Enfin, les vitesses de bioérosion ont été étudiées par des approches expérimentales : installation de blocs pour le suivi des organismes perforants (Fig. 1) et la quantification de l'action des érodeurs (oursins, poissons) (Chazotte, 1994; Sartoretto 1996).

Tab. 1 : Approches méthodologiques appliquées pour l'étude de la dynamique des bioconcrétionnements.

	Bioherme	Paramètre mesuré	Méthodes	Analyse et perspectives
Paramètres environnementaux	Récifs coralliens Coralligène	Sédimentation, COT, MES, Température, Courantologe	Pièges à particules, thermomètres enregistreurs, courantomètres	Grande variabilité de la quantité de sédiments piégés en fonction des conditions météorologiques (tempêtes). Contrainte de l'échantillonnage
	Récifs coralliens	Nutriments	Prélèvement et analyse de l'eau de mer	A prendre en compte pour l'étude des bioconcrétionnements méditerranéens
Bioconstruction	Récifs coralliens	Cartographie	Photographie aérienne	Technique non utilisable en Méditerranée sauf pour certains bioconcrétionnements de sub-surface (ex : plateformes à vermet-*Neogoniolithon*)
			Transect vidéo	-
		Couverture par les bioconstructeurs	Transect plongée (« line intercept »)	Technique simple pouvant être adaptée en zone tempérée (ex : coralligène)
		Croissance des madréporaires (par espèce)	Carottage et bandes de croissance (rayons X)	Technique non applicable *a priori*, sur les bioconstructeurs méditerranéennes
			Marquage (calcéine, alizarine) et prélèvement	Technique à tester en Méditerranée
			Photographies 3D	Technique adaptée pour des suivis à l'échelle métrique. A développer
		Datation	Carottage : mesure ^{14}C	Technique adaptée aux espèces massives
	Coralligène Encorbellement à *Lithophyllum byssoides*	Cartographie	méthodes acoustiques (coralligène)/Cartographie par plongeurs (*L. byssoides*)	Cartographies acoustiques : distinction difficile ou impossible entre roche et concrétions
		Couverture bioconstructeurs	Suivis photographiques et analyses d'images	A développer pour l'ensemble des bioconcrétionnements méditerranéens
			Transects vidéo permanents	Technique à développer
		Croissance, datation des bioconstructions	Prélèvement de blocs : mesure ^{14}C	Problème lié au prélèvement, la porosité des concrétions est un obstacle au carottage

Bioérosion	Récifs coralliens	Vitesse d'érosion Volumes érodés	Blocs expérimentaux (*Porites*) : moulage des galeries (microperforants), analyses d'images (érodeurs et macroperforants)	Problème posé par le type de substrat expérimental (porosité) et la forme des blocs utilisés (cubique)
		Etude des érodeurs (oursins et poissons)	Analyse des contenus digestifs	-
	Coralligène	Peuplements de perforants Vitesse d'érosion Volumes érodés	Blocs expérimentaux (pilier à *Mesophyllum alternans*) : identification des espèces et volume des macroperforants	Substrat expérimental hétérogène gênant le traitement des blocs pour l'évaluation des volumes érodés (notamment les microperforants)
		Etude des érodeurs (oursins)	Analyse des contenus digestifs ; densités d'oursins	Méthode adaptable pour les différentes espèces vagiles érodant les bioconstructions

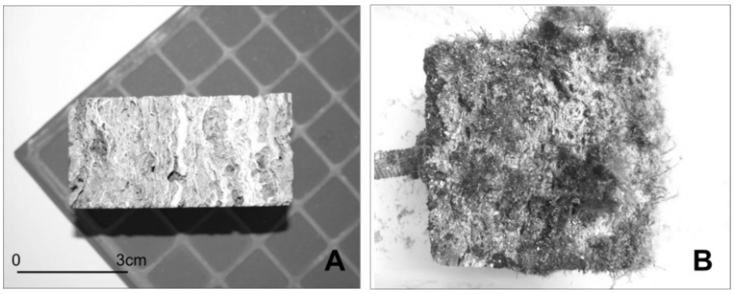

Fig. 1 : Bloc expérimental (pilier à *Mesophyllum alternans*) utilisé pour l'étude de la bioérosion des formations coralligènes (-8m). A : bloc avant installation ; B : après 18 mois d'immersion.

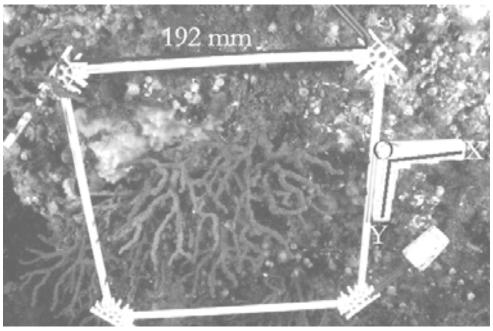

Fig. 2 : Application de la photogrammétrie pour le suivi des colonies de corail rouge (in Graille 2007). A noter le cadre et le repère nécessaire pour le traitement des images.

L'utilisation de tels blocs en Méditerranée est prometteur mais il pose le problème de la sélection d'un substrat type « homogène » (ex : bloc de Porites en milieu tropical) et de la mise au point de méthodes adaptées pour leur suivi : suivi par photogrammétrie (Fig. 2), quantification de l'action des microperforants (Le Campion-Alzumard, 1979; Sartoretto, 1996; Graille, 2007).

DISCUSSION ET CONCLUSION

Les méthodes issues de l'étude des récifs coralliens ne sont que partiellement applicables en zone tempérée, en raison de la complexité structurale des bioconcrétions et de la lenteur des mécanismes dynamiques mis en jeu. De nouvelles techniques doivent donc être développées, notamment :

- des moyens cartographiques (sonar, AUV,…) pour la distinction roche/structures bioconstruites (*étude à grande échelle (secteur littoral), suivi pluri-annuel (décennal)*) ;
- des moyens de marquage et de prélèvement pour les études structurales et la datation des concrétions biologiques (*étude à l'échelle métrique, suivi annuel, étude à l'échelle géologique*) ;
- la mise au point d'un substrat expérimental standardisé pour l'évaluation de la bioérosion et l'application de nouvelles méthodes d'estimation des volumes érodés (ex : la photogrammétrie) (*étude à l'échelle sub-métrique, suivi annuel*).

Enfin, les mécanismes de diagénèse, jouant un rôle fondamental dans la formation des biolithes, ont été peu abordés jusqu'à présent. Il convient donc de développer des techniques adaptées pour appréhender ces mécanismes (vitesses de lithification, influence des paramètres environnementaux,…).

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CRUSTACEAN DIVERSITY OF THE CORALLIGENOUS (MAËRL) BEDS OF THE AGEAN SEA COAST OF TURKEY

ABSTRACT

The present study analyses the crustacean diversity associated with coralligenous habitats of Aegean Sea, based on qualitative and quantitative data. Samples of coralligenous habitats were obtained from benthic samplings carried out on the Aegean coast of Turkey in 2000, 2002 and 2003, respectively. Samples collected by dredge were all equivalent (25-30 liters), and were preserved in 4% formalin for further analysis in the laboratory. The coralligenous habitats of this area ranged from 30 to 75 m depth, and were characterized mostly by an abundance of the coralline algae, Mesophyllum alternans *(Foslie) Cabioch & Mendoza*, 1998, Pymatolithon sp., Lithothamnion sp., Halimeda tuna *(J.Ellis & Solander) J.V. Lamouroux*, *1816*, Flabellia petiolata (*Turra*) *Nizamuddin, and* Vidalia volubilis *(Linnaeus) J. Agardh. As a result of the samplings carried out at the 17 stations at Aegean Sea, 1783 individuals belonging to 146 species were identified. Amhipods were the dominant group both in terms of species richness and abundance, with 62 species and 901 individuals, while decapods and cumaceans were represented by 52 and 12 species, and 346 and 187 individuals, respectively.*

KEY-WORDS**:** Crustacea, Coralligenous, Agean Sea, Turkey

INTRODUCTION

The coralligenous, is a typical Mediterranean biogenic buildup basically made by coralline algae growing in dim light conditions and in relatively calm waters. It usually develops in the circalittoral zone but it can also thrive in the lower infralittoral zone if irradiance levels are low enough to allow the growth of the encrusting corallines which make the buildup (SAP BIO project report, 2003). Maërl, refers to loose-lying, normally nongeniculate (i.e. unsegmented because they lack decalcified joints), coralline red algae (Irvine & Chamberlain, 1994). Coralligen algae are the main coralligenous builders in the Mediterranean Sea (Sartoretto, 1996). Studies on the coralligenous communities distributed along the Turkish coasts are few as well. Tortonese & Demir (1960), pointed out the dominance of coralligenous (maërl) bottoms on the inner shelf near Istanbul. According to Müller (1985), there is a well developed association of calcareous red algae and sciaphilous soft macrophyta along the westernmost parts of the Sea of Marmara, dominated by *Phyllophora nervosa* (De Candolle) Greville, in 16-20 m depths, sheltering a rich faunal assemblage. The community belongs to the precoralligenous unit, occuring at secondary hard bottoms of the upper circalittoral zone. Bakır & Katağan (2005) reported 1458 individuals belonging to 122 crustacean species on coralligenous beds on Markiz Island (Aegean Sea, Turkey). The present study analyses the crustacean diversity associated with coralligenous habitas of Turkish Aegean Sea coast.

MATERIALS AND METHODS

Samples of coralligenous habitats were obtained from 17 benthic samplings carried out at Turkish Aegean Sea coast in 2000, 2002 and 2003, respectively (Fig. 1). Samples collected by dredge were all equivalent (25-30 liters), and were preserved in 4% formalin for further analysis in the laboratory. The coralligenous habitats in this area ranged from 30 to 75 m depth, and were characterized by an abundance of the coralline algae, Mesophyllum alternans (Foslie) Cabioch & Mendoza, 1998 *Lithothamnion sp.*, Pymatolithon sp., *Halimeda tuna* (J.Ellis & Solander) J.V. Lamouroux, 1816, *Flabellia petiolata* (Turra) Nizamuddin, and *Vidalia volubilis* (Linnaeus) J. Agardh. The samples were washed through a 1 mm sieve and crustacean specimens were sorted. The total numbers of species and individuals belonging to groups of Crustacea were calculated, for an interpretation of the data obtained.

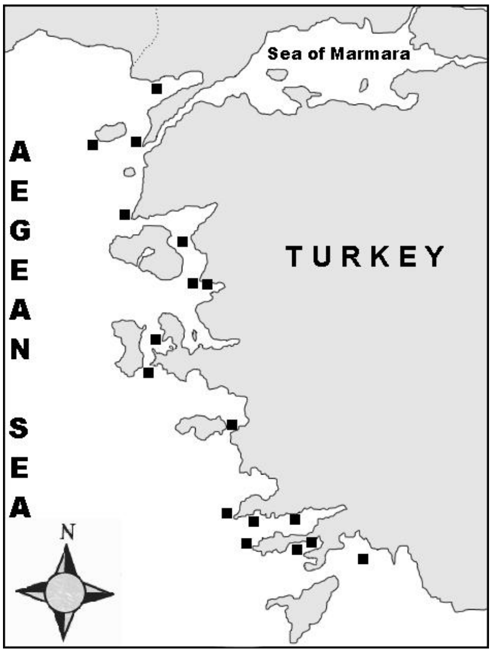

Fig. 1: Map of the study area showing the sampling stations.

RESULTS

As a result of the samplings carried out at the 17 stations at Turkish Aegean Sea coast, 1783 individuals belonging to 146 species were identified. Amhipods were the dominant group both in terms of species richness and abundance, with 62 species and 901 individuals, while decapods and cumaceans were represented by 52 and 12 species, and 346 and 187 individuals, respectively (fig. 2). The highest dominance value was recorded for *Metaphoxus simplex*, and *Leptocheirus bispinosus* (7%) and next for *Nannastacus longirostris*, *Vaunthompsonia cristata*, and, *Cheirocratus sundevalli*, *Cestopagurus timidus*, and *Paragnathia formica* (4%) (fig. 3).

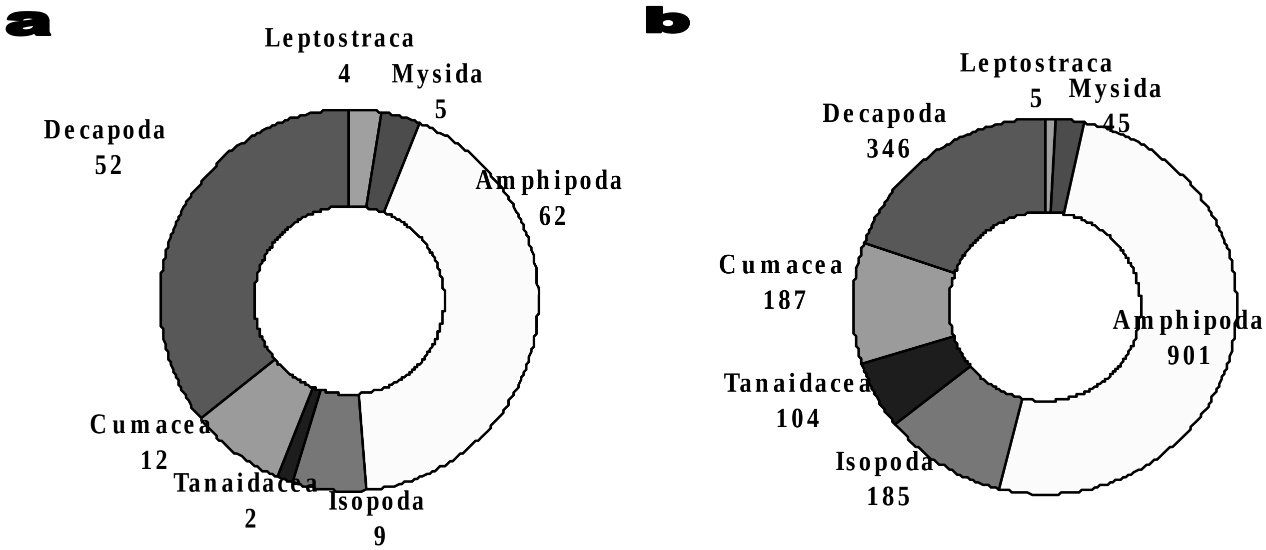

Fig. 2: Distribution of identified species, with their numbers (a), and of individuals (b) collected over various groups of Crustacea.

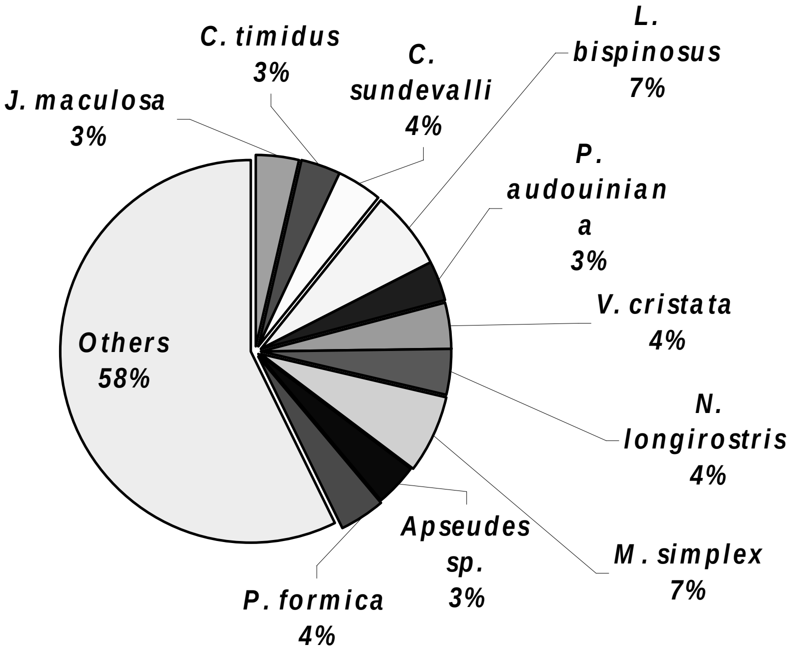

Fig. 3: Dominance values of species: *Janira maculosa* Leach, 1814; *Cestopagurus timidus* (Roux, 1830); *Cheirocratus sundevalli* (Rathke, 1843); *Leptocheirus bispinosus* Norman, 1908; *Perrierella audouiniana* (Bate, 1857); *Vaunthompsonia cristata* Bate, 1858; *Nannastacus longirostris* G. O. Sars, 1879; *Metaphoxus simplex* (Bate, 1857), *Apseudes sp.*, *Paragnathia formica* (Hesse, 1864).

CONCLUSION

Among groups, amphipods were represented by 42.5% and decapods by 35.6%, together constituting 78.1% of the total number of species identified. According to the results of previous study conducted at maërl grounds along Aegean Sea coasts, crustacean species diversity was reported as 122 in the Markiz Island (Bakır & Katağan, 2005). In general, high water transparency observed at the sampling stations and this provide high species diversity at the coralligenous habitats in the Aegean Sea. Information about the coralligenous concretions from the Aegean Sea is not sufficient. Special effort has to be made in the description and functioning of the coralligenous in this area.

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POLYSIPHONIA PERFORANS CORMACI, G. FURNARI, PIZZUTO & SERIO AND *BONNEMAISONIA HAMIFERA* HARIOT, NEW RECORDS FOR THE MEDITERRANEAN SPANISH COAST

ABSTRACT

While we were studying the community of Lithophyllum stictaeforme *throughout Catalonian coast, two scarcely cited species in the Mediterranean Sea were identified. We provide a description of these species, which represent new records for the Mediterranean coasts of the Iberian Peninsula.* Polysiphonia perforans *(Ceramiales, Rhodophyta) described by Cormaci* et al. *(1998) from Catania (Italy) and until now only found throughout Italian coasts, and* Bonnemaisonia hamifera *(Bonnemaisoniales, Rhodophyta) a native species of Japan widely distributed in the Atlantic and Pacific Oceans (Guiry & Guiry 2008), but only cited as Trailliella phase in the Mediterranean Sea (Cormaci* et al.*, 2004). Although both generations were initially cited from the Mediterranean coasts by Conde* et al. *(1996) and Furnari* et al. *(2003), in the revision of the Mediterranean alien species by Cormaci* et al. *(2004) only the sporophytic generation was confirmed in the Mediterranean.*

KEY-WORDS: *Lithophyllum stictaeforme* community, coralligene, *Polysiphonia perforans*, *Bonnemaisonia hamifera*, new records.

INTRODUCTION

Studying some samples from the coralligenous community of *Lithophyllum stictaeforme* of the coasts of Catalonia (NE of the Iberian Peninsula) we identified two species that until now have been scarcely cited in the Mediterranean and represent new records for the Mediterranean coasts of the Iberian Peninsula: *Polysiphonia perforans* Cormaci, G. Furnari, Pizzuto & Serio and *Bonnemaisonia hamifera* Hariot. The first was described by Cormaci *et al*. (1998) from Catania (Italia) and until now its distribution had been restricted to the Italian coasts (Rindi *et al*., 2002; Cormaci *et al*., 2004). *Bonnemaisonia hamifera* is a Japanese species with a heteromorphic life history that is widespread in both Atlantic and Pacific oceans (Guiry & Guiry, 2008). Both generations of this species have been cited for the Mediterranean Sea (Conde *et al*., 1996; Furnari *et al*., 2003) but in the review of the Mediterranean alien species, Cormaci *et al*. (2004) indicate that only the sporophyte (Trailliella phase) occurs in the Mediterranean. We present a morphological and anatomical description of our specimens and we compare it with available information.

MATERIALS AND METHODS

The specimens were collected in two localities of the Catalonian coasts [Arenys de Mar (Barcelona) and Hospitalet de l'Infant (Tarragona)] in the coralligenous *Lithophyllum stictaeforme* community. Other collection details are given in the species accounts. Specimens were preserved in 4% formalin-seawater and deposited BCN-Phyc (the Herbarium of the Plant Biodiversity Documentation Centre of the University of Barcelona). Cells and other anatomical features were measured with an ocular micrometric and expressed as a variation interval. Some morphological and anatomical features were drawn with a *camera lucida* or photographed.

RESULTS AND DISCUSSION

Polysiphonia perforans Cornaci, G. Furnari, Pizzuto & Serio

Plant dark red in colour, consisting of prostrate and erect axes; axes polysiphonous, ecorticated and composed of an axial cell (6 µm in diameter) and four periaxial cells (Fig. 1e). Prostrate axes 27-30 µm diameter, with segments 1.2-1.6 times longer than broad (30-42 x 21-25 µm), occurring under the blades of *Peyssonnelia bornetii* Boudouresque & Denizot (Fig. 1b) and attached to it through dorsal rhizoids (Fig. 1d); rhizoids unicellular, ending in a digitate attachment disc, arising from the periaxial cells and remaining in open connection with them. Erect axes up to 3 mm high, scarcely branched, originated from the prostrated ones and crossing the blades of *Peyssonnelia*, often forming a more or less right angle at the exit site in the upper face of the blade (Fig. 1c); erect axes 30-40 µm in diameter in its median part (26-30 µm at the apical zone and up to 50 µm at the base) with segments 0.8-0.9 times longer than broad (36-42 x 21-25 µm); segments of the upper part of the erect axes 0.5-0.6 times longer than broad (15-18 x 27-30 µm). Branching endogenous (Fig. 1f). Trichoblasts or scar-cells lacking. Tetrasporangia not completely developed, located in straight series in the upper part of the branches, one in every segment (Fig. 1a); other reproductive structures not seen.

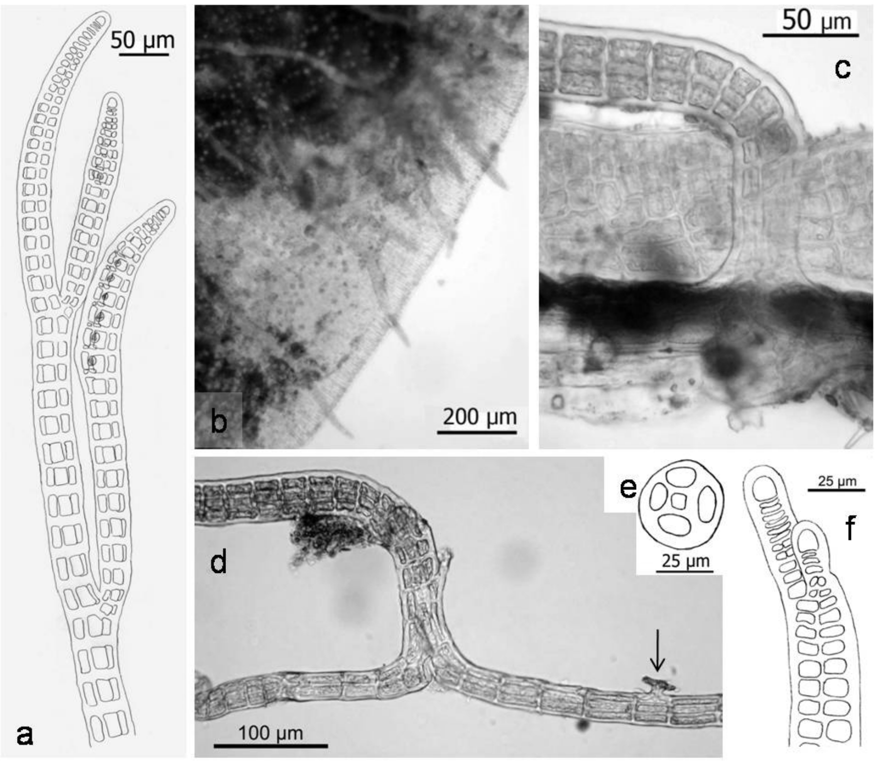

Fig 1: *Polysiphonia perforans*. a: upper part of an erect axis with tetrasporangia; b: prostrate axes under Peyssonnelia blade; c: erect axis crossing the Peyssonnelia blade; d: prostrate axis with a dorsal rhizoid (arrow) and an erect axis; e: axis cross section; f: endogenous branching.

Habitat: Growing on *Peyssonnelia bornetii* in the *Lithophyllum stictaeforme* community, at 30 m depth.

Studied specimens: Wamgarrós (Arenys de Mar, Barcelona), 28/04/2006, BCN-Phyc 3233.

Distribution: Until now only known from the Italian coasts (Cormaci *et al*., 1998; Rindi *et al*., 2002).

Remarks: *Polysiphonia perforans* was described by Cormaci *et al*. (1998) on the basis of material from Catania (Italy) collected at 25 m depth on *Peyssonnelia rubra* (Greville) J. Agarth. At the same time, these authors also report this species from Tremiti Islands, in the Adriatic coast of Italy. Subsequently, *P. perforans* only has been cited from the Toscana, in the north western Italy (Rindi *et al*., 2002). Therefore, the specimens here described represent the third record of *P. perforans* for the Mediterranean Sea and a new species for the flora of the Iberian Peninsula. Our specimens agree very well with the description of *P. perforans* provided by Cormaci *et al*. (1998), although they are smaller (3 mm high in comparison with 5-10 mm in Italian specimens) and present shorter segments (0.8-1.6 times longer than broad in comparison with 1.5-2 times in Italian material).

Bonnemaisonia hamifera Hariot

Gametophyte erect, 2 cm high, consisting of a much branched main axis, 740-860 µm in diameter. Branching opposite and spirally arranged, with unequal development of the two components of each pair; the longer branch of 0.9-1.7 mm in length and 130-170 µm in diameter, with thorny cells at the apical zone (Fig. 2a); the shorter branch is a small protuberance, some of them replaced by an indeterminate axes, other modified to form hook branches (Fig. 2c) and one converted into a cystocarp. Axes of uniaxial structure; axial cells long, 265-305 x 20-40 µm (Fig. 2e), bearing two opposite periaxial cells; cortex composed of three cell-layers, the innermost with cells more or less isodiametric, 80-90 µm in diameter, and the outer with cells ovoid or polygonal in shape (10-20 µm in greater diameter) forming a continuous layer (Fig. 2b); vesicle cells of 11-20 µm in diameter scattered among outer cortical cells. A single cystocarp (490 x 400 µm) without carposporangia was found (Fig, 2d). Sporophyte not seen.

Habitat: Growing in the community of *Lithophyllum stictaeforme*, at 28 m depth.

Studied specimens: Hospitalet de L´Infant (Tarragona), 06/06/2007, BCN-Phyc 3234.

Distribution: Widespread in the Atlantic and Pacific oceans (Guiry & Guiry, 2008). In the Mediterranean Sea, only the presence of Trailliella phase has been confirmed until now (Cormaci *et al*., 2004).

Remarks: Our specimens are compatible with the available descriptions of *B.hamifera* gametophyte, showing thorny cells at the apical zone of the long branches and the typical hook branches. Likewise, other typical features of the genus *Bonnemaisonia* were also observed, such as the presence of vesicle cells and the endophyte *Colaconema asparagopsis* Chemin among the cortical cells. Despite the collected specimen had little dimensions, it presented a cystocarp, although without carposporangia. The wide distribution of *B. hamifera* contrasts with the absence of its gametophyte in the Mediterranean Sea, where up to date this species has been only reported as Trailliella phase (Cormaci *et al*., 2004). In fact, previously the gametophyte was cited from Sicily and the Italian Peninsula (Furnari *et al*., 2003) but in the review on the Mediterranean alien species of Cormaci *et al.* (2004) these cites were excluded. Comparing the gametophyte and sporophyte distributions of *B. hamifera*, McLachlan *et al*. (1969) and Breeman *et al*. (1988) noted that the Trailliella phase shows a wider distribution than the gametophyte. Breeman *et al*. (1988) pointed out that in *B. hamifera* both sporophyte and gametophyte show different temperature tolerance in relation to growth, survival and reproduction, being Trailliella the generation more resilient. This fact would explain its wider distribution.

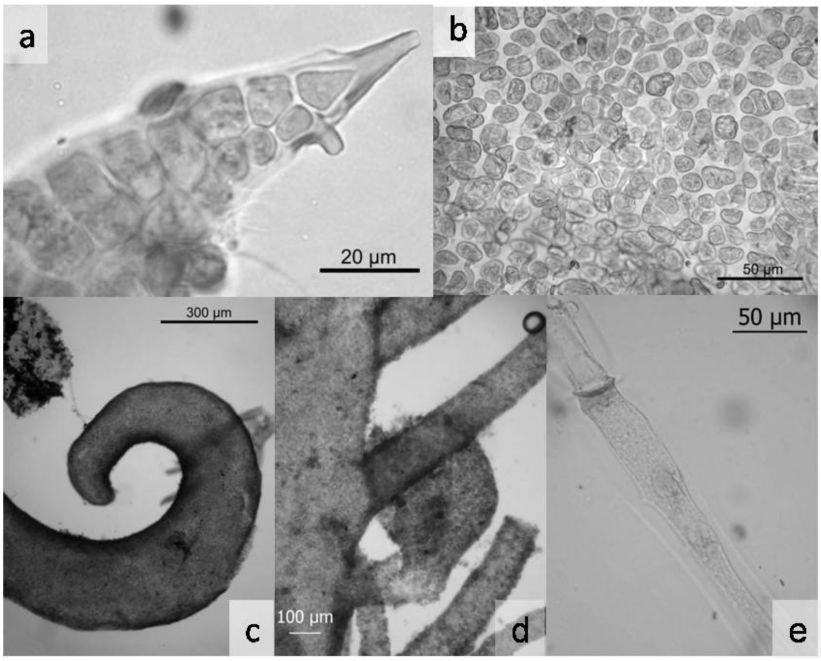

Fig. 2: *Bonnemaisonia hamifera*. a: apex of a long branch; b: outer cortical cells in surface view; c: hook branch; d: cystocarp; e: axial filament fragment.

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