Regional Activity Centre for Specially Protected Areas (RAC/SPA)
Centre d'Activités Régionales pour les Aires Spécialement Protégées (CAR/ASP)

Boulevard du Leader Yasser Arafat | B.P. 337 - 1080 Tunis Cedex -Tunisia
phone: +216 71 206 649 / +216 71 206 485 / +216 71 206 851 / +216 71 206 765
Fax: +216 71 206 490
E-mail: car-asp@rac-spa.org
web: www.rac-spa.org

UNEP

MAP

RAC/SPA

PROCEEDINGS OF THE 1st MEDITERRANEAN SYMPOSIUM ON THE CONSERVATION OF DARK HABITATS

Portorož, Slovenia, 31 October 2014

ACTES DU 1er SYMPOSIUM MEDITERRANEAN SUR LA CONSERVATION DES HABITATS OBSCURS

Portorož, Slovénie, 31 octobre 2014

INSTITUTE OF THE REPUBLIC OF SLOVENIA FOR NATURE CONSERVATION

May 2015

PROCEEDINGS OF THE 1st MEDITERRANEAN SYMPOSIUM ON THE CONSERVATION OF DARK HABITATS

Portorož, Slovenia, 31 October 2014

ACTES DU 1er SYMPOSIUM MEDITERRANEAN SUR LA CONSERVATION DES HABITATS OBSCURS

Portorož, Slovénie, 31 octobre 2014

With the support of MedKeyhabitats project Financed by the MAVA Foundation

Avec le support du projet MedKeyhabitats Finance par la fondation MAVA

May 2015

Citation :

UNEP/MAP – RAC/SPA, 2015. Proceedings of the 1st Mediterranean Symposium on the conservation of Dark Habitats (Portorož, Slovenia, 31 October 2014). LANGAR H., BOUAFIF C., OUERGHI A., edits., RAC/SPA publ., Tunis: 92 p.

PNUE/PAM – CAR/ASP, 2015. Actes du 1er Symposium méditerranéen sur la conservation des Habitats Obscurs (Portorož, Slovénie, 31 octobre 2014). LANGAR H., BOUAFIF C., OUERGHI A., édits., CAR/ASP publ., Tunis : 92 p.

ISBN: 978-9938-9574-1-9

AVANT-PROPOS

Suite aux recommandations 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), du **Plan d'action pour la conservation du coralligène et des autres bio-constructions de Méditerranée** (adopté par les Parties contractantes à la Convention de Barcelone, en 208)**, du Plan d'Action pour la conservation des habitats et espèces associés aux monts sous-marins, aux grottes et canyons sous-marins, aux fonds durs aphotiques et aux phénomènes chimio-synthétiques en mer Méditerranée (Plan d'action pour les habitats obscurs)** (adopté par les Parties contractantes à la Convention de Barcelone, en 2013) et dans le but du développement des connaissances, une série de symposiums scientifiques, dédiée à ces habitats, a été initiée en 2000 par l'organisation du 1er symposium Méditerranéen sur la végétation marine. Ces initiatives visent essentiellement à faire le point sur les données scientifiques disponibles et à promouvoir la coopération entre les spécialistes qui travaillent en Méditerranée.

Cette année, avec la mise en œuvre du projet de Cartographie des habitats marins clés de la Méditerranée et la promotion de leur conservation par l'établissement d'Aires Spécialement Protégées d'Importance Méditerranéenne (ASPIM) « Projet Medkeyhabitats » financé par la fondation MAVA, l'opportunité s'est présentée pour organiser ensemble les symposiums suivants:

- 5ème Symposium Méditerranéen sur la Végétation Marine
- 2ème Symposium Méditerranéen sur la conservation du Coralligène et autres Bio-concrétions
- 1er Symposium Méditerranéen sur la conservation des Habitats Obscurs

Suite à l'offre de « the institute of the republic of Slovenia for nature conservation » lors du quatrième symposium organisé à Yasmine-Hammamet (Tunisie) du 2 au 4 décembre 2010 d'abriter la 5ème édition du même symposium, il a été convenu de les organiser ensemble back to back à Portorož, Slovenie, du 27 au 31 octobre 2014 comme suit :

- 5ème Symposium Méditerranéen sur la Végétation Marine du 27 au 28 octobre 2014
- 2ème Symposium Méditerranéen sur la conservation du Coralligène et autres Bio-concrétions du 29 au 30 octobre 2014)
- 1er Symposium Méditerranéen sur la conservation des Habitats Obscurs le 31 octobre 2014

Cette édition a vu l'inscription de plus de 140 participants en provenance de 17 pays Méditerranées, ce ne sont pas moins de 126 communications orales et posters qui devraient y être présentés.

Cette édition sera aussi l'occasion d'aborder des sujets d'actualités tels que les invasions biologiques, le réchauffement global, et leurs impacts sur les habitats clés de Méditerranée et de renforcer les liens entre les scientifiques et entre les institutions scientifiques.

Khalil ATTIA
Directeur du CAR/ASP

CONTENTS / SOMMAIRE

PROGRAMME

Friday 31 october 2014

8:00-8:15 Participants welcome and registration

8:15-8:45 **Opening of the Symposium**

8:45-9:45 Keynote conference: **Campagnes océanographiques d'exploration des têtes de canyons de Méditerranée française – MedSeaCan & CorSeaCan** by **Boris DANIEL,** DAMIER E., FERRARI B., WATREMEZ P., Equipe Scientifique des campagnes MedSeaCan et CorSeaCan.

Session 1: **Current Knowledge of the deep habitats**
Chair: **Vasilis GEROVASILEIOU**, Rapporteur: **Vesna MAČIĆ**

9:45-10:00 "**Vulnerable habitats and species in the deep-sea Emile Baudot Escarpment (South Balearic Islands) surveyed by ROV**" by **Ricardo AGUILAR**, SERRANO A., GARCÍA S., ALVAREZ H., BLANCO J., LÓPEZ J., MARÍN P., PASTOR X.

10:00-10:15 "**Exploration visuelle des canyons et bancs rocheux profonds en Méditerranée française : apports a la typologie nationale des habitats profonds**" by **Maïa FOURT**, MICHEZ N., CHEVALDONNÉ P., GOUJARD A., HARMELIN J.G., VACELET J., VERLAQUE M., Equipe scientifique des campagnes MedSeaCan et CorSeaCan.

10:15-10:30 Discussion

10:30-11:00 ***Coffee break***

Session 1: (Continued) **Current Knowledge of the deep habitats**
Chair: **Vasilis GEROVASILEIOU**, Rapporteur: **Vesna MAČIĆ**

11:00-11:15 "**French Mediterranean submarine canyons and deep rocky banks: a regional view for adapted conservation measures**" by **Maïa FOURT**, GOUJARD A., PEREZ T., VACELET J., SARTORETTO S., CHEVALDONNE P., the scientific team of the MedSeaCan and CorSeaCan cruises.

11:15-11:30 "**Fishing impact on Italian deep coral gardens and management of these vulnerable marine ecosystems**" by **Marzia BO**, ANGIOLILLO M., BAVA S., BETTI F., CANESE S., CATTANEO-VIETTI R., CAU A., PRIORI C., SANDULLI R., SANTANGELO G., TUNESI L., BAVESTRELLO G..

11:30-11:45 Discussion

11:45-12:30 **Poster Session**

12:30-13:00 ***Side event***

Mission Canyons, voyage dans les vallées sous-marines de Méditerranée by **Boris DANIEL**

13:00-14:00 *Lunch*

Session 2: **Current Knowledge of undersea caves**
Chair: **Pierre CHEVALDONNE**, Rapporteur: **Antonietta ROSSO**

14:00-14:15 "**Submerged marine caves of Liguria: updating the knowledge**" by **Martina CANESSA**, MONTEFALCONE M., CANOVAS MOLINA A., COPPO S., DIVIACCO G., BAVESTRELLO G., MORRI C., BIANCHI C.N.

14:15-14:30 "**Mediterranean marine caves as biodiversity reservoirs: a preliminary overview**" by **Vasilis GEROVASILEIOU**, VOULTSIADOU E.

14:30-14:45 "**Unnoticed inhabitants of marine caves: amphipod assemblages in caves of the Alboran Sea**" by **Carlos NAVARRO-BARRANCO**, GUERRA-GARCÍA J.M., SÁNCHEZ-TOCINO L., GARCÍA-GÓMEZ J.C.

14:45-15:00 "**An ecosystem-based approach to evaluate the ecological quality of Mediterranean undersea caves**" by **Pierre-Alexandre RASTORGUEFF**, BELLAN-SANTINI D., BIANCHI C.N., BUSSOTTI S., CHEVALDONNE P., GUIDETTI P., HARMELIN J.G., MONTEFALCONE M., MORRI C., PEREZ T., RUITTON S., VACELET J., PERSONNIC S.

15:00-15:15 Discussion

15:15-15:45 **Awards for best poster**
Jury: **Vasilis GEROVASILEIOU** and **Pierre CHEVALDONNE**, Secretaries: **Cyrine BOUAFIF** et **Habib LANGAR**

15:45-16:15 *Side event*

The Lost Forest by Simone BAVA, BETTI F., BAVESTRELLO, G., **Marzia BO**, CATTANEO-VIETTI R.

16:15-17:00 **Closure of the Symposium**

PROGRAMME

Vendredi 31 octobre 2014

8:00-8:15 Accueil et inscription des participants

8:15-8:45 **Ouverture du Symposium**

8:45-9:45 Conférence introductive : **Campagnes océanographiques d'exploration des têtes de canyons de Méditerranée française – MedSeaCan & CorSeaCan** par **Boris DANIEL,** DAMIER E., FERRARI B., WATREMEZ P., Equipe Scientifique des campagnes MedSeaCan et CorSeaCan.

Session 1 : **Etat des connaissances sur les habitats profonds**
Président : **Vasilis GEROVASILEIOU**, Rapporteur : **Vesna MAČIĆ**

9:45-10:00 "**Vulnerable habitats and species in the deep-sea Emile Baudot Escarpment (South Balearic Islands) surveyed by ROV**" par **Ricardo AGUILAR**, SERRANO A., GARCÍA S., ALVAREZ H., BLANCO J., LÓPEZ J., MARÍN P., PASTOR X.

10:00-10:15 "**Exploration visuelle des canyons et bancs rocheux profonds en Méditerranée française : apports a la typologie nationale des habitats profonds**" par **Maïa FOURT**, MICHEZ N., CHEVALDONNÉ P., GOUJARD A., HARMELIN J.G., VACELET J., VERLAQUE M., Equipe scientifique des campagnes MedSeaCan et CorSeaCan.

10:15-10:30 Discussion

10:30-11:00 *Pause café*

Session 1 : (Suite) **Etat des connaissances sur les habitats profonds**
Président : **Vasilis GEROVASILEIOU**, Rapporteur : **Vesna MAČIĆ**

11:00-11:15 "**French Mediterranean submarine canyons and deep rocky banks: a regional view for adapted conservation measures**" par **Maïa FOURT**, GOUJARD A., PEREZ T., VACELET J., SARTORETTO S., CHEVALDONNE P., the scientific team of the MedSeaCan and CorSeaCan cruises.

11:15-11:30 "**Fishing impact on Italian deep coral gardens and management of these vulnerable marine ecosystems**" par **Marzia BO**, ANGIOLILLO M., BAVA S., BETTI F., CANESE S., CATTANEO-VIETTI R., CAU A., PRIORI C., SANDULLI R., SANTANGELO G., TUNESI L., BAVESTRELLO G..

11:30-11:45 Discussion

11:45-12:30 **Session Posters**

12:30-13:00 *Evènement parallèle*

Mission Canyons, voyage dans les vallées sous-marines de Méditerranée par **Boris DANIEL**

13:00-14:00 *Déjeuner*

Session 2 : Etat des connaissances sur les grottes sous-marines
Président : **Pierre CHEVALDONNE**, Rapporteur : **Antonietta ROSSO**

14:00-14:15 "**Submerged marine caves of Liguria: updating the knowledge**" par **Martina CANESSA**, MONTEFALCONE M., CANOVAS MOLINA A., COPPO S., DIVIACCO G., BAVESTRELLO G., MORRI C., BIANCHI C.N.

14:15-14:30 "**Mediterranean marine caves as biodiversity reservoirs: a preliminary overview**" par **Vasilis GEROVASILEIOU**, VOULTSIADOU E.

14:30-14:45 "**Unnoticed inhabitants of marine caves: amphipod assemblages in caves of the Alboran Sea**" par **Carlos NAVARRO-BARRANCO**, GUERRA-GARCÍA J.M., SÁNCHEZ-TOCINO L., GARCÍA-GÓMEZ J.C.

14:45-15:00 "**An ecosystem-based approach to evaluate the ecological quality of Mediterranean undersea caves**" par **Pierre-Alexandre RASTORGUEFF**, BELLAN-SANTINI D., BIANCHI C.N., BUSSOTTI S., CHEVALDONNE P., GUIDETTI P., HARMELIN J.G., MONTEFALCONE M., MORRI C., PEREZ T., RUITTON S., VACELET J., PERSONNIC S.

15:00-15:15 Discussion

15:15-15:45 **Remise de prix pour le meilleur poster**
Jury : **Vasilis GEROVASILEIOU** et **Pierre CHEVALDONNE**, Secrétaires : **Cyrine BOUAFIF** et **Habib LANGAR**

15:45-16:15 ***Evènement parallèle***

The Lost Forest par Simone BAVA, BETTI F., BAVESTRELLO, G., **Marzia BO**, CATTANEO-VIETTI R.

16:15-17:00 Clôture du Symposium

KEYNOTE CONFERENCE

****

CONFERENCE INTRODUCTIVE

Boris DANIEL, DAMIER E., FERRARI B., WATREMEZ P., Equipe Scientifique des campagnes MedSeaCan et CorSeaCan
Agence des aires marines protégées - Antenne Méditerranée. 26, rue de la République, 13001 MARSEILLE
E-mail: boris.daniel@aires-marines.fr

CAMPAGNES OCEANOGRAPHIQUES D'EXPLORATION DES TETES DE CANYONS DE MEDITERRANEE FRANCAISE – MEDSEACAN & CORSEACAN

Abstract
The numerous submarine canyons cutting across the Mediterranean continental shelf represent key habitats for understanding and managing the biodiversity of coastal areas and the continental shelf.
In 2007, a review of the available data showed a severe lack of information, between a depth of 100 and 600 metres, in particular to implement the Barcelona Convention, to extend the Natura 2000 network offshore and to define new marine protected areas.
Through this programme, the French Agency of the marine protected areas has drawn up an inventory of habitats and species present in the Mediterranean canyon heads off the French coast. The study area stretches from the Spanish border to the border of Monaco (MEDSEACAN campaign) and includes the western coast of Corsica (CORSEACAN campaign).
The objective was to obtain a reference state of the ecosystems between a depth of 100 and 600 metres, including specific information about the presence and distribution of deep-sea corals and specific biological species (fish, crustaceans, cnidarians), and data about these ecosystems and the impact of human activities on these particularly vulnerable areas.
To compare the canyon heads and better understand the ecological importance of these entities, the exploration work was evenly distributed, with about ten days of work in each of the 13 predefined survey areas. The canyon slopes were explored using the same approach, with the same technical means implemented by the same scientific and technical teams. The description of the environment is based mainly on the acquisition of image data (photos, video) obtained from manned or unmanned submarines.

Key-words: canyon, Mediterranean, French.

Introduction
Les canyons sous-marins, nombreux, qui entaillent le plateau continental méditerranéen facilitent les échanges entre les eaux côtières et les eaux profondes et forment des habitats essentiels à la compréhension et à la gestion de la biodiversité des zones côtières et du plateau continental. Ils constituent un lieu de refuge, de nurserie et d'exportation vers le plateau continental pour de nombreuses espèces (larves de poissons, décapodes, cétacés, etc.), dont certaines ont un intérêt patrimonial, voire commercial. Des observations ont été effectuées à plusieurs reprises il y a près de cinquante ans par soucoupes plongeantes (Reyss, 1964, 1972) et plus récemment par ROV sur les canyons de Lacaze-Duthiers au large de Banyuls-sur-mer et de Cassidaigne au large de Marseille (Bourcier et Zibrowius, 1972, Vivier, 1976). Ces campagnes ont révélé l'existence de peuplements à coraux froids, mais elles n'ont fourni qu'un éclairage très limité sur une biodiversité à priori importante et sur la vulnérabilité de cette zone. La zone entre 50 et 1 000 m de profondeur est très mal connue.

C'est pour répondre à cette lacune que l'Agence a conçu et mis en œuvre les campagnes MedSeaCan et CorSeaCan «Exploration des têtes des canyons méditerranéens», un programme ambitieux dont les campagnes de terrain se sont déroulées entre novembre 2008 et août 2010. L'objectif de cette campagne a été d'établir un état de référence des têtes de canyon concernant les habitats, les espèces protégées et commerciales, les écosystèmes et les pressions anthropiques, en s'appuyant sur les compétences d'un réseau de scientifiques.
Par ailleurs, l'exploration de certains sites a très vite apporté les connaissances nécessaires à la délimitation d'espaces protégés comme le Parc naturel marin du golfe du Lion et le Parc National des Calanques.

Matériels et méthodes
Les canyons de Méditerranée, au large des côtes françaises, ont fait ainsi l'objet, pour la première fois, d'une campagne de reconnaissance systématique. Pour pouvoir comparer les têtes de canyons entre elles et mieux comprendre l'importance écologique de ces entités, l'effort d'exploration a été réparti de façon aussi homogène que possible, avec une dizaine de jours de travail dans chacune des 13 boîtes prédéfinies (Fig. 1).

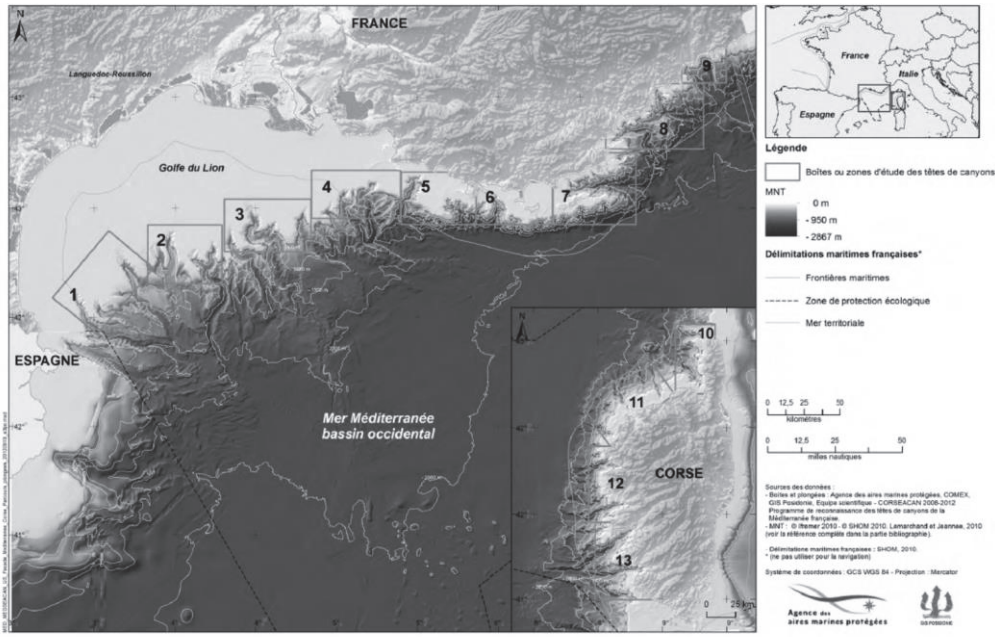


Fig. 1 : Localisation des 13 « boites » - zones d'études des têtes de canyons des campagnes MedSeaCan & CorSeaCan (d'après Fourt & Goujard, 2012)

Dans chacune de ces boîtes et durant les différents legs qui se sont succédés, l'exploration des flancs de canyons a été faite selon la même démarche en utilisant les mêmes moyens techniques mis en œuvre par les mêmes équipes scientifiques et techniques. La description du milieu repose en priorité sur l'acquisition de données images (photos, vidéo) obtenues à partir de sous-marins, habités ou téléguidés. L'identification des espèces de la mégafaune est faite visuellement en s'appuyant parfois sur les prélèvements réalisés durant les campagnes.
Les moyens utilisés pour acquérir des données étaient ceux de la COMEX S.A. (Fig. 2) : navire de 30 mètres le « Minibex », un ROV (Remotely Operated Vehicle) télécommandé Super Achille pouvant atteindre 800 mètres de profondeurs et permettant la capture

d'échantillons biologiques, et un sous-marin biplace REMORA limité à - 610 mètres. La bathymétrie et des images acoustiques des bancs rocheux situés en haut de canyons ou entre les canyons ont été obtenues grâce à l'utilisation d'un sondeur multifaisceaux et d'un sonar multifaisceaux.
Cette campagne a réuni une trentaine de scientifiques de l'Ifremer, des Universités d'Aix-Marseille, Perpignan, Nice, Paris IV, de l'Institut des Sciences de la Mer de Barcelone, des Observatoires Océanologiques de Villefranche-sur-Mer et de Banyuls-sur-Mer, du CNRS, du GIS3M, *etc*. Les gestionnaires d'aires marines protégées, les acteurs et techniciens concernés ont également embarqué. Près de 90 personnes se sont succédé lors des missions de terrain en mer.

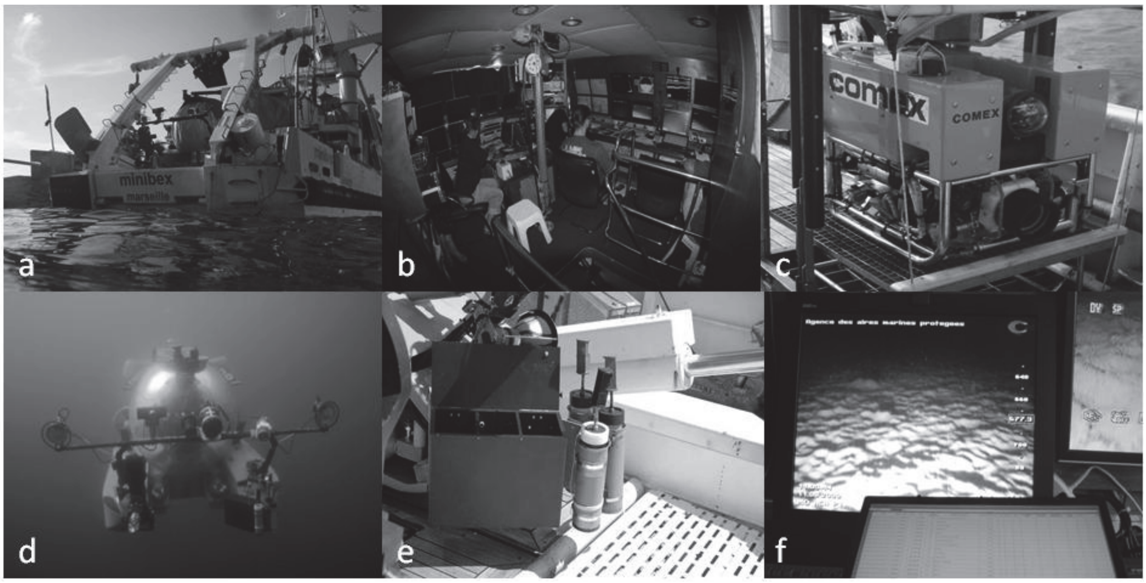


Fig. 2 : a : Navire océanographique « Minibex » utilisé pendant les campagnes ; b : Régie de surface ; c : ROV « Super Achille » ; d : Sous-marin 2 places Rémora 2000 ; e : Carottiers et boîte de prélèvements ; f : Ecrans de contrôle et logboox scientifique.
(Crédits photos : AAMP & COMEXS.A.)

Résultats

34 canyons, 9 bancs rocheux ont été explorés durant 143 jours de avec 295 plongées de 50 à 800 m de profondeur, dont 32 en sous-marin. Près de 22 000 photos, 590 heures de vidéos, 520 kilomètres parcourus en plongée et des dizaines de prélèvements ont été complétés en temps réel par des observations des scientifiques embarqués. Les logbooks ainsi créés, rassemblent les données faunistiques, floristiques (peu fréquentes dans les canyons) et géologiques, ainsi que diverses observations notées à la volée.
Le travail d'homogénéisation, de traitement des données et d'identification a été confié au GIS Posidonie, qui l'a conduit en collaboration avec les scientifiques ayant participé aux campagnes. Le GIS Posidonie a ainsi développé le ZOODEX (ZOOlogical Data EXploitation system) qui est une façon de traiter et d'organiser les données qui s'appui sur plusieurs logiciels pour le traitement et la consultation. L'outil regroupe la base de données, les photos et vidéos associées, les fichiers géoreférencés de type shapefile ainsi que d'autres documents en lien avec la base de données (Fig. 3).

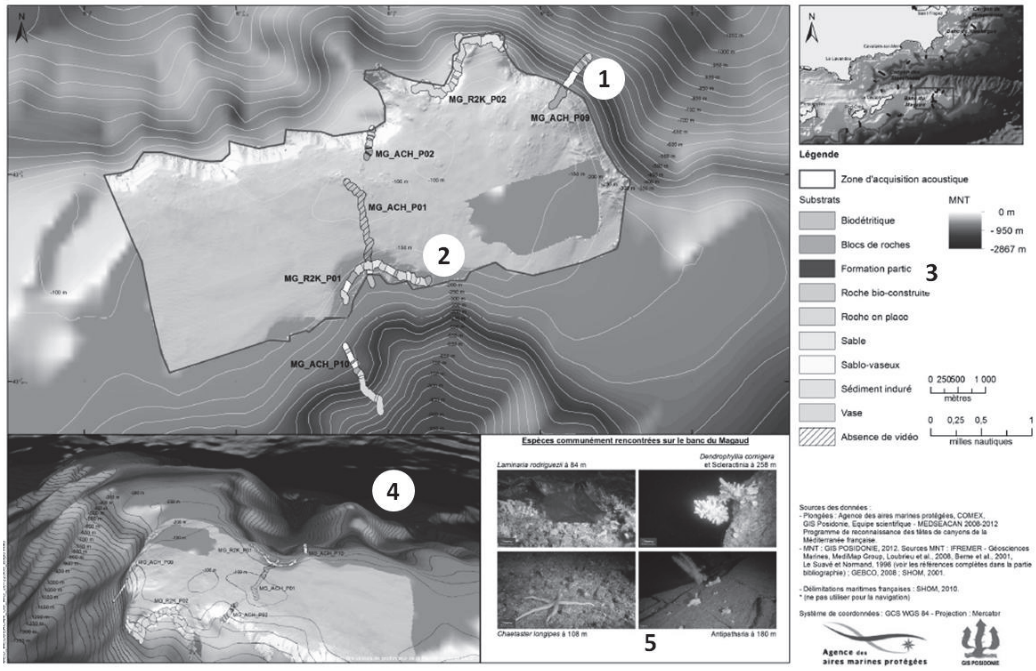


Fig. 3 : Représentation du substrat sur l'ensemble des plongées réalisées sur le banc de Magaud Parc National de Port-Cros – Boîte 7 - 1 : Profil ROV et nature du substrat observé ; 2 : Profil du sous-marin et nature du substrat observé ; 3 : Nature du substrat ; 4 : Représentation 3D de la zone d'exploration ; 5 : photographies d'observations caractéristiques de la zone (d'après Fourt & Goujard, 2012).

Les nombres de données acquises sont très importantes plus 6 téraoctets. Ces données nous permettent d'obtenir plusieurs informations scientifiques telles : (i) signalisation et géolocalisation d'espèces connues, nouvelles ; (ii) répartition bathymétrique des signalisations ; (iii) fréquence d'observation (rare, fréquente) ; (iii) milieu de vie et contexte (assemblages) ; (iv) parfois comportement ; (v) les sites de biodiversité importante ; (vi) les sites visiblement impactés par l'homme.
La démarche d'acquisition cohérente sur l'ensemble des canyons de Méditerranée a permis une description homogène des têtes de canyons permettant la comparaison et l'identification de site d'intérêt écologique (Fabri *et al*, 2014).
Les premières observations des boîtes continentales (MedSeaCan) permettent d'esquisser des remarques générales : (i) on constate une très grande hétérogénéité des canyons entre eux par leur morphologie, leur géologie et leur distance à la côte ; (ii) un examen rapide de la biodiversité montre des différences sensibles entre les canyons rocheux : les canyons de la partie Est révèlent que la présence de substrats durs n'implique pas nécessairement la présence d'une important faune fixée. De nombreuses espèces vagiles, voir fixées ont été observées dans certains canyons envasés ; (iii) l'impact anthropique est clairement visible avec une nette accumulation de déchets (où les plastiques prédominent) quand le plateau continental est étroit et que les canyons se situent à proximité de grandes villes telles que Marseille et Nice ; (iv) sur les canyons envasés du Golfe du Lion, l'activité de pêche est visible (traces de traits de chalut). Pour les canyons aux flancs rocheux les palangres et des filets perdus sont très présents.
Les canyons Corse (CorSeaCan) présentent des différences avec ceux du continent, notamment au niveau des assemblages faunistique. Aucun corail blanc n'a été observé.

Le peu de déchets et de traces d'activités de pêche, permettent de conclure à une bonne préservation des communautés benthiques.
Les canyons de Lacaze-Duthiers et de Cassidaigne constituent des spots de biodiversité exceptionnels en Méditerranée. Le Lacaze-Duthiers présente d'importante colonie de *Madrepora oculata* et de *Lophelia pertusa*, parmi les plus importantes en Méditerranée. La Cassidaigne quant à lui montre une diversité d'anthozoaires sur une même station remarquable. Ces observations ont contribué à la définition du périmètre du Parc Naturel Marin du Golfe du Lion et à la création d'une zone de non prélèvement sur le canyon de Cassidaigne dans le cœur du Parc National des Calanques.
Suite à l'acquisition de ces nouvelles données sur les habitats marins méditerranéens la typologie des biocénoses benthiques de Méditerranée a été mis à jour par le Muséum National d'Histoire Naturelle (Michez *et al*., 2014).

Discussion and conclusions
Les campagnes MedSeaCan et CorSeaCan ont permis de révéler la dimension écologique de ces têtes de canyons et d'établir le premier état des lieux à l'échelle de façade méditerranéenne française.
Ainsi tous les enjeux biologiques mis en évidence lors de ces campagnes ne sont actuellement pas tous couverts par les outils de protection et de gestion existants ainsi plusieurs grands secteurs d'intérêt pourraient servir à la création d'aires marines protégées au large (Ecologically or Biologically Significant marine Areas, Aire Spécialement Protégée d'Intérêt Méditerranéen – ou encore sites Natura 2000).
Un programme de surveillance des habitats profonds doit permettre de répondre à l'ensemble des engagements qu'ils soient locaux, nationaux ou internationaux. Il s'agit notamment d'évaluer l'efficacité de gestion des aires marines protégées concernés comme les Parcs Nationaux, le Parc naturel marin du Golfe du Lion ou les sites Natura 2000. L'état de conservation de habitat d'intérêt communautaire « récifs » (Directive Européenne Habitat, Faune et Flore) ou encore le Bon Etat Ecologique des habitats profonds (Directive Cadre Stratégie pour le Milieu Marin) doivent être mesurés pour rendre compte des efforts de conservation et de gestion mis en œuvre.
Tous les patrimoines identifiés ne nécessitent peut-être pas un suivi spécifique et leur intérêt doit être apprécié. Des outils de suivis existent, mais ils ne sont probablement pas suffisant et demandent à être complété.
D'ores et déjà à la suite de ces campagnes des intérêts scientifiques ont été exprimés pour revenir sur certains secteurs qui ont été peu explorés ou pour faire des prélèvements ciblés sur des espèces nouvelles. En août de 2014 deux journées en Corse, sur les canyons de Valinco et des Moines ont été dédiées à cet objectif.
Une surveillance par la mise en place d'une approche plus systématique de la cartographie des assemblages et de suivis temporels dans certains canyons-clé est en cours avec l'utilisation l'outil de photocartographie 3D développé par la COMEX et par l'analyse comparée de profils ROV 2009-2014. A l'image du site atelier pour le suivi et l'expérimentation du canyon Lacaze-Duthiers animé par l'Université Pierre et Marie Curie et dont l'objectif est de travailler sur la dynamique des transferts d'énergie dans l'écosystème, plusieurs stations de suivi pourraient contribuer à un observatoire profond de la biodiversité.
« Sur le bassin méditerranéen, les lacunes de connaissances sur les canyons restent importantes. Ces canyons représentent des systèmes fondamentaux pour appréhender les

fonctionnements de la Méditerranée et sont des outils privilégiés pour une meilleure gouvernance de l'ensemble de l'écosystème méditerranéen (Wurt, 2012) ».

Liens
http://cartographie.aires-marines.fr/?q=node/47
http://tecamed.canalblog.com/

Remerciements
Les auteurs remercient l'équipe de la COMEX S.A. pour son professionnalisme, sa motivation et sa passion de la mer. Un grand merci aux scientifiques qui ont participé et travaillent encore sur les données.

Bibliographie
BOURCIER M., ZIBROWIUS H. (1972) - Les boues rouges déversées dans le canyon de la Cassidaigne : Observations en soucoupe plongeante SP350 (Juin 1971) et résultats de dragages. *Tethys*. Vol 4 (4): 811-842.
FABRI M.-C., PEDEL L., BEUCK L., GALGANI F., HEBBELN D., FREIWALD A. (2014) - Megafauna of the Vulnerable Marine Ecosystems in French Mediterranean Submarine canyons : Spatial Distribution and Anthropogenic Impacts, *Deep-Sea Research II.*
FOURT M., GOUJARD A., équipe scientifique (2014) - Apports des campagnes d'explorations méditerranéennes MEDSEACAN et CORSEACAN à la typologie des habitats profonds. Convention Agence des aires marines protégées & GIS Posidonie. *GIS Posidonie publ*. 23 p.
FOURT M., GOUJARD A., équipe scientifique (2014) - Rapport final de la campagne MEDSEACAN (Têtes des canyons méditerranéens continentaux) novembre 2008 – avril 2010. Partenariat Agence des aires marines protégées. Rapport final, Partenariat Agence des aires marines protégées - *GIS Posidonie, Marseille : GIS Posidonie publ*., 218pp.
MICHEZ N., FOURT M., AISH A., BELLAN G., BELLAN-SANTINI D., CHEVALDONNE P., FABRI M.-C., GOUJARD A., HARMELIN J.G., LABRUNE C., PERGENT G., SARTORETTO S., VACELET J., VERLAQUE M. (2014) - Typologie des biocénoses benthiques de Méditerrané Version 2. Rapport SPN 2014-33. 33pp
REYSS D. (1964) - Observations faites en soucoupe plongeante dans deux vallées sous-marines de la mer Catalane: le rech du Cap et le rech Lacaze-Duthiers. *Bulletin de l'Institut Océanographique, Monaco*. Vol. 63 (1308): 1-8.
REYSS D. (1971) - Les canyons sous-marins de la mer catalane, le rech du Cap et le rech Lacaze-Duthiers. 3. Les peuplements de macrofaune benthique. Vie Milieu (B). Vol. 22 (3) : 529-613.
VIVIER M.H. (1976) - Influence d'un déversement industriel profond sur la nématofaune (Canyon de Cassidaigne, Mediterranée). *Téthys*. Vol. 8 (4): 307- 321.
WURTZ M. (ed.) (2012) - Mediterranean Submarine Canyons: Ecology and Governance. Gland, Switzerland and Malaga, Spain: IUCN 216pp.

ORAL COMMUNICATIONS

****

COMMUNICATIONS ORALES

Ricardo AGUILAR, SERRANO A., GARCÍA S., ALVAREZ H., BLANCO J., LÓPEZ J., MARÍN P., PASTOR X.
OCEANA, Leganitos, 47. 28013 Madrid-SPAIN.
E-mail: raguilar@oceana.org

VULNERABLE HABITATS AND SPECIES IN THE DEEP-SEA EMILE BAUDOT ESCARPMENT (SOUTH BALEARIC ISLANDS) SURVEYED BY ROV

Abstract

Geological features like seamounts and canyons are known to be potential biodiversity hotspots due to the variety of bathymetric ranges, substrata, habitats and species that they can host. Escarpments share these characteristics and new findings show they can be considered as important biological hotspots.

Remotely operated vehicle (ROV) dives between 100 and 1000 m depth carried out in the Emile Baudot Escarpment (Southern Balearic Islands) and the surrounding shelf-break have provided new data on the distribution of deep-sea habitats and species. The most important factor influencing species and habitats' presence is the nature of the substrate and the bathymetry. Although most of the area is heavily covered by sediment, rocky outcrops and overhangs show thanatocenoses of oysters and corals. Coral framework and oyster shells are colonized by other cnidarians, mollusks and sponges like Caryophyllia calveri, Spondylus gussonii or Tretodyctium tubulosum. Some Neopycnodonte zibrowii individuals can even still be found alive. Important aggregations and communities of the crinoid Leptometra phalangium and the brachiopod Gryphus vitreus occupy a wide area on the shelf-break and on top of the escarpment. Different researches and international fora (like UNEP or FAO) include these communities in the classification of vulnerable, sensitive or essential habitats and ecosystems.

Key-words: Deep-sea, vulnerable, Escarpment, Mediterranean Sea, Balearic Islands

Introduction

Emile Baudot is the largest escarpment in the Western Mediterranean, stretching up to 275 kilometers long. It is SW-NE oriented, with depths ranging from 200 m in the shallowest part to deeper than 2,000 m at its base (Acosta *et al.*, 2002). It splits the Western basin into two regions: the Balearic Sea in the North and the Algerian Basin in the South.

The Northeastern area of the escarpment has sharper gradients and is highly covered by sediments, while the Southwestern flank is dotted by different submarine elevations and the lower sediment deposition allows rocks to emerge. The escarpment concentrates a wide array of geomorphological features including guyots, seamounts, submarine canyons, underwater cliffs, volcanic pinnacles, etc. (Acosta *et al.*, 2001; 2004).

ROV dives have provided images of the biological communities present over soft and hard bottoms, giving a first overview of the species and habitats´ distribution range. The geodiversity in this deep-sea area allows the proper settlement of peculiar species and the occurrence of ecologically important habitats.

Material and methods

In 2013, Oceana carried out a total of 11 ROV dives in the southernmost area of the NE part of the escarpment, some 3 to 5 nautical miles to the S-SE off the Cabrera National Park (Fig. 1). The survey was performed between 114 m and 1,004 m depth, using a Saab

Seaeye Falcon DR ROV equipped with an HDV camera of 480 TVL with Minimum Scene Illumination 2.0 LUX (F1.4), Pick Up Device ½" CCD, Image Sensor, and spherical ½ of 3.8 mm and wide angle lens.

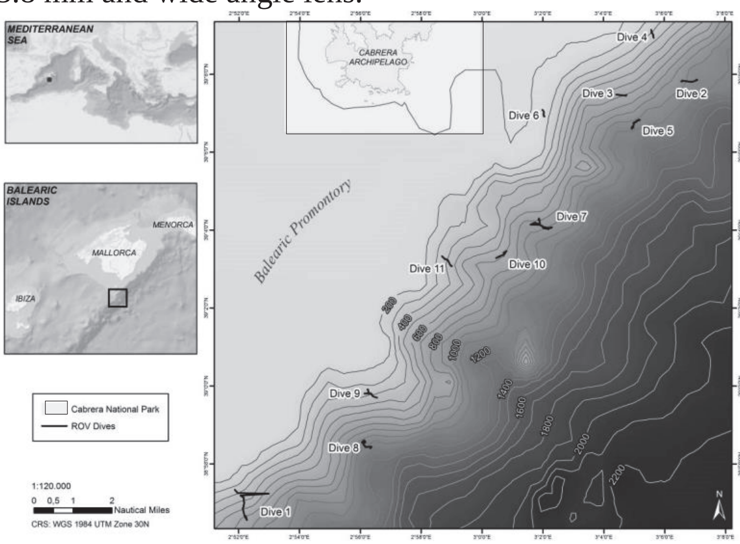


Fig. 1: Location map and deep-sea dives in the Emile Baudot escarpment.

The ROV footage was filmed both in HD and Low Res. Data on the position, depth, course and time was also recorded for the future examination of the images. The average sailing speed of the ROV was 0.2 knots.

Most of the taxonomic identifications were made by visual means, although several samples of key habitat-forming species were collected (with the ROV's robotic arm and a dredge) for detailed analyses to confirm preliminary identifications. Every sighting was counted per individual – estimated when high aggregations (e.g. pandalids) – and taxa, and annotated together with the depth distribution.

Results

Considering the 11 dives undertaken, the ROV sailed across over 15.2 kilometers of seabed, covering an area of almost 228,000 square meters filmed and surveyed. The observation effort was of 20h09'27", sighting an average of 13.48 individuals and 0.3 species per minute.

In total, close to 200 taxa were recorded in all transects, for a total of 16,218 individuals. Among the taxonomic groups found, chordate (46 species), cnidarian (35 species) and crustacean (29 species) were the groups with greater species representation (Fig. 2), and Echinodermata (4932 ind), Brachiopoda (4121 ind), Crustacea (2733 ind) and Cnidaria (2572 ind) were the dominant taxonomic groups in abundance.

The general trend observed reveals that the total number of species and individuals decreases with the depth (Fig. 3), so the vast majority of observations (50% species; 83% individuals) have been made in the shallower bottoms, from -100 down to -350 m (Fig. 3). Independently of this trend, a continuous species replacement in depth is also observed (Fig. 4). The results also show a significant decrease in species and abundance in the range of 600-750 m depth (0.14% individuals; 2.2% species) (Fig. 4), although it should be noted that such a breach coincides with the area where less observation effort was concentrated. Nevertheless, when taking into account the observation effort (Fig. 5), a strong abundance reduction trend in depth is confirmed, while the species reduction trend seems less pronounced if the less surveyed depth range is excluded.

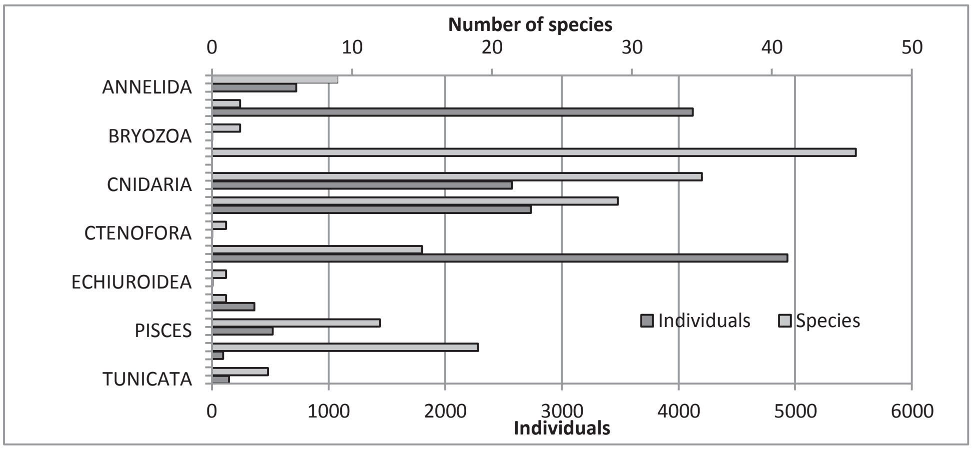


Fig. 2: Distribution of number of species and total abundance by taxonomic groups

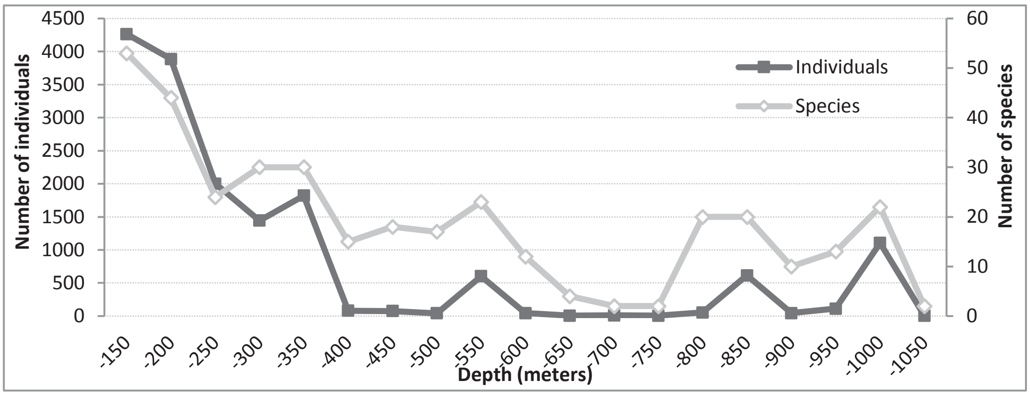


Fig. 3: Depth distribution of the number of individuals and species

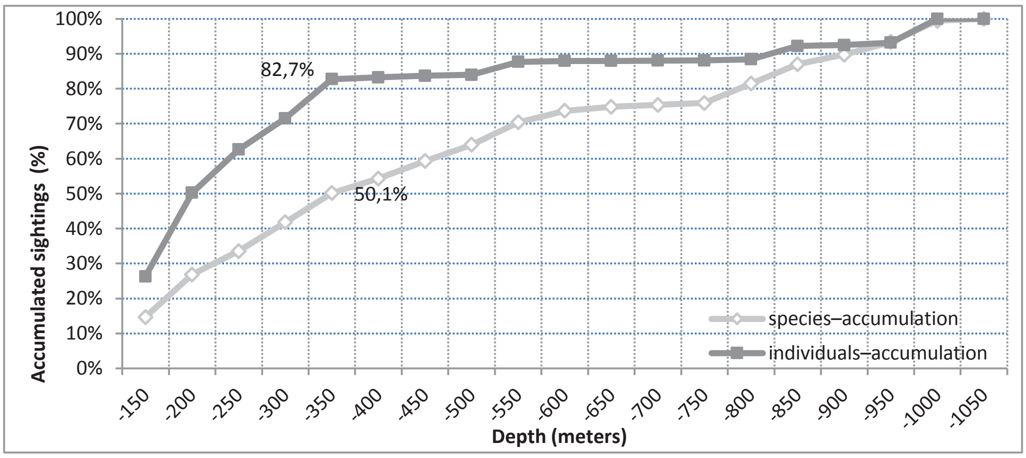


Fig. 4: Species and individuals accumulation

The general trend observed reveals that the total number of species and individuals decreases with the depth (Fig. 3), so the vast majority of observations (50% species; 83% individuals) have been made in the shallower bottoms, from -100 down to -350 m (Fig. 3). Independently of this trend, a continuous species replacement in depth is also observed (Fig. 4). The results also show a significant decrease in species and abundance in the range of 600-750 m depth (0.14% individuals; 2.2% species) (Fig. 4), although it should be noted that such a breach coincides with the area where less observation effort was concentrated. Nevertheless, when taking into account the observation effort (Fig. 5), a

strong abundance reduction trend in depth is confirmed, while the species reduction trend seems less pronounced if the less surveyed depth range is excluded.
Abundance peaks in the shelf and shelf break (150m and 250m) are the result of the large populations of *Leptometra phalangium*, *Megerlia truncata, Gryphus vitreus,* and *Lanice conchilega*. While in deep areas, it coincides with specific sightings of large populations of *Plesionika narval* (300m) and *P. edwardsii* (350m), and colonies of an unidentified epilithic zoanthid joined by stolons covering the rocks (550m, 850m and 1000m).

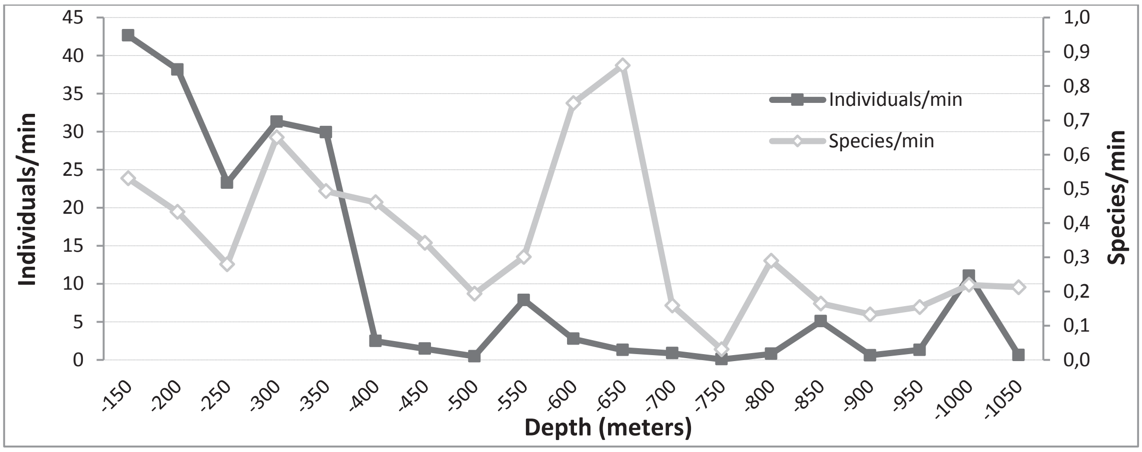


Fig. 5: Sightings per effort unit

Main facies and communitites observed:

1) *Gryphus vitreus* beds, mainly documented on detritic bottoms of the shelf-break before the escarpment, with estimated densities reaching up to 50-60 ind./m^2.
2) *Leptometra phalangium* beds, observed on sedimentary beds of the shelf, sometimes are mixed with *Gryphus vitreus* when closer to the escarpment. The highest estimated densities were of some 15-20 ind./m^2.
3) *Lanice conchilega* beds, occur in combination with *Gryphus vitreus* and *Leptometra* beds, but sometimes being the dominant species.
4) Ceriantharia beds, appear mainly at two different depth ranges, one on the shelf (150m) with *Arachnanthus* cf. *nocturnus* as the dominant species, and another on deeper areas (800m and 850m) with *Cerianthus* sp. and other Ceriantharia species.

With regards to the sea bottom typology and geomorphology:

5) Caves. Located on the shallowest part of the shelf down to approximately -170 m, the caves host an abundant and rich fauna, including several protected and/or regulated species (*Ranella olearia*, *Centrostephanus longispinus, Scyllarus arctus*, etc.).
6) Rocky overhangs with thanatocenoses of *Neopycnodonte zibrowii*. Dead giant oyster aggregations appear at around -300 m, but the densest ones are located in the deepest areas below -950 m providing substrate for other oysters (*Spondylus gussonii*), polychaetes and sponges´ settlement.
7) Rocky outcrops with coral framework. Have a very similar distribution to the oysters' thanatocenoses. Different sessile fauna attached to these beds includes live coral species such as *Caryophyllia* spp. and *Desmophyllum dianthus*.
8) Soft bottoms with burrowing megafauna. Widely distributed along the escarpment with higher bioturbation due to *Nephrops norvegicus* and other crustaceans' burrows below -450 m.

Discussion and conclusions

Seamounts and canyons, considered as potential biodiversity hotspots (Morato, 2003; Samadi *et al*., 2007; Abdulla *et al.*, 2009; de Juan & Lleonart, 2010; Morato *et al.*, 2010; Harris & Baker, 2012; Würtz, 2012), share characteristic escarpments which result in a wide diversity of substrates, habitats, communities and species (Drazen *et al*., 2003; Taviani *et al*., 2011; Van Rooij *et al.*, 2011).

Outcomes from ROV surveys presented in this document and others in different Mediterranean areas provide the evidence that escarpments and their overhangs host important Scleractinia and Ostreidae fossil assemblages (e.g. Strait of Sicily (Freiwald *et al.*, 2009); area between Malta and Syracuse (Taviani & Colantoni, 1984); Alboran Sea (Hebbeln *et al.*, 2009)). These communities in the Emile Baudot Escarpment still keep some remaining alive aggregations of oysters and small colonies of scleractinians which may have been strongly reduced from what they originally were in the past.

This research has shown that the shelf and shelf-break between the Cabrera National Park and the Emile Baudot Escarpment displays important areas for communities considered as Sensitive Habitats (Colloca *et al.*, 2004; Mangano *et al.*, 2010), such as *Leptometra phalangium* and *Gryphus vitreus* beds.

The area seems to be important for several vulnerable, threatened and protected species, like deep-sea sharks (*Centrophorus granulosus*), manta rays (*Mobula mobular*), hatpin urchins (*Centrostephanus longispinus*), wandering tritons (*Ranella oelaria*) or the anthozoans *Callogorgia verticillata* and *Savalia savaglia* that were also documented during this survey The escarpment has been already appointed as a feeding and, possible, breeding ground for sperm whales (*Physeter macrocephalus*) (Pirotta et al., 2011).

Further analyses are needed to estimate the impact on these communities and species of lost fishing gears, garbage and sedimentation rates observed in the escarpment.

Infralittoral caves have been studied in many Mediterranean areas and they are often recognized as reservoirs of unknown biodiversity and non-resilient communities (Harmelin *et al.*, 1985; UNEP/MAP, 2013). However information on deep-sea caves and cavities is pretty scarce. The area between the circalitoral and bathyal zones on the shelf break beside the Emile Baudot Escarpment host caves that are largely unexplored, but first images collected show important communities and species.

Bibliography

ABDULLA A., GOMEI M., HYRENBACH D., NOTARBARTOLO-DI-SCIARA G., AGARDY T. (2009) - Challenges facing a network of representative marine protected areas in the Mediterranean: prioritizing the protection of underrepresented habitats. *ICES Journal of Marine Science: Journal du Conseil*, 66 (1), 22-28.

ACOSTA J., MUÑOZ A., HERRANZ P., PALOMO C., BALLESTEROS M., VAQUERO M., UCHUPI E. (2001) - Geodynamics of the Emile Baudot Escarpment and the Balearic Promontory, Western Mediterranean. *Mar. Pet. Geol.*, 128: 349–369.

ACOSTA J., CANALS M., LOPEZ-MARTINEZ J., MUÑOZ A., HERRANZ P., URGELES R., PALOMO C., CASAMOR J.L. (2002) - The Balearic Promontory geomorphology (western Mediterranean): morphostructure and active processes. *Geomorphology*, 49: 177–204.

ACOSTA J., ANCOCHEA E., CANALS M., HUERTAS M.J., UCHUPI E. (2004) - Early Pleistocene Volcanism in the Emile Baudot Seamount, Balearic Promontory (Western Mediterranean Sea). *Marine Geology*, V 207/1-4: 247-257.

COLLOCA F., CARPENTIERI P., BALESTRI P., ARDIZZONE G. D. (2004) - A critical habitat for Mediterranean fish resources: shelf-break areas with *Leptometra phalangium* (Echinodermata: Crinoidea). *Marine Biology*, 145: 1129–1142.

DE JUAN S., LLEONART J. (2010) - A conceptual framework for the protection of vulnerable habitats impacted by fishing activities in the Mediterranean high seas. *Ocean & Coastal Management*, 53: 717-723.

DRAZEN J.C., GOFFREDI S.K., SCHLINING B., STAKES D.S. (2003) - Aggregations of egg brooding deep-sea fish and cephalopods on the Gorda Escarpment: a reproductive hotspot? *Biological Bulletin*, 205: 1-7.

FREIWALD A., BEUCK L., RÜGGEBERG A., TAVIANI M., R/V METEOR M70–1 PARTICIPANTS (2009) - The white coral community in the central Mediterranean revealed by ROV surveys. *Oceanography*, 22: 58–74.

HARMELIN J.G., VACELET J., VASSEUR P. (1985) - Dark submarine caves - An extreme environment and a refuge-biotope. *Téthys*, 11: 214-229.

HARRIS P.T., BAKER E.K. (eds) (2012) - Seafloor geomorphology as benthic habitat. Geohab atlas of seafloor geomorphic features and benthic habitats. *Elsevier*. ISBN: 978-0-12-385140-6.

HEBBELN D., WIENBERG C., BEUCK A., FREIWALD A., WINTERSTELLER P., DEHNING K., KLANN M., NOWALD N., RUHLAND G., KLAUCKE I. (2009) - Report and preliminary results of RV Poseidon cruise POS 385 "Cold-Water corals of the Alboran Sea (Western Mediterranean Sea)". *Berichte aus dem Fachbereich der Geowissenschaften der Universität Bremen*, 273: 1–79

MANGANO M.C., PORPORATO E., DE DOMENICO F., PROFETA A., BUSALACCHI B., SPANO N. (2010) - *Leptometra phalangium* (J. Müller, 1841). Fields from the southern Tyrrhenian Sea: Preliminary data on the associated fauna. *Biol. Mar. Mediterr*., 17 (1): 304-305.

MORATO T. (2003) - Seamounts – hotspots of marine life. *ICES Newsletter* 40: 4-6.

MORATO T., HOYLE S.D., ALLAIN V., NICOL S.J. (2010) - Seamounts are hotspots of pelagic biodiversity in the open ocean. *Proceedings of the National Academy of Sciences*, 107 (21): 9707-9711.

PIROTTA E., MATTHIOPOULOS J., MACKENZIE M., SCOTT-HAYWARD L., RENDELL L. (2011) - Modeling sperm whale habitat preference: a novel approach combining transect and follow data. *Marine Ecology Progress Series*, Vol. 436: 257–272.

SAMADI S., SCHLACHER T., RICHER DE FORGES B. (2007) - Seamount benthos. Seamounts: *Ecology, Fisheries, and Conservation*, 12: 119-140.

TAVIANI M., COLANTONI P. (1984) - Paléobiocenoses profondes a scléractiniaires sur l'escarpement de Malte-Syracuse (Mer Méditerranée): leur structure, leur âge et leur signication. *Rev. Inst. Fr. Pétr*., 39: 547–552.

TAVIANI M., VERTINO A., LÓPEZ CORREA M., SAVINI A., DE MOL B., REMIA A., MONTAGNA P., ANGELETTI L., ZIBROWIUS H., ALVES T., SALOMIDI M., RITT B. (2011) - Pleistocene to Recent scleractinian deep-water corals and coral facies in the Eastern Mediterranean. *Facies*, 57 (2011): 579-603.

UNEP/MAP (2013) - Action Plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic phenomena in the Mediterranean Sea (Dark Habitats Action Plan). 18th Ordinary Meeting of the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols Istanbul (Turkey), 3-6 December 2013. United Nations Environment Program. UNEP(DEPI)/MED IG.21/9. 16 December 2013. UNEP/MAP. Athens, 2013. 115-131.

VAN ROOIJ D., BLAMART D., DE MOL L., MIENIS F., PIRLET H., WEHRMANN L.M., BARBIERI R., MAIGNIEN L., TEMPLER S.P., DE HAAS H., HEBBELN D., FRANK N., LARMAGNAT S., STADNITSKAIA A., STIVALETTA N., VAN WEERING T., ZHANG Y., HAMOUMI N., CNUDDE V., DUYCK P., HENRIET J.-P., THE MICROSYSTEMS MD 169 SHIPBOARD PARTY (2011) - Cold-water coral mounds on the Pen Duick Escarpment, Gulf of Cadiz: the MiCROSYSTEMS approach. *Marine Geology*, 282: 102-117

WÜRTZ M. (ed.) (2012) - Mediterranean Submarine Canyons: Ecology and Governance. Gland, Switzerland and Málaga, Spain: IUCN. 216 pages.

Marzia BO, ANGIOLILLO M., BAVA S., BETTI F., CANESE S., CATTANEO-VIETTI R., CAU A., PRIORI C., SANDULLI R., SANTANGELO G., TUNESI L., BAVESTRELLO G.
Dipartimento di Scienze della Terra, della Vita, dell'Ambiente, Università di Genova, Corso Europa 26, 16132 Genova, Italia.
E-mail: marzia.bo@unige.it

FISHING IMPACT ON ITALIAN DEEP CORAL GARDENS AND MANAGEMENT OF THESE VULNERABLE MARINE ECOSYSTEMS

Abstract
Coral gardens have been internationally recognized as unique habitats characterized by numerous structuring species, generating complex and fragile ecosystems, which act as important oases of biodiversity in the deep realm. Deep corals are generally believed to constitute poorly resilient assemblages presenting a low recovery potential from the impact of destructive deep fishing activities. For these reasons, the international scientific community has recently proposed the inclusion of some of these species in many protection lists, recognizing their ecological value and their vulnerability to human activities.
A wide ROV video archive was used to characterize the fishing impact on numerous deep rocky shoals along the entire Tyrrhenian and Ligurian Seas (Italy). Lost fishing gears represent the great majority of the marine litter on the bottom, reported in the totality of the explored sites. Some regional differences were highlighted, with Liguria and Campania among the most impacted areas. Various features, such as the explored depth range, the accessibility of the shoals and the local fishing traditions play a synergistic role in defining the observed pattern. Additional indicators of impact have been identified in order to characterize the health status of the coral aggregations in heavily impacted fishing grounds.
No active ecosystem-based fishery management of the deep Italian rocky shoals hosting these coral gardens has still been defined, if we exclude some local initiatives. A network of deep marine protected areas, that might apply experimental fishing restrictions, is here proposed for the Italian Seas.

Key-words: Coral gardens; Italian Seas; ROV-imaging; Fishing impact; VMEs.

Introduction
The effects of fishing activities on the benthic biocoenoses represent a worldwide problem particularly relevant in the Mediterranean Sea, a site characterized by intense historical fishing traditions. Similarly to what happens in other areas of the world, also in the Mediterranean basin the majority of the studies concerning fishing impact have been addressed on the soft bottom assemblages subjected to trawling activities (Smith *et al.*, 2000; Maynou & Cartes, 2012), while very few information is available on the response of hard bottom communities, with the exception of some priority habitats such as seamounts (Freiwald *et al.*, 2011) and white coral gardens (Tudela, 2000; Orejas *et al.*, 2009; D'Onghia *et al.*, 2010, 2012).
In the Mediterranean Sea, the rocky bottoms between 50 and 700 m depth, being generally avoided by trawlers, represent important fishing grounds for artisanal and recreational fleets. These areas may host rich benthic biocoenoses, dominated by large anthozoans (such as gorgonians, antipatharians, and scleractinians), that are vulnerable to the impact

of the fishing gears due to their arborescent morphology (the so called Vulnerable Marine Ecosystems, VMEs). Their longevity and ability to form dense three-dimensional habitats assimilable to coral gardens, attract a rich associated fauna, including fish species of commercial interest, which therefore increase the importance of these habitats for fishermen (Cerrano *et al.*, 2010; Bo *et al.*, 2014). The most commonly used gears (trammel nets, gill nets and long lines) produce a continuous mechanical scouring on the sea bottom, determining a progressive and extended reduction of the coral coverage, which, in turns, leads to a substantial decrease of the biodiversity levels towards opportunistic species with a faster growth rate and adapted to live on more silted or unstable habitats (Bo *et al.*, 2014).
At present, very few quantitative data are available on the unintentional negative effects or by-catch of the Mediterranean artisanal fishing activities. Nevertheless these data are very impressive: experimental fishing surveys conducted with trawl-nets and long-lines on the Santa Maria di Leuca white coral reefs reported for coral by-catch (mostly alive) in 55% of the investigated stations (D'Onghia *et al.*, 2012). Data about coral bycatch obtained during experimental long-line fishing surveys conducted in the eastern Ionian Sea between 500 and 600 m depth, reported specimens, almost all alive, belonging to 8 anthozoan taxa in 72% of the surveys (Mytilineou *et al.*, 2014). These data are comparable also with some analyses made in the Azores Islands reporting a wide by-catch covering 39 cold-water corals taxa in about 15% of the surveys (Sampaio *et al.*, 2012). In the Aegean Sea, Mytilineou *et al.* (2014) estimated about 30-130 colonies of antipatharians and *Isidella elongata* accidentally collected per fishermen per year during the seabream long line fishing, with variability on the basis of hook size, bottom topography and size and shape of the dominant coral species.
Not only the removal of the colonies is of concern. There are, in fact, also evidences of indirect damage due to the friction acted by moving or entangled gears on the colonies (Bo *et al.*, 2014). The tissue wounds favor bacterial infections as well as the exposure of naked skeleton that is quickly covered by epibiont agglomerates adding weight to the ramifications that eventually break up increasing the colony mortality (Bavestrello *et al.*, 1997). Due to the extremely slow degradation of nylon, lost gears may persist for a long time accumulating on the sea bottom and covering wide areas impeding the re-colonization for large anthozoans.
Thanks to novel technology for deep investigation, this problem is no longer out of sight. The aim of this work was to give, through the use of ROV-Imaging technique, a general picture of this phenomenon on the deep Italian rocky habitats between 50 and 600 m depth, evaluating the impact, in terms of quantity and typology of fishing gears as well as the responses of the benthic species. Finally, this work aimed at producing, based on the knowledge gained so far on the distribution of the best preserved communities, a preliminary mapping of the possible Italian VMEs, to be discussed for future off-shore marine protected areas.

Materials and methods

Data have been collected between 2008 and 2013 during five ROV surveys carried out on board of the R/V *Astrea* (ISPRA) in five Italian regions on hard bottoms found between 50 and 600 m depth. In order to characterize the communities formed by structuring arborescent cnidarian species in each area, a visual census was performed on over 12,000 video frames, randomly extrapolated from the video footage, corresponding to about 24,000 m^2 of explored area. Species richness and abundance (expressed as N° colonies.m^{-2}), percentage of frames showing lost fishing gears (IF=Impacted Frames), percentage of various gears typologies (nets, long lines, other gears, litter), and percentage of entangled colonies (EC) were also evaluated for each frame. For four target study sites (Mantice Shoal and St. Lucia Bank in Liguria, Marco Bank in Sicily and Vedove Shoal in Campania) the influence of the bathymetric range, the quantity of gears, and the percentage of colonies covered by epibionts were also taken into account. Finally, the most frequently impacted species have been studied in order to evaluate their response to mechanical impacts.

Results

During the ROV surveys, over 55,000 colonies belonging to 22 species of structuring arborescent cnidarians (hydrozoans, scleractinians, gorgonians, zoanthids and antipatharians) have been counted. Considering the four target study areas, it is possible to observe a significant difference between the communities in terms of species composition and abundance in relation to the explored bathymetric range and to the sea bottom topography. These factors influence the frequency of occurrence of shallow-water species (such as numerous gorgonians) or deep-water taxa (such as antipatharians and scleractinians), as well as the occurrence of fast growing species (on unstable sea bottoms such as mounds of dead corals) or extremely long-lived ones.

Traces of fishing impact have been detected in almost all explored sites (Fig. 1), with occurrence of long lines (Fig. 1A) as most frequent, followed by nets (trammel nets, gill nets and occasionally trawling nets and ‘ingegno’ nets) (Fig. 1B-D). Other gears clearly related to fishing activities have been often reported, such as disposable moorings (Fig. 1E) and anchors (Fig. 1F).

The quantitative analysis of the frames showing traces of lost gears shows significant differences among the study areas, with Liguria and Campania characterized by the highest values (average percentage of IF, 36% and 35%, respectively), followed by Calabria (17%), Sicily (15%), and last by Sardinia (6%). This pattern may be explained both in terms of different regional fishing traditions, hence efforts, as well as accessibility of the fishing grounds. There is, in fact, a clear reduction of the impact with distance from the coast, considering that both artisanal and recreational fishermen exploit the most coastal, shallow rocky shoals. Among the less impacted site there is, for example, the Vercelli Seamount located over 60 nautical miles from the nearest coasts.

Among the most impacted species there are those with a medium-large colony size, an arborescent morphology and a flexible skeleton, that easily remain entangled (Fig. 1H). It is likely that such colonies can be completely eradicated from some heavily fished sites, as demonstrated in some Ligurian or Campanian sites, where coral gardens have almost disappeared. The occurrence of isolated and damaged or entangled colonies for a species that usually forms dense populations, as *Leiopathes glaberrima*, may indeed be considered as a trace of a lost biocoenosis. Some species, such as *Callogorgia verticillata*, are highly vulnerable due to the fragility of their skeleton (Fig. 1A) as demonstrated by the morphometric comparison of specimens measured in areas subjected to different degrees of impact (the height/width ratio is halved). Among the species with a carbonate skeleton, those with thick ramifications, such as *Dendrophyllia cornigera*, are often removed, while those with thin branches, such as *Madrepora oculata*, are frequently crushed. The presence of these species on flat hardgrounds covered by silt, makes them vulnerable also to accidental trawling activity carried out nearby the rocky shoals which may drag and accumulate them on the sea bottom or may partially cover them with resuspended fine sediment. Finally, in some highly impacted sites, there is a high percentage of damaged colonies (but not necessarily evidently entangled) that are partially or entirely covered by epibionts (Fig. 1G), showing a rapid growth rate and an encrusting development, such as many zoanthids or some alcyonacean. Even though these opportunistic organisms may naturally occur, their high frequency may suggest a general state of stress of the community.

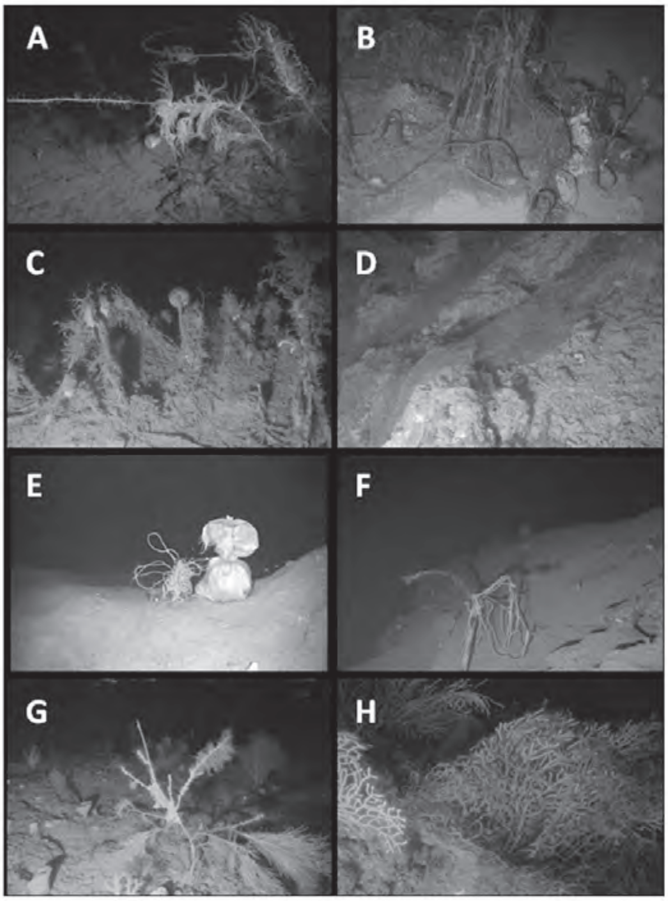


Fig. 1: Fishing impact on Tyrrhenian and Ligurian deep rocky shoals. A. Lines entangled on *Callogorgia verticillata* colonies (Sicily). B. Lost trawling net on a white coral reef (Sardinia). C. Lost trammel net on a Ligurian shoal. D. Pieces of "ingegno" on red coral bank (Sicily). E. Disposable mooring on the Vedove Shoal (Campania). F. Lost anchor. G. Damaged and colonized colony of *C. verticillata* (Liguria). H. Colony of *E. cavolinii* completely covered by a net (Liguria).

Discussion and conclusions

The ROV exploration of the Italian deep circalittoral habitats carried out in the last decade revealed the heavy impact of fishing activities on the benthic communities. Some biocoenoses, such as that characterized by the gorgonian *Isidella elongata*, thriving on the bathyal muds of some areas of the western basin, may now be considered almost disappeared in heavily trawled fishing grounds (Arena & LiGreci, 1973; Relini *et al.*, 1986; Cartes et al., 2013). Otherwise, this species is now confined below 1000 m depth, where trawling is banned, or in shallow-water muddy enclaves that, due to heterogeneous rocky bottoms or wrecks, are protected from fishing (Tunesi *et al.*, 2001; Bo *et al.*, in press). The data of this study, in parallel to those gathered through experimental fishing surveys evaluating the coral by-catch, suggest that it is highly probable that pristine coral gardens no longer exist also on rocky sea bottoms, especially in traditionally exploited fishing grounds. What we observe at present may actually represent the result of a dramatic reduction of the geographic and bathymetric distribution boundaries of these species (Bo *et al.*, 2014).

The percentage of video frames showing traces of lost gears is a practical and objective indicator that allows the comparison among different areas (Bo *et al.*, 2014). In the Tyrrhenian and Ligurian Seas the majority of the impact is ascribable to lines, contributing for more than 90% of the impacted frames. It is difficult to attribute the origin of lost gears to artisanal fishermen with certainty, especially in the case of long lines. In this sense, it is very important to keep into consideration the great difficulty, in the Italian waters, to monitor the recreational sector since no official licenses are provided nor any experimental study has been carried out to quantify the entity of its by-catch.

Among the other factors to consider when evaluating the degree of impact of a certain area, the distance from the coast and the exploited depth range that obviously influence the fishing effort, the typology of employed gears, the species composition of the community and, therefore, the response of the community to the impact and its recovery ability, must be taken into account (Bo *et al.*, 2014). It is important to identify and validate indicators of impact that may apply in order to differentiate areas in terms of priority of protection measures.

The present data demonstrate that it is necessary to apply a prompt fisheries management policy that takes into consideration all possible information on deep ecosystems (Davies *et al.*, 2007; de Juan & Lleonart, 2010). In this sense, it will be essential to promote a census of the deep coral gardens of our seas and define offshore protection areas subjected to important restrictions to fishing. This approach is now an international priority that proceeds together with the inclusion of the structuring species in numerous directives and through their extinction risk assessment. For the Italian Seas, around 20 top priority for protection areas have been identified based on the current biological knowledge that may be considered among the most well-preserved and vulnerable deep assemblages known so far.

Acknowledgements

We would like to thank the crew members of R/V Astrea for their help in the field work. This work was financed by: Ministero dell'Ambiente e della Tutela del Territorio e del Mare (Project 2010, "Red Coral"), Ministero delle Politiche Agricole, Alimentari e Forestali (Project 2012, "Use of ROV in the management of deep *Corallium rubrum* populations"), CoCoNet Project ("Towards Coast to COast NETworks of marine protected areas (from the shore to the high and deep sea), coupled with sea-based wind energy potential", 7th Framework Programme, EU, RITMARE Project ("La ricerca italiana per il mare"), COFIN-PRIN 2011-2012, ENPI-ECOSAFIMED - II-B/2.1/1073 ("Towards Ecosystem Conservation and Sustainable Artisanal Fisheries in the Mediterranean basin").

Bibliography

ARENA P., LI GRECI F. (1973) Indagine sulle condizioni faunistiche e sui rendimenti di pesca dei fondali batiali della Sicilia occidentale e della bordura settentrionale dei banchi della soglia siculo-tunisina. *Quad. Lab. Tecnol. Pesca*, 1: 157-201.

BAVESTRELLO G., CERRANO C., ZANZI D., CATTANEO-VIETTI R. (1997) - Damage by fishing activities to the gorgonian coral *Paramuricea clavata* in the Ligurian *Sea. Aquat. Conserv*., 7: 253-262.

BO M., BAVA S., CANESE S., ANGIOLILLO M., CATTANEO-VIETTI R., BAVESTRELLO G. (2014) - Fishing impact on deep Mediterranean rocky habitats as revealed by ROV investigation. *Biol. Conserv*., 171: 167-176.

BO M., BAVESTRELLO G., ANGIOLILLO M., CALCAGNILE L., CANESE S., CANNAS R., CAU AL., D'ELIA M., D'ORIANO F., FOLLESA M.C., QUARTA G., CAU A. Persistence of pristine deep coral gardens in the Mediterranean Sea (SW Sardinia). *Plos-One, in press*.

CARTES J.E., LOIACONO C., MAMOURIDIS V., LOPEZ-PEREZ C., RODRIGUEZ P. (2013). - Geomorphological, trophic and human influences on the bamboo coral Isidella elongata assemblages in the deep Mediterranean: To what extent does Isidella form habitat for fish and invertebrates?. *Deep Sea Res.I: Ocean. Res. Pap*., 76: 52-65.

CERRANO C., DANOVARO R., GAMBI C., PUSCEDDU A., RIVA A., SCHIAPARELLI S. (2010) - Gold coral (*Savalia savaglia*) and gorgonian forests enhance benthic biodiversity and ecosystem functioning in the mesophotic zone. *Biodivers. Conserv*., 19: 153-167.

DAVIES A. J., ROBERTS J.M., HALL-SPENCER J. (2007) - Preserving deep-sea natural heritage: emerging issues in offshore conservation and management. *Biol. Conserv*., 138: 299-312.

DE JUAN S., LLEONART J. (2010) - A conceptual framework for the protection of vulnerable habitats impacted by fishing activities in the Mediterranean high seas. *Ocean Coast. Manag*., 53: 717-723.

D'ONGHIA G., MAIORANO P., SION L., GIOVE A., CAPEZZUTO F., CARLUCCI R., TURSI A. (2010) - Effects of deep-water coral banks on the abundance and size structure of the megafauna in the Mediterranean Sea. *Deep Sea Res. Part II*, 57: 397-411.

D'ONGHIA G., MAIORANO P., CARLUCCI R., CAPEZZUTO F., CARLUCCIO A., TURSI A., SION L. (2012) - Comparing deep-sea fish fauna between coral and non-coral "Megahabitats" in the Santa Maria di Leuca cold-water coral province (Mediterranean Sea). *PloS-One*, 7: e44509.

FREIWALD A., BOETIUS A., BOHRMANN G. (2011) - RV METEOR, Cruise Report M70/L1, M70/L2a+b, M70/L3, Deep water ecosystems of the Eastern Mediterranean 2006 313 pp., DFG Senatskommission für Ozeanographie.

MAYNOU F., CARTES J.E. (2012) - Effects of trawling on fish and invertebrates from deep-sea coral facies of *Isidella elongata* in the western Mediterranean. *J. Mar. Biol. Ass. UK*, 92: 1501-1507.

MYTILINEOU C., SMITH C.J., ANASTASOPOULOU A., PAPADOPOULOU K.N., CHRISTIDIS G., BEKAS P., KAVADAS S., DOKOS J. (2014) - New cold-water coral occurrences in the Eastern Ionian Sea: Results from experimental long line fishing. *Deep-Sea Res. Pt II*, 99: 146-157.

OREJAS C., GORI A., LO IACONO C., PUIG P., GILI J.M., DALE M.R. (2009) - Cold-water corals in the Cap de Creus canyon, northwestern Mediterranean: spatial distribution, density and anthropogenic impact. *Mar. Ecol. Prog. Ser*., 397: 37-51.

RELINI G., PEIRANO A., TUNESI L. (1986) - Osservazioni sulle comunità dei fondi strascicabili del Mar Ligure Centro-Orientale. *Boll. Mus. Ist.. Biol. Univ. Genova,* 52 suppl.:139-161.

SAMPAIO I., BRAGA-HENRIQUES A., PHAM C., OCANA O., DE MATOS V., MORATO T., PORTEIRO F.M. (2012) - Cold-water corals landed by bottom long line fisheries in the Azores (north-eastern Atlantic). *J. Mar. Biol. Ass. UK*, 92: 1547-1555.

SMITH C.J., PAPADOPOULOU K.N., DILIBERTO S. (2000) - Impact of otter trawling on an eastern Mediterranean commercial trawl fishing ground. *ICES J. Mar. Sci. J. Cons.*, 57: 1340 - 1351.

TUDELA S. (2000) - Ecosystem effects of fishing in the Mediterranean: An analysis of the major threats of fishing gear and practices to biodiversity and marine habitats. FAO Fisheries Department (EP/INT/759/GEF). *Studies and Reviews*.

TUNESI L., DIVIACCO G., MO G. (2001) - Observations by submersible on the biocoenosis of the deep-sea corals off Portofino Promontory (Northwestern Mediterranean Sea). In: *Proceedings of the First International Symposium on Deep-Sea Corals*, Ecology Action Centre and Nova Scotia Museum, Halifax, Nova Scotia, J.H. Martin Willison et al. (eds): 76-87.

Martina CANESSA, MONTEFALCONE M., CANOVAS MOLINA A., COPPO S., DIVIACCO G., BAVESTRELLO G., MORRI C., BIANCHI C.N.
DiSTAV, Dipartimento di Scienze della Terra, dell'Ambiente e della Vita, Università di Genova, Corso Europa 26, 16132 Genova, Italy
E-mail: montefalcone@dipteris.unige.it

SUBMERGED MARINE CAVES OF LIGURIA: UPDATING THE KNOWLEDGE

Abstract

Marine caves are priority coastal habitats according to the EU Habitat Directive, but they have received a comparatively lower attention with respect to other Mediterranean key coastal habitats, such as seagrass meadows and coralligenous reefs. This paper reviews and updates the existing knowledge on the underwater marine caves of Liguria, an administrative region in NW Italy. The available bibliographic information, retrieved from regional archives, grey literature and scientific publications, has been implemented with records by divers to build a database on the distribution and typology (both geological and biological) of marine underwater caves of Liguria. The database has been implemented on a GIS platform. Out of the 76 marine caves recorded along the coast, only 20 are submerged, reaching a maximum depth of 40 m. 21 caves are distributed in the Western Ligurian Riviera and 56 in the Eastern Riviera. Major caves are located in karst areas. Geological and morphological information is available for virtually all caves, whereas biological data are limited to 13 caves, and are rarely accompanied by historical series. This first attempt provides useful indications to focus future investigations, and could become a potential management tool for local administrations to protect these habitats.

Key-words: Marine caves, bibliographic information, GIS, Liguria, Mediterranean Sea.

Introduction

Submerged marine caves are today considered priority habitats according to current EU standards, including the Marine Strategy Framework Directive and the Barcelona Convention (Giakoumi *et al.*, 2013). The scientific interest that these delicate habitats received in the last 50 years, however, is not yet supported by complete and updated information for all the cavities that, being unique, require specific management measures. At national and regional level, there are few examples of detailed knowledge on the topography and the biological communities characterizing an underwater cave (e.g. Parravicini *et al*., 2010; Gerovasileiou *et al*., 2013), because caving and speleological tradition has always been more developed on land than at sea, due to the practical limits of the exploration of the latter (Bixio, 1987; Bianchi *et al.*, 1996).
Liguria, an administrative region in NW Italy, has a record of excellence in the state of knowledge and protection of *Posidonia oceanica* seagrass meadows (Bianchi & Peirano, 1995; Diviacco & Coppo, 2006), but today it is necessary to extend this knowledge to other priority habitats: actions are being undertaken for coralligenous reefs, whereas underwater marine caves have received to date a comparatively lower attention with respect to other Mediterranean key coastal habitats.

Materials and methods

Available information on positioning, type of survey, geology, topography and biology of each cave of Liguria, with the relevant bibliography, has been collected from regional archives, grey literature, scientific publications, and records by divers. The database has been implemented on a GIS platform.

Getting inspiration from the method developed by Leriche *et al.* (2004), we constructed a Reliability Index (RI) to assess the quality of the information existing on each cave. Each available source of data was classified based on five items: i) positioning, ii) survey, iii) geology, iv) biology, and, v) for the latter category, data acquisition period.

For each item, a score 0 to 3 was assigned. RI, ranging from 0 to 15, was computed as the sum of all scores for each cave.

- Positioning
  - Approximate localisation = 0
  - Coordinates reconstructed = 1
  - Coordinates provided = 2
  - Coordinates provided and verified = 3
- Survey
  - No data = 0
  - Size and depth only = 1
  - Rapid survey = 2
  - Instrumental survey = 3
- Geology
  - No data = 0
  - Indirect information = 1
  - General description = 2
  - Information on geology and genesis = 3
- Biology
  - No data = 0
  - General description = 1
  - Quali-quantitative information = 2
  - Quali-quantitative information with historical series =3
- Age of biological data
  - No data = 0
  - Data more than 20 years old = 1
  - Data between 10 and 20 years old = 2
  - Data less than 10 years old = 3

Results

The database of the Ligurian marine caves was mainly built using information provided by the Land Registry of caves and karst areas of Liguria Region, containing well articulated data about the geological, morphological, and topographical aspects, updated to 2008. There are, however, gaps of knowledge about biology for almost all cavities. The book "*Sea caves: fifty years of research in Italy*" by Cicogna *et al.* (2003) provided additional cadastral information. A total of 84 sources of data, divided as shown in Fig. 1, have been collected.

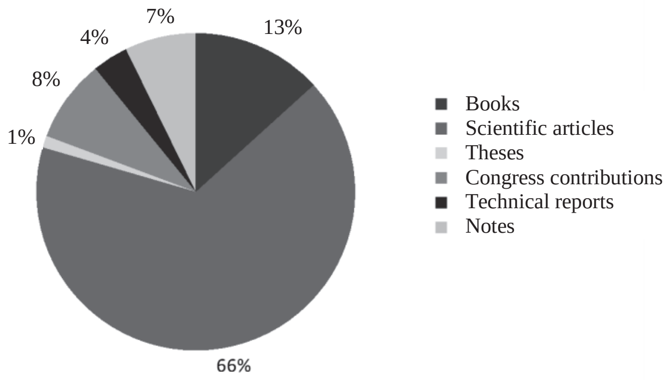


Fig. 1: Bibliographic sources used for the implementation of the database on Ligurian marine caves.

A total of 77 marine cavities are known along the coast of Liguria (Fig. 2): 21 caves are located in the Western Riviera and 56 in the Eastern Riviera; considering their distribution by administrative district, Imperia (IM) hosts 3 caves, Savona (SV) 18 caves, Genova (GE) 30 caves, and La Spezia (SP) 26 caves. Major caves are located in karst areas, and originated by marine ingression into pre-existing terrestrial cavities. Only 20 marine caves exhibit a significant submerged portion, some reaching a maximum depth of 40 m; 51 caves are semi-submerged, while 6 are undefined due to lack of information. Here we will focus on the submerged cavities only.

Geological, morphological and topographical information was found for virtually all cavities, but the biological information is available for 13 cavities only (Grotta Grande di Marina de' La Rocca, Grotta Piccola di Marina de' La Rocca, Grotta delle Sirene, Grotta Marina di Bergeggi, Grotta I di Punta Falc67%ıra, Grotta dei Gamberi, Grotta I della Colombara or Grotta Tortonese, Grotta II della Colombara or Grotta dell'Armato, Grotta III della Colombara or Grotta Marcante, Grotta del Presepe di Paraggi, Grotta del Castello di Paraggi, Grotta Perora, and Fossa del Tinetto) and is rarely accompanied by historical data series.

In conclusion, the most well-studied Ligurian cavities are the two caves of Ventimiglia, i.e., the Grotta Grande and the Grotta Piccola di Marina de' La Rocca (Montefalcone, unpublished data), the Marine cave of Bergeggi, which counts the higher numbers of bibliographic references (Bianchi *et al.*, 1988; Morri *et al.*, 1994; Parravicini *et al.*, 2010; Sgorbini *et al.*, 1988; to mention scientific publications only), and the Fossa del Tinetto together with other caves of the islands of La Spezia (Chelli *et al.*, 2008; Ugolini *et al.*, 2003; and references therein). A few little-known Ligurian submarine caves have been shortly described, in terms of topography and biology, by Bianchi & Morri (1994).

Historical series of data exist only for Bergeggi, since 1974 (Bianchi *et al.*, 1988), and Ventimiglia, since 2010 (Montefalcone, unpublished data). The former allowed evaluating change due to seawater warming (Parravicini *et al.*, 2010), the latter the impact caused by the construction of a marina (Montefalcone, unpublished data).

The cavities that achieved the highest RIs are the Grotta Marina of Bergeggi, the twocaves of Marina de' La Rocca, and the Fossa del Tinetto (Fig. 3).

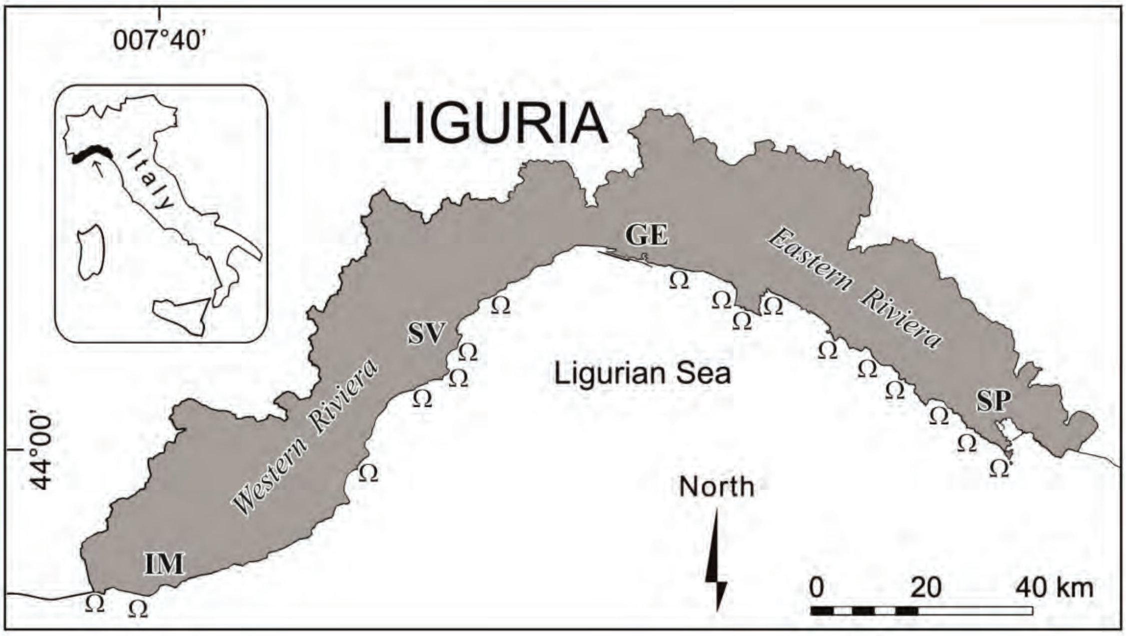


Fig. 2: Distribution of marine caves along the coasts of Liguria. Each symbol (Ω) may represent more than one cavity. IM = Imperia, SV = Savona, GE = Genova, SP = La Spezia.

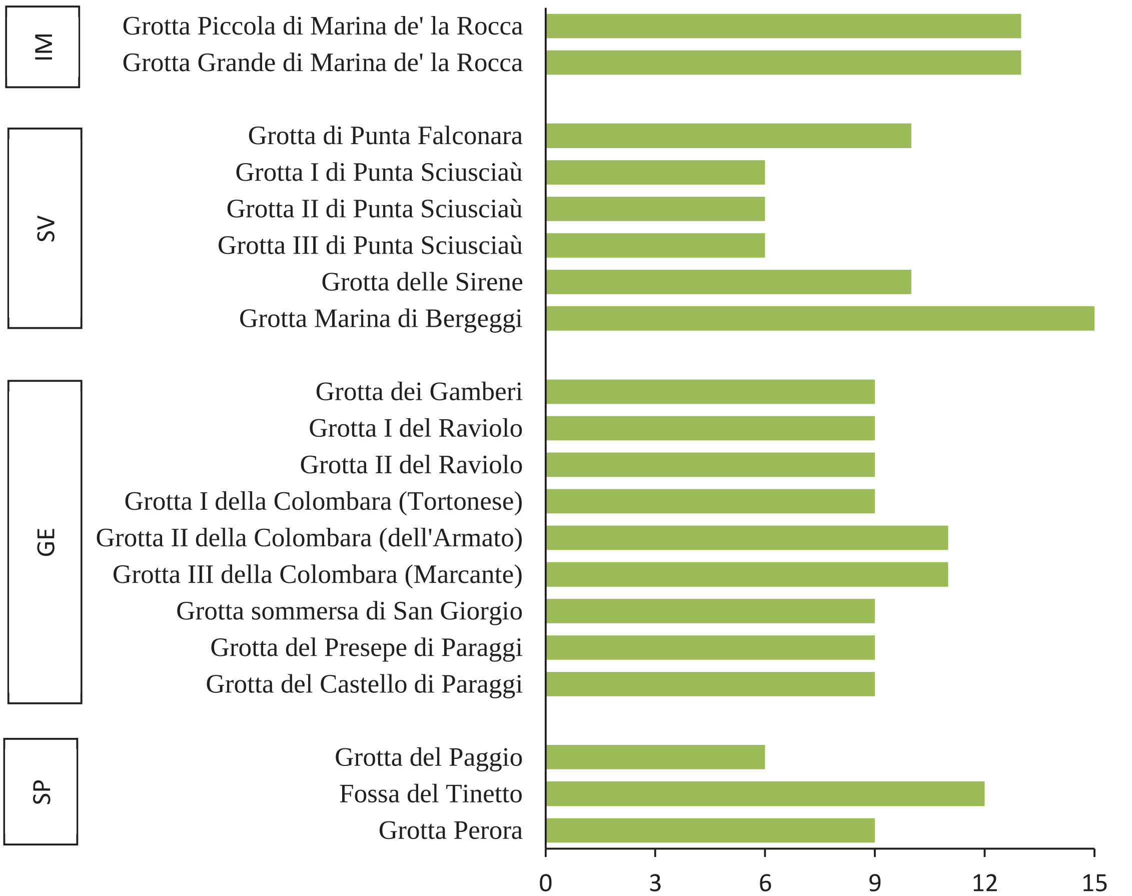


Fig. 3: Values of the Reliability Index (RI) for the Ligurian submerged caves, divided by district. IM = Imperia, SV = Savona, GE = Genova, SP = La Spezia.

Conclusions

This first attempt to assess the state of knowledge on the submarine caves of Liguria evidenced that the most important gap that should be filled in the near future concerns the biology and ecology of cave-dwelling communities. Reconnaissance surveys should be planned in those caves where no data are available, and regular monitoring activities should be carried out in caves where historical information is available, in order to obtain continuous data series that will supply useful indications on the health status of the cave communities and to highlight change in the cave ecosystem following global and local impacts.

A detailed and updated knowledge on the submarine caves of Liguria would provide the basic information for enforce protection measures, especially for those caves that today are still outside the boundaries of marine protected areas and of sites of community interest.

Bibliography

BIANCHI C.N., CATTANEO-VIETTI R., CINELLI F., MORRI C., PANSINI M. (1996) - Lo studio biologico delle grotte sottomarine: conoscenze attuali e prospettive. *Boll. Mus. Ist. Biol. Univ. Genova*, 60-61 (1994-1995): 41-69.

BIANCHI C.N., CEVASCO M.G., DIVIACCO G., MORRI C. (1988) - Primi risultati di una ricerca ecologica sulla grotta marina di Bergeggi (Savona). *Boll. Mus. Ist. Biol. Univ. Genova*, 52 suppl. (1986): 267-293.

BIANCHI C.N., MORRI C. (1994) - Studio bionomico comparativo di alcune grotte marine sommerse: definizione di una scala di confinamento. *Mem. Ist. Ital. Speleol.*, 6 (2) : 107-123.

BIANCHI C.N., PEIRANO A. (1995) - *Atlante delle fanerogame marine della Liguria:* Posidonia oceanica *e* Cymodocea nodosa. ENEA, Centro Ricerche Ambiente Marino, La Spezia: 146 pp.

BIXIO R. (1987) - *Le nostre grotte. Guida speleologica ligure*. Sagep, Genova: 176 pp.

CHELLI A., PAPPALARDO M., CALLEGARI F. (2008) - Rapporti fra livelli di carsificazione e paleo-linee di riva nelle isole del Golfo della Spezia (Liguria Orientale). *Atti Soc. Tosc. Sci. Nat., Mem.*, serie A, 113 : 25-37.

CICOGNA F., BIANCHI C.N., FERRARI G., FORTI P., eds (2003) - Grotte marine: cinquant'anni di ricerca in Italia. *Ministero dell'Ambiente e della Tutela del Territorio*, Roma: 505 pp.

DIVIACCO G., COPPO S. (2006) - Atlante degli habitat marini della Liguria: descrizione e cartografia delle praterie di *Posidonia oceanica* e dei principali popolamenti marini costieri. *Regione Liguria*, Genova: 205 pp.

GEROVASILEIOU V., TRYGONIS V., SINI M., KOUTSOUBAS D., VOULTSIADOU E. (2013) - Three-dimensional mapping of marine caves using a handheld echosounder. *Mar. Ecol. Progr. Ser.*, 486 : 13-22.

GIAKOUMI S., SINI M., GEROVASILEIOU V., MAZOR T., BEHER J., POSSINGHAM H.P., ABDULLA A., ÇINAR M.E., DENDRINOS P., GUCU A.C., KARAMANLIDIS A.A., RODIC P., PANAYOTIDIS P., TASKIN E., JAKLIN A., VOULTSIADOU E., WEBSTER C., ZENETOS A., KATSANEVAKIS S. (2013) - Ecoregion-based conservation planning in the Mediterranean: dealing with large-scale heterogeneity. *PLoS ONE*, 8(10): e76449.

LERICHE A., BOUDOURESQUE C.F, BERNARD G., BONHOMME P., DENIS J. (2004) - A one-century suite of seagrass bed maps: can we trust ancient maps? *Estuar. Coast. Shelf Sci.*, 59 (2): 353-362.

MORRI C., BIANCHI C.N., DEGL'INNOCENTI F., DIVIACCO G., FORTI S., MACCARONE M., NICCOLAI I., SGORBINI I., TUCCI S. (1994) - Gradienti fisico-chimici e ricoprimento biologico nella Grotta Marina di Bergeggi (Mar Ligure). *Mem. Ist. Ital. Speleol.*, 6 (2): 85-94.

PARRAVICINI V., GUIDETTI P., MORRI C., MONTEFALCONE M., DONATO M., BIANCHI C.N. (2010) - Consequences of sea water temperature anomalies on a Mediterranean submarine cave ecosystem. *Estuar. Coast. Shelf Sci.*, 86 (2) : 276-282.

SGORBINI S., BIANCHI C.N., DEGL'INNOCENTI F., DIVIACCO G., FORTI S., MORRI C., NICCOLAI I. (1988) Méthodologie d'une étude hydrobiologique dans la grotte marine de Bergeggi (mer Ligure). *Rapp. Comm. Int. Mer Médit*., 31 (2) : 119.

UGOLINI U., FERDEGHINI F., SARA G., MORRI C., BIANCHI C.N. (2003) - Indagine ecologica sulla grotta sottomarina dell'isola del Tinetto (Golfo di La Spezia, Mar Ligure orientale): dati preliminari. *Biol. Mar. Medit.*, 10 (2): 48-57.

Maïa FOURT, GOUJARD A., PEREZ T., VACELET J., SARTORETTO S., CHEVALDONNE P., the scientific team of the MedSeaCan and CorSeaCan cruises.
Institut Méditerranéen de Biodiversité et Ecologie Marine et Continentale (IMBE), UMR 7263 CNRS, IRD, Aix Marseille Université, Avignon Université, Station Marine d'Endoume, Marseille, France
E-mail: maia.fourt@univ-amu.fr

FRENCH MEDITERRANEAN SUBMARINE CANYONS AND DEEP ROCKY BANKS: A REGIONAL VIEW FOR ADAPTED CONSERVATION MEASURES

Abstract
The MedSeaCan and CorSeaCan cruises aimed to provide a reference state of the ecosystem in the general context of deep-sea canyons. This included specific information about the presence and distribution of deep-sea habitats, deep-sea coral communities, commercial, vulnerable or poorly-known deep-water species, mesophotic assemblages and the impact of human activities in these areas. This was achieved through direct observation with submersible (ROV and HOV), and the collection of photographic, video and biological samples, all integrated in an Information System. After data treatment, five regional entities were defined by their geomorphology, substrates, habitats, species, different degrees of human impacts and vulnerability to specific human pressures.

Key-words: submarine canyons, Mediterranean Sea, conservation, bathyal, rocky banks

introduction
The general geomorphological features of the North-Western Mediterranean sea-floor are similar to those of other areas, with a continental shelf gradually sloping down to the shelf edge, followed by the steep continental slope, the gently sloped rise that gradually leads to the abyssal plain. The shelf is adorned with rocky banks near its edge and canyons cut deeply into the shelf and slope. The Western Mediterranean displays regions with a large continental shelf such as the Gulf of Lions and others, where canyons may penetrate directly in bays a few kilometres from the river mouth as in Corsica (Shepard, 1972; Hickey, 1995; Jordi, *et al.*, 2005). The network of Mediterranean deep-sea canyons is rather specific with a high density of canyons, steep canyon flanks and a small depth range (Harris and Whiteway, 2011).
Deep-sea canyons are a pathway between the continental shelf and the abyssal zone for sediment and organic material transfers (Durrieu de Madron *et al*., 2000; Canals *et al*., 2006; Schlacher *et al.*, 2007; Lofi and Berné, 2008; De Leo *et al.*, *in press*; Palanques *et al.*, 2012). They are also routes of coastal nutrient enrichment through the upwelling of deep waters (Alberola and Millot, 2003; Monaco, *et al.* 1990; Allen and Durrieu de Madron, 2009). Canyons are key structures that locally modify water circulation, funnel particles, provide various physical substrates and therefore greatly contribute to the Mediterranean Sea biodiversity (Jordi *et al*., 2005, Würtz, 2011), Being main pathways between the littoral and the abyssal zone, canyons also suffer of human impact such as litter (Galgani *et al*., 1996). Furthermore, benthic fisheries activities have been shifting deeper and deeper in the last decades, from the continental shelf to the continental slope and the canyons (Morato *et al.,* 2006).

Materials and methods

The MedSeaCan and CorSeaCan cruises (November 2008-August 2010) took place along the margin of the French continental shelf, from the Spanish border to Monaco (MedSeaCan) and on the western coast of Corsica (CorSeaCan) (Fig. 1). These two series of cruises were the very first attempt to systematically explore the French Mediterranean deep-sea canyons. The surveying effort was distributed as equally as possible among canyons in order to allow comparisons. The same data acquisition techniques were used throughout the two campaigns and the same scientific team treated the data.

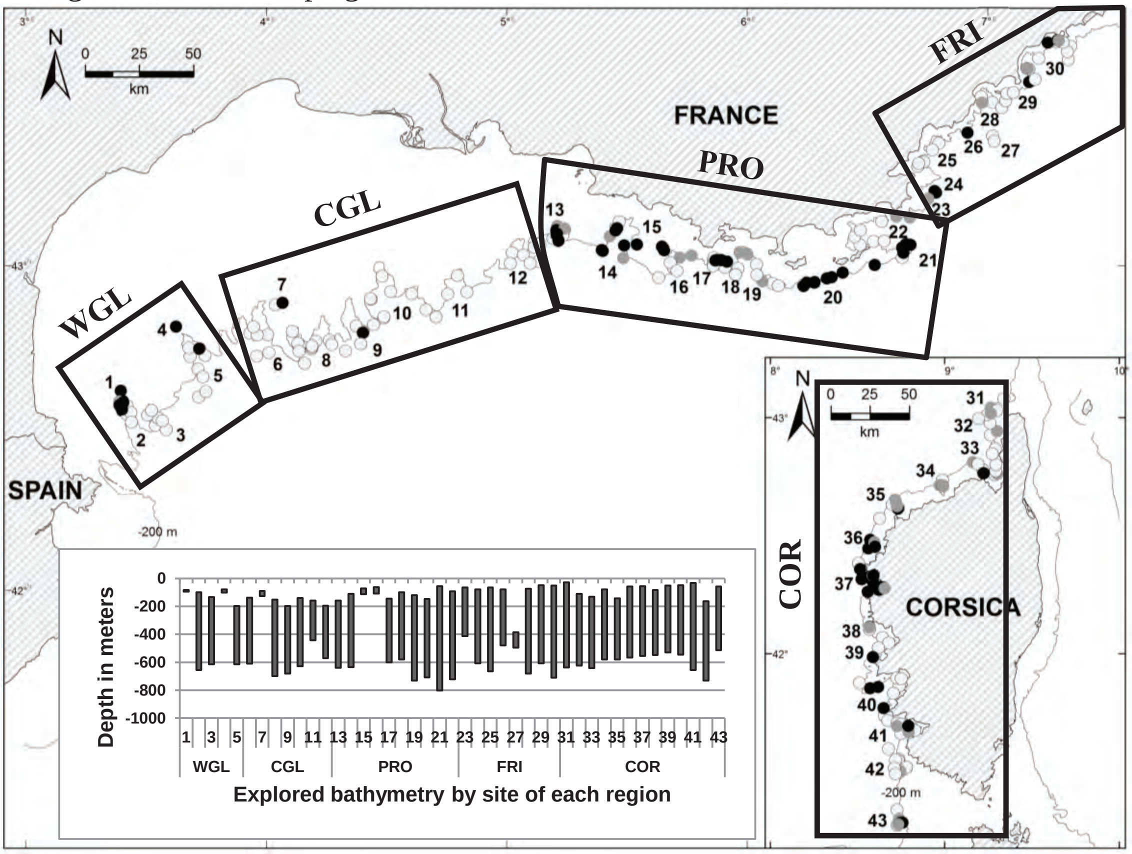


Fig. 1: Study zone. From West to East and from North to South: 1: Lacaze-Duthiers Rocks, 2: Lacaze-Duthiers C., 3: Pruvot C., 4: Sète Rocks, 5: Bourcart C., 6: Marti C., 7: Ichtys Bank, 8: Sète C., 9: Montpellier C., 10: Petit Rhône C., 11: Grand Rhône C., 12: Couronne C., 13: Planier C., 14: Cassidaigne C., 15: Esquine Bank, 16: Blauquières Bank, 17: No Name C., 18: Sicié C., 19: Toulon C., 20: Porquerolles C., 21: Magaud Bank, 22: Stoechades C., 23: Nioulargue Bank, 24: Pampelonne C., 25: Saint-Tropez C., 26: Dramont C., 27: Méjean Bank, 28: Cannes C., 29: Juan C., 30: Nice C., 31: North Centuri C., 32: South Centuri C., 33: Saint-Florent C., 34: Ile Rousse C., 35: Calvi C., 36: Galeria C., 37: Porto C., 38: Cargèse C., 39: Sagone C., 40: Ajaccio C., 41: Valinco C., 42: Les Moines C., 43: Asinara Bank. Areas: 1-5: Western Gulf of Lions (WGL), 6-12 Central Gulf of Lions (CGL), 13-22: Provence Region (PRO), 23-30 French Riviera (FRI), 31-43: Western coast of Corsica (COR). Main type of substrate encountered during each dive. Black: majority of hard substrate. Grey: half soft half hard. Light grey: majority of soft substrate.

The study area spans from 3°35’ to 9°35’ E and from 41°25’ to 43°70’N. In this area, the canyons as well as the offshore rocky banks of the continental shelf were explored from depths of 34 to 802 m. The main focus was on the continental shelf rocky banks around 100 m and canyon heads between 100 and 600 m.

Up to 43 different sites were explored (34 canyons and 9 rocky banks) with a Remotely Operated Vehicle (ROV) and a Human Occupied Vehicle (HOV). Surveys were all conducted from R/V ‘Minibex’ (owned and operated by Comex S.A.).
All the data collected was assembled and treated in the ZOODEX (ZOOlogical Data EXploitation system) working platform (Fourt and Goujard, 2012), which is based on a database and a Geographic Information System (GIS) and provides a friendly environment in which to plot and extract the observations. Data included the assessment of substrate type, the occurrence of megafauna, main habitats and facies, encountered litter and trawling scars. The main substrate type encountered during each dive was synthesized (Fig. 1). The 2D distances covered by the surveys were fed into the GIS. For each site, occurrences of litter and trawling scars were ploted by depth (Fig. 2). Species identification was conducted with the help of a pool of 25 specialists by visual means and occasional samples conducted to ascertain taxonomic identifications.

Results
A total of 475 km have been explored through 264 dives with a ROV and 23 with a HOV. The image data consists of 550 hours of video recordings of the dives, 18 hours of high definition video images on specific subjects, 17,600 high definition photos and 4,300 video screen captures.
The underwater canyons and rocky banks explored showed differences in their geomorphological features, in the habitats and species hosted as well as the impact of human activities. Canyons cut into the continental slope, which is situated far from the coastline in the Gulf of Lions (30-85 km) and much closer to the shore in the Liguro-Provençal (1-18 km) and Corsican (1-3 km) regions. In Corsica, the continental shelf is drastically reduced and the shelf limit, at the head of canyons, is shallower (120-160 m in WGL and CGL vs. -50-130 m in COR).
Hard substrate distances have been underestimated since they often present more vertical or sub-vertical distances not taken into account here. Nevertheless, the Gulf of Lions showed a majority of soft bottoms, often silty, but with some rocky substrate in the Western part (WGL) and some shelf rocky banks. The PRO region showed both soft and hard bottoms whereas the FRI region showed three times more soft substrates. The COR region revealed mixed and soft bottoms in the North-West and harder substrates in the central part (Fig. 1).
The rocky banks on the continental shelf of the WGL and the CGL regions were often covered with silt, and the sessile fauna was present in rather small forms. In PRO and FRI the shelf rocky banks harboured diverse and rather dense mesophotic communities including large sponges, gorgonians and on the Magaud Bank, a quite dense population of the rare *Laminaria rodrigezii*.
By region, the number of taxa (identified down to genus or species level weighted by the survey 2D distance) was of 129 for WGL, 62 for CGL, 71 for PRO, 101 for FRI and 58 for COR. The main biological communities were (i) Cold Water Corals, (ii) dense assemblages of deep sessile fauna on hard substrates, (iii) deep sessile fauna on soft substrate. Cold Water Corals were seen as reefs in the Lacaze-Duthiers canyon (WGL) and the Cassidaigne canyon (PRO) between 200 and 550 m depth. In the first, *Lophelia pertusa*, *Madrepora oculata* and *Desmophyllum dianthus* mainly composed the reefs, whereas in the Cassidaigne canyon, *L. pertusa* was not seen and reefs co-existed with other hard substrate sessile fauna communities. Two isolated but healthy colonies of *M. oculata* were observed in the Bourcard canyon (WGL) and the Sicié canyon (PRO),

whereas in the Nice canyon (FRI) a few small, isolated and damaged colonies were spotted. No white corals were recorded in Corsica but *Desmophyllum dianthus* was often observed either sub-fossil (PRO and COR), or alive especially in the Valinco and Les Moines canyons (COR), locally covering marl walls.

Other communities of deep sessile fauna on hard substrates were seen in the Bourcard Canyon (WGL) and on rocky bottoms in some canyons of PRO, FRI and COR, mainly between 50 and 250 m. Colonies of *Dendrophyllia cornigera*, of Antipatharia (*Leiopathes glaberrima*, *Antipathes dichotoma, Antipathella subpinnata, Paranthipathes larix, Paranthipathes* sp.), of Octocorallia (e.g. *Acanthogorgia hirsuta, Eunicella cavolini, Paramuricea clavata, Callogorgia verticillata, Viminella flagellum, Dendrobrachia bonsai*, *Placogorgia massiliensis*, *Corallium rubrum*, *Swiftia dubia*), and Porifera (e.g. *Haliclona magna*, *Poecillastra compressa*, *Phakelia* sp., *Hamacantha falcula*) composed these deep-sea forests. Dead shells of the deep oyster *Neopycnodonte zibrowii*, in live position were seen in WGL, PRO, FRI and COR between 240 and 750 m depth. Only two individuals were identified as being alive.

Sessile fauna on soft substrate was often quite monospecific with either *Isidella elongata*, *Thenea muricata*, *Kophobelemnon* sp., *Virgularia mirabilis*, or Ceriantharia. Isolated colonies of *Funiculina quadrangularis* and other Pennatulacea were occasionally encountered. *I. elongata* and *T. muricata* were seen in WGL, CGL and COR. In spite of a majority of soft substrates observed in FRI, these species were not seen in that region. In FRI soft substrate showed steeper slopes and very little visible bio-turbation.

Continental canyons and banks lying closer to the shore such as in the south WGL, in PRO and FRI appeared to be more impacted by litter. They are often dominated by either derelict fishing gear as in the Lacaze-Duthiers bank or the Dramont canyon, or various anthropogenic litter as in the Nice canyon. Trawling scars were encoutered mainly in the Gulf of Lions (WGL and CGL) frequently between 200 and 450 m but going down to 600 m depth (Fig. 2).

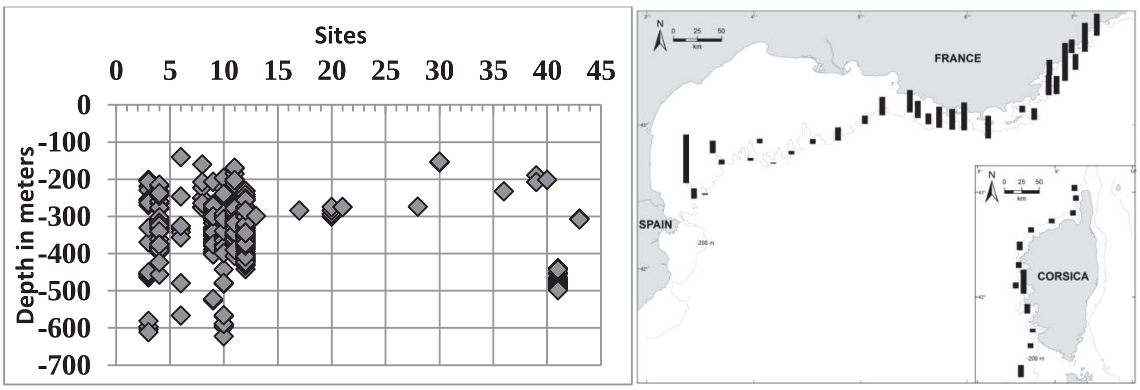


Fig. 2: Depth and geographical distribution of trawling scars occurrences by site explored (A) and relative importance of litter by km for each site (B). (A) Site numbers 1-5: WGL, 6-12: CGL, 13-22: PRO, 23-30 FRI, 31-43: COR

Discussion and conclusion

The western Gulf of Lions continental slope appears to be a region where rocky bottoms harbour a rich and uncommon cold water community of corals and other sessile hard bottom invertebrates. The rocky banks, sometimes rather close to the shore, showed a lot of lost fishing gears. The soft bottom canyons of the area (Pruvot and Bourcart canyons) show numerous trawling scars and the WGL is known to undergo an important fishing pressure (Le Corre and Farrugio, 2011). This region has been recently included in the MPA “Parc naturel marin du golfe du Lion” but with no specific restriction concerning fishing.

The Central Gulf of Lions (CGL) soft bottom canyons showed fewer litter but numerous trawling tracks. Sessile species observed such as *Isidella elongata, Thenea muricata* and *Funiculina quadrangularis* are vulnerable to bottom trawling. CGL canyons are also a shelter for the development and reproduction of commercial fish already intensely exploited on the continental shelf, and additional fishing pressure in the canyons could have dramatic effects on the whole Gulf of Lions fish stocks (Le Corre and Farrugio, 2011). Trawling regulations in this area could help maintaining the commercial species populations in a sustainable state.

The canyons of PRO and FRI are sometimes only a few hundred meters from a densely populated coast. There, the amount of litter is the most important but trawling scars are scarce. Some hotspots of biodiversity were seen such as in the Cassidaigne Canyon, and the Blauquière, Esquine and Magaud banks. These hot spots would deserve to be monitored, especially the Cassidaigne canyon head which is included in the MPA “Parc National des Calanques”.

West Corsica canyons often penetrate the bays bringing canyon heads very close to the shore. The coast is less populated than the continental PRO and FRI, but is much more abrupt, with canyons being sometimes literally the continuation of terrestrial mountain valleys with steep flanks.

Torrential rains washing down the soils and quickly bringing large amounts of freshwater in the bays might have an impact on canyon head communities that are sometimes shallow (50 m) and close to the shore (< 1 km). The bathyal zone explored in this region is weakly impacted by human litter and fishing activities.

Acknowledgements

We are grateful to the “Agence des Aires Marines Protégées” for supporting the MedSeaCan and CorSeaCan cruises and their data treatment, with special thanks to Pierre Watremez (project manager), Boris Daniel and Elodie Damier. We thank the crew of the MINIBEX (Comex) for the efficient work and their joyfulness. Acknowledgements are also due to H. Zibrowius, S. von Boletzky, C. Froglia, H. Galea, S. Iglesias, T. Molotsova and J. Mascle for species identification and scientific expertise.

Maps

Substrates: Agence des aires marines protégées, COMEX, GIS Posidonie, Equipe scientifique - MEDSEACAN-CORSEACAN 2008-2012. Programme de reconnaissance des têtes de canyons de la Méditerranée française. Isobathes : d'après le MNT de Lemarchand O., Jeannee N., Géovariances, Aout 2010. Géovariances, Cartographie de données bathymétriques (MNT à 100 m)- Façades Méditerranée et Corse Version 1.0. (client IFREMER, opportunité n°2009220694022).

Bibliography

ALBEROLA C., MILLOT C. (2003) - Circulation in the French Mediterranean coastal zone near Marseilles: The influence of wind and the Northern Current. *Continental shelf research* 23, (6) : 587-610.

ALLEN S.E., DURRIEU DE MADRON X. (2009) - A review of the role of submarine canyons in deep-ocean exchange with the shelf. *Ocean Science* 5: 607-620.

CANALS M., PUIG P., DURRIEU DE MADRON X., HEUSSNER S., PALANQUES A., FABRES J. (2006) - Flushing submarine canyons. *Nature* 444: 354-357.

DE LEO F.C., VETTER E.W., SMITH C.R., ROWDEN A.A., MCGRANAGHAN M. (*in press*) - Spatial scale-dependent habitat heterogeneity influences submarine canyon macrofaunal abundance and diversity off the Main and Northwest Hawaiian Islands. *Deep Sea Research Part II: Topical Studies in Oceanography*.

DURRIEU DE MADRON X., ABASSI A., HEUSSNER S., MONACO A., ALOISI J-C., RADAKOVITCH O., GIRESSE P., BUSCAIL R.; KERHERVE P. (2000) - Particulate matter and organic carbon budgets for the Gulf of Lions (NW Mediterranean). *Oceanologica Acta* 23 (6): 717-730.

FOURT M., GOUJARD A. (2012) - Rapport final de la campagne MEDSEACAN (Têtes des canyons méditerranéens continentaux) novembre 2008 – avril 2010. Partenariat Agence des aires marines protégées – *GIS Posidonie, Marseille, Fr. 218 p.* Rapport final, Partenariat Agence des aires marines protégées - GIS Posidonie, Marseille: GIS Posidonie publ., 218p.

GALGANI F., SOUPLET A., CADIOU Y. (1996) - Accumulation of debris on the deep sea floor off the French Mediterranean coast. *Marine Ecology Progress Series* 142(1): 225-234.

HARRIS T.P., WHITEWAY T. (2011) - Global distribution of large submarine canyons: Geomorphic differences between active and passive continental margins. *Marine Geology* 285: 69-86.

HICKEY B.M. (1995) - Coastal submarine canyons. *Proceedings 'Aha Huloko'a Hawaiian Winter Workshop University of Hawaii.* Mano: Peter Müller and Diane Henderson. 95-110.

JORDI A., ORFILA A., BASTERRETXEA J., TINTORE J. (2005) - Shelf-slope exchanges by frontal variability in a steep submarine canyon. *Progress in Oceanography* 66 (2): 120-141.

LE CORRE G., FARRUGIO H. (2011) - Note sur la création par la CGPM d'une Zone de pêche réglementée dans le golfe du Lion en mars 2009. Rapport Ifremer.

LOFI J., BERNE S. (2008) - Evidence for pre-Messinian submarine canyons on the Gulf of Lions slope (Western Mediterranean). *Marine and Petroleum Geology* 25 (8): 804-817.

MONACO A., BISCAYE P., SOYER J., POCKLINGTON P., HEUSSNER S. (1990) - Particle fluxes and ecosystem response on a continental margin: the 1985–1988 Mediterranean ECOMARGE experiment. *Continental Shelf Research* 10 (9): 809-839.

MORATO T., WATSON R., PITCHER T.J., PAULY D. (2006) - Fishing down the deep. *Fish and fisheries* 7 (1): 24-34.

PALANQUES A., PUIG P., DURRIEU DE MADRON X., SANCHEZ-VIDAL A., PASQUAL C., MARTÍN J., CALAFAT A., HEUSSNER S., CANALS M. (2012) - Sediment transport to the deep canyons and open-slope of the western Gulf of Lions during the 2006 intense cascading and and open-sea convection period. *Progress in Oceanography* 106: 1-15.

SCHLACHER A.T., SCHLACHER-HOENLINGER A.M., WILLIAMS A., ALTHAUS F., HOOPER N.A.J., KLOSER R. (2007) - Richness and distribution of sponge megabenthos in continental margin canyons off southeastern Australia. *Marine Ecology Progress Series* 340: 73-88.

SHEPARD F.P. (1972) - Submarine canyons. *Earth-Science Reviews* 8: 1-12.

WÜRTZ M. (2011) - Submarine canyons and their role in the Mediterranean ecosystem in Mediterranean submarine Canyons, ecology and governance. *Gland Switzerland and Malaga*, Spain: IUCN.: Würtz M. (ed.).

Maïa FOURT, MICHEZ N., CHEVALDONNÉ P., GOUJARD A., HARMELIN J.G., VACELET J., VERLAQUE M., Equipe scientifique des campagnes MedSeaCan et CorSeaCan.
Institut Méditerranéen de Biodiversité et Ecologie Marine et Continentale (IMBE), UMR 7263 CNRS, IRD, Aix Marseille Université, Avignon Université, Station Marine d'Endoume, Marseille, France.
E-mail: maia.fourt@univ-amu.fr

EXPLORATION VISUELLE DES CANYONS ET BANCS ROCHEUX PROFONDS EN MEDITERRANEE FRANÇAISE : APPORTS A LA TYPOLOGIE NATIONALE DES HABITATS PROFONDS

Résumé
Les campagnes d'exploration MedSeaCan et CorSeaCan menées par l'Agence française des Aires Marines Protégées entre 2008 et 2010 ont largement contribué à une meilleure connaissance des habitats profonds et de l'étage bathyal dans la zone des canyons de la Méditerranée française. Les moyens d'exploration, essentiellement visuels complétés par des prélèvements, apportent des connaissances sur la distribution de la mégafaune et des communautés macrobenthiques en particulier de substrat dur et fournissent une information paysagère précieuse. La typologie nationale actuelle des biocénoses benthiques est une typologie bio-écologique, fondée sur l'étude des communautés macrobenthiques et la compréhension de leur répartition selon les conditions environnementales. En milieu profond, elle a surtout été élaborée à partir de prélèvements sur les fonds meubles et très peu d'observations directes avaient été effectuées jusqu'à présent pour la qualification des biocénoses de substrat dur. La typologie nationale étant le langage commun utilisé pour faciliter la mise en œuvre des politiques publiques de conservation des habitats marins benthiques, il est primordial qu'elle reflète l'état des connaissances actuelles. L'intégration de ces nouvelles informations a soulevé un certain nombre de questionnements et va permettre de compléter le référencement des habitats profonds bien que certaines zones d'ombre subsistent.

Key-Words: Mediterranean Sea, bathyal, bedrock, typology.

Introduction

Les fonds marins littoraux du Nord-Ouest de la Méditerranée jusqu'à 50 m de profondeur environ, sont aujourd'hui bien caractérisés, répertoriés et même cartographiés avec une bonne précision. Le bas du circalittoral, le bathyal et l'abyssal restent encore mal connus, en particulier les peuplements et habitats des canyons qui incisent le talus continental. Ces structures complexes caractérisent le talus de la Méditerranée du nord-occidentale par leur relief très escarpé et leur distribution dense (Harris et Whiteway, 2011). Les canyons peuvent être assez éloignés de la côte lorsque le plateau continental est large comme dans le golfe du Lion, ou pénétrer les baies, comme en Corse (Shepard, 1972 ; Hickey, 1995 ; Jordi *et al.*, 2005).

Le référentiel français des habitats marins comprend une typologie des biocénoses benthiques de Méditerranée réalisée en 2011 (Michez *et al*., 2011). Elle sert à définir un langage commun permettant d'inventorier les habitats présents en France métropolitaine et facilitant la mise en œuvre des politiques publiques de conservation . Elle s'inscrit dans la lignée des travaux de Pérès et Picard (1964) sur la définition des termes et des biocénoses benthiques. Elle a été élaborée en synthétisant l'existant dont la classification du PNUE, PAM, CAR/ASP (2006) et grâce à la collaboration d'experts benthologues (voir Michez *et al.*, 2011). Cette typologie est bio-écologique, fondée sur l'étude des communautés macrobenthiques et la compréhension de leur répartition selon les conditions environnementales.

En milieu profond et particulièrement dans l'étage bathyal, quelques rares observations directes avaient été effectuées à l'aide du bathyscaphe FNRS III dans les années 60 (Pérès et Picard, 1964), ainsi qu'avec la soucoupe plongeante Cousteau (Laborel *et al.*, 1961). Cependant, les informations restaient ponctuelles et essentiellement collectées par prélèvements sur les fonds meubles en utilisant des dragues et des bennes (Maurin, 1962 ; Carpine, 1970).

Les campagnes MedSeaCan et CorSeaCan ont permis d'explorer et d'enregistrer des images des habitats présents dans les canyons sous-marins et de mieux les connaitre. Ces images apportent surtout des informations concernant les habitats structurés par des macro-invertébrés dont l'identification est parfois délicate mais elles fournissent une vision paysagère de la répartition des communautés. Ces données ont été utilisées pour mettre à jour la typologie française des habitats benthiques méditerranéens (Michez *et al.*, 2014).

Matériel et Méthodes

Entre 2008 et 2010, l'Agence des Aires Marines Protégées a entrepris une exploration systématique des têtes de canyon et des roches profondes en Méditerranée française de la côte Espagnole à Monaco (campagnes MedSeaCan) et le long de la côte Ouest de la Corse (campagnes CorSeaCan) (Fig. 1). Pour la première fois, ces canyons sous-marins ont été explorés de manière systématique. L'effort d'investigation a été réparti, autant que possible, de manière égale entre les canyons. Les mêmes techniques d'acquisition ont été utilisées et le traitement des données a été réalisé par la même équipe scientifique du GIS Posidonie.

La zone de prospection s'étend de 3°35' à 9°35' E et de 41°25' à 43°70' N. Dans ce secteur, les canyons et les bancs rocheux du plateau continental ont été explorés de 34 à 802 m mais surtout autour de 100 m pour les bancs rocheux et entre 100 et 600 m pour les têtes de canyons. 43 sites ont été explorés dont 34 canyons et 9 bancs rocheux (Fig. 1). Les prospections en plongée par engin télécommandé (ROV) et sous-marin biplace étaient menées à partir du navire « Minibex » de la Comex S.A. Les données acquises sont principalement des images constituées de vidéos et de photos. Des prélèvements ont été effectués afin de préciser l'identification de certaines espèces.

Toutes les données ont été rassemblées et traitées dans la plateforme spécifique ZOODEX (ZOOlogical Data Exploitation system) (Fourt et Goujard, 2012) qui s'appuie sur une base de données et un Système d'Information Géographique (SIG). Le type de substrat, les occurrences d'espèces ainsi que les habitats et faciès sont parmi les informations qui ont été référencées le long de chaque parcours plongée. L'identification des taxons, sur images et dans certains cas sur prélèvements, a été effectuée avec l'aide de nombreux spécialistes.

Pour l'intégration de ces nouvelles informations à la typologie française, une comparaison a été réalisée entre ces observations et les biocénoses et faciès déjà référencés. Des propositions d'ajouts ou de modifications de la typologie ont été formulées (Fourt *et al.*, 2014) et discutées avec des experts benthologues (voir Michez *et al.*, 2014). L'acquisition de données par images vidéo et photo ne permet pas d'apprécier avec exactitude la granulométrie des substrats meubles, ni d'inventorier toutes les espèces benthiques présentes, en particulier l'endofaune qui nécessite des prélèvements. A l'inverse, pour

l'exploration des fonds durs bathyaux, l'utilisation d'images a apporté des informations précieuses.
Certaines propositions ont abouti à une mise à jour des habitats rocheux bathyaux, d'autres nécessiteront plus de discussions.

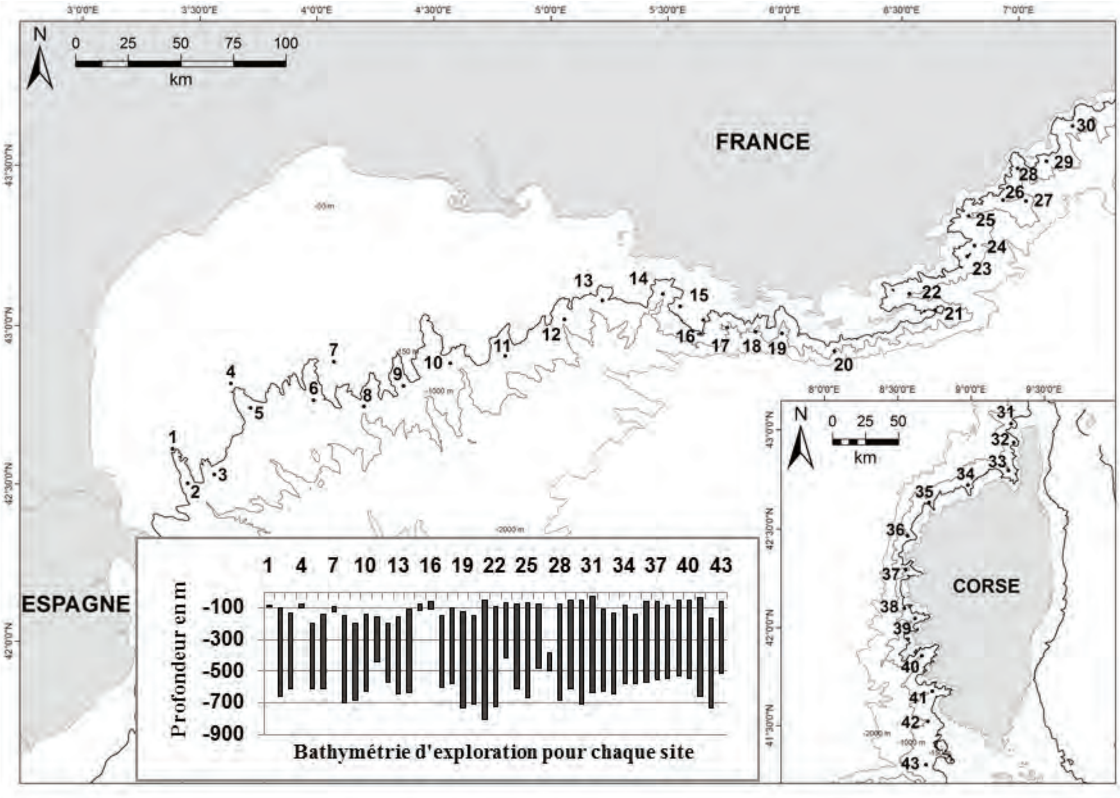


Fig. 1 : Zone et sites d'étude.

Résultats
Un total de 475 km a été parcouru par 264 plongées en engin télécommandé (ROV) et 23 en sous-marin biplace. Les données images récoltées, intégrées et traitées dans ZOODEX représentent 550 h de vidéo des plongées, 18 h de vidéo haute définition sur des sujets spécifiques, 17 600 photos haute définition et 4 300 captures d'écran.
Les algues calcaires, qui sont parmi les algues les plus sciaphiles, n'ont pas été observées dans le golfe du Lion même sur les roches du plateau continental explorées entre 80 et 120 m. Elles ont été vues sur les bancs de roches du plateau continental de la région Liguro-Provençale (sites 15 à 30, Fig. 1) généralement à moins de 100 m de profondeur, tandis qu'en Corse, les algues calcaires sont présentes bien après la rupture de pente (souvent peu profonde en Corse), dans la partie supérieure des flancs de canyons jusqu'à 130 m de profondeur.
Sous la limite de pénétration de la lumière, l'orientation par rapport au courant, la rugosité et la dureté du substrat ainsi que le degré d'inclinaison et des phénomènes locaux (e.g. « cascadings », « up-wellings ») deviennent les facteurs prépondérants qui façonnent les habitats de ces profondeurs.
Visuellement, il a généralement été possible de caractériser le substrat et de le catégoriser en meuble ou dur. Cependant, dans plusieurs canyons, des marnes, indurées à divers degrés, ont été observées. Elles se présentent sous forme de tombants verticaux, plus ou moins forés (Fig. 2), où se trouvent parfois des espèces sessiles de substrats durs telles

que le scléractiniaire *Desmophyllum dianthus* mais aussi l'éponge carnivore *Asbestopluma hypogea*. Cet habitat abrite de nombreux crustacés qui semblent attirer les prédateurs observés à proximité (*Helicolenus dactylopterus, Nezumia aequalis, Octopus salutii, Phycis blennoides, Polyprion americanus*).

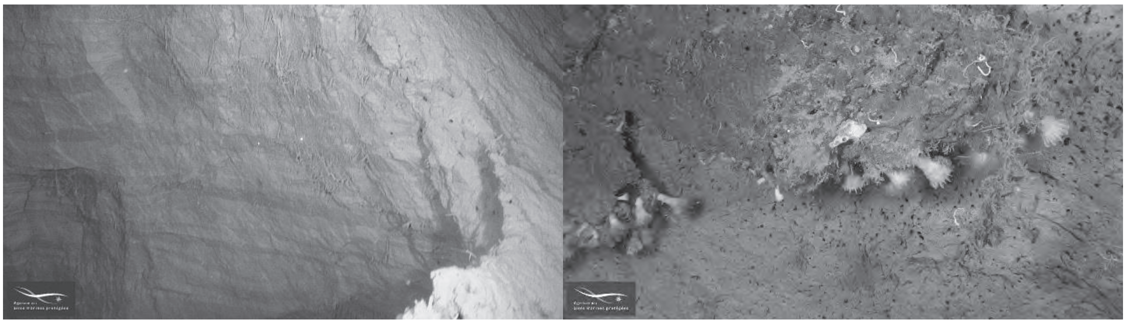


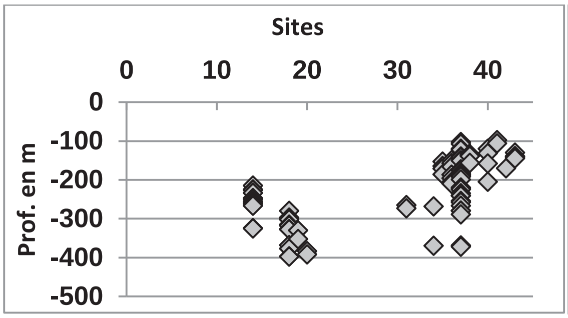
Fig. 2 : Murs de marnes indurées à gauche dans le canyon de Montpellier, golfe du Lion à 545 m, à droite dans le canyon des Moines, Sud Corse, à 480 m avec des *Desmophyllum dianthus*.

Seuls deux canyons explorés ont montré de véritables récifs de coraux blancs, il s'agit des canyons Lacaze-Duthiers et de Cassidaigne. Dans ce dernier, seul *Madrepora oculata* a été observé, tandis que dans le canyon Lacaze-Duthiers des colonies de *Lophelia pertusa* étaient aussi présentes et colonisaient à la fois les corniches rocheuses et des fonds sub-horizontaux envasés. Parmi ces espèces coloniales, le scléractiniaire solitaire *Desmophyllum dianthus* a souvent été observé, mais des colonies vivantes n'ont été que très rarement vues avec une forte concentration (site 42 : canyon des Moines, uniquement). Cependant, *D. dianthus* a été trouvé dans plusieurs canyons, faisant partie de thanatocénoses recouvrant des tombants de roche, ce qui témoigne de la forte présence de cette espèce par le passé.

Une autre espèce observée, très majoritairement sous forme de thanatocénoses encore fixées, est la grande huître *Neopycnodonte zibrowii*, dont les coquilles ont été observées dans 22 des 34 canyons explorés entre 240 et 750 m de profondeur, tandis que deux individus seulement ont été vus vivants, l'un au canyon de Sicié l'autre au canyon de Cargèse (sites 13 et 38).

Des faciès de l'octocoralliaire *Viminella flagellum* ont été recensés sur plusieurs sites entre 100 et 400 m de profondeur (Figure 3) formant des populations denses souvent situées sur des replats le long de tombants. La limite supérieure de distribution observée est moins profonde en Corse que dans les canyons continentaux (Figure 3). Il en est de même de la limite supérieure de *Callogorgia verticillata* dont les colonies isolées ont été vues dans 11 canyons et en faciès seulement dans 4 d'entre eux. Un autre gorgonaire formant des faciès localisés est *Acanthogorgia hirsuta*. Il présente également une limite supérieure moins profonde en Corse.

Dans le haut du bathyal, des assemblages à grands invertébrés ont été fréquemment observés. Ils comprennent des grandes éponges, des antipathaires et des gorgonaires et leur composition varie. Il ne s'agit pas de faciès mono-spécifiques mais d'assemblages à dominance soit de grandes éponges soit d'antipathaires et/ou gorgonaires suivant les sites.



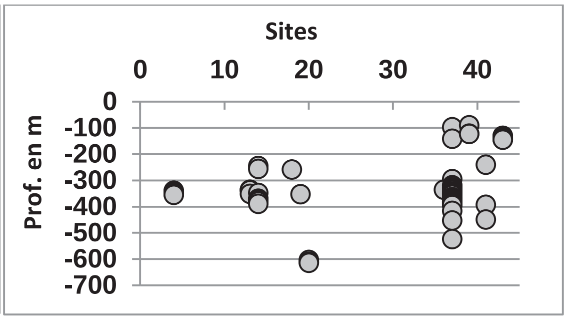


Figure 3 : Distribution géographique et bathymétrique des occurrences de *Viminella flagellum* (gauche) et *Callogorgia verticillata* (droite). Pour le nom des sites, se référer à la Fig. 1.

Discussion

L'ampleur de ces campagnes et la quantité très importante d'informations récoltées ont permis d'acquérir une vision globale de la répartition géographique et bathymétrique des espèces physionomiquement marquantes et des habitats rencontrés dans la zone de prospection. Il a paru important d'utiliser ces nouvelles connaissances pour mettre à jour les habitats bathyaux référencés dans la typologie française.

Cet exercice a permis de soulever et de discuter de points généraux tels que la limite entre l'étage circalittoral et le bathyal mais aussi de points plus précis comme la caractérisation des faciès existants (densité, surface) ou la définition de nouveaux faciès. Il a soulevé également des questions sur la compatibilité des méthodologies (visuelles et par prélèvements) et la disponibilité des données historiques (retour sur les données d'origine). Pour la limite entre le circalittoral et le bathyal, aucun critère géomorphologique, topographique ou métrique n'a été ajouté. Les données concernant les espèces observées sur les substrats meubles devront être confirmées par des prélèvements et des explorations supplémentaires avant de proposer des modifications de la typologie.

Les répartitions bathymétriques des grands invertébrés sessiles du bathyal tels *Acanthogorgia hirsuta*, *Callogorgia verticillata* et *Viminella flagellum*, semblent varier géographiquement, mais aucune explication ne peut être proposée pour le moment. Une comparaison avec les données récoltées en Espagne et en Italie serait intéressante.

Les principaux changements dans la typologie concernent les habitats rocheux bathyaux et sont la modification de la biocénose des coraux profonds qui devient un faciès de la biocénose des roches bathyales et l'ajout à cette biocénose de 3 nouveaux faciès : faciès à *Acanthogorgia hirsuta*, à grandes éponges et à antipathaires et/ou gorgonaires.

Toutes les propositions n'ont pas abouti à des modifications de la typologie mais restent des pistes à approfondir par la suite, bien que l'objectif d'une typologie à cette échelle ne soit pas de référencer toutes les particularités du milieu. Cette mise à jour du référentiel sera la base pour la révision de la liste française des habitats déclinés des habitats d'intérêt communautaire (Directive Habitats Faune Flore). Ce travail constitue également une proposition robuste pour les discussions à venir entre pays méditerranéens dans le cadre de la mise à jour d'EUNIS et de l'intégration de nouveaux habitats à ce référentiel européen.

Remerciements

Nous remercions l'Agence des Aires Marines Protégées d'avoir mis en œuvre les campagnes MedSeaCan et CorSeaCan et d'avoir permis le traitement de données. Des remerciements sont dus en particulier au responsable du programme Pierre Watremez ainsi qu'à Boris Daniel et Elodie Damier. Nous remercions l'équipage du Minibex (Comex) pour leur efficacité et leur bonne humeur. Nous remercions également D. Bellan-Santini, G. Bellan, S. von Boletzky, C. Froglia, H. Galea, S. Iglesias, J. Mascle, T. Molotsova, T. Pérez, S. Sartoretto et H. Zibrowius pour leur contribution aux identifications d'espèces et leur expertise scientifique.

Cartes

Agence des Aires Marines Protégées, COMEX, GIS Posidonie, Equipe scientifique - MEDSEACAN-CORSEACAN 2008-2012. Programme de reconnaissance des têtes de canyons de la Méditerranée française. Isobathes : d'après le MNT de Lemarchand O., Jeannee N., Géovariances, Aout 2010. Géovariances, Cartographie de données bathymétriques (MNT à 100 m) - Façades Méditerranée et Corse Version 1.0. (client IFREMER, opportunité n°2009220694022).

Bibliographie

CARPINE C. (1970) - Ecologie de l'étage bathyal dans la Méditerranée occidentale. Mémoires de l'Institut océanographique de Monaco, 146 pp.

FOURT M., GOUJARD A. (2012) - Rapport final de la campagne MEDSEACAN (Têtes des canyons méditerranéens continentaux) novembre 2008 – avril 2010. Partenariat Agence des Aires Marines Protégées - GIS Posidonie, *GIS Posidonie publ.*, Marseille, 218 pp.

FOURT M., GOUJARD A., et coll. (2014) - Apports des campagnes d'explorations méditerranéennes MEDSEACAN et CORSEACAN à la typologie des habitats profonds. Convention Agence des Aires Marines Protégées - GIS Posidonie, *GIS Posidonie publ.*, Marseille, 23 pp.

HARRIS T.P., WHITEWAY T. (2011) - Global distribution of large submarine canyons: Geomorphic differences between active and passive continental margins. *Marine Geology* 285: 69-86.

HICKEY B.M. (1995) - Coastal submarine canyons. Proceedings 'Aha Huloko'a Hawaiian Winter Workshop University of Hawaii. Mano: Peter Müller and Diane Henderson. 95-110.

JORDI A., ORFILA A., BASTERRETXEA J., TINTORE J. (2005) - Shelf-slope exchanges by frontal variability in a steep submarine canyon. *Progress in Oceanography* 66 (2): 120-141.

LABOREL J., PERES J.-M., PICARD J., et VACELET J. (1961) - Etude directe des fonds des parages de Marseille de 30 à 300 m avec la soucoupe plongeante COUSTEAU. *Bulletin de l'Institut océanographique de Monaco* 1206.

MAURIN C. (1962) - Etude des fonds chalutables de la Méditerranée occidentale (écologie et pêche) « Président-Théodore-Tissier » 1957 à 1960 et « Thalassa » 1960 et 1961. Revue des Travaux de l'Institut des Pêches Maritimes 26 (2): 163-218.

MICHEZ N., DIRBERG G., BELLAN-SANTINI D., VERLAQUE M., BELLAN G., PERGENT G., PERGENT-MARTINI C., LABRUNE C., FRANCOUR P., SARTORETTO S. (2011) - Typologie des biocénoses benthiques de Méditerranée, Liste de référence française et correspondances. Rapport SPN 2011 - 13, MNHN, Paris, 50 pp.

MICHEZ N., FOURT M., AISH A., BELLAN G., BELLAN-SANTINI D., CHEVALDONNE P., FABRI M.-C., GOUJARD A., HARMELIN J.-G., LABRUNE C., PERGENT G., SARTORETTO S., VACELET J., VERLAQUE M. (2014) - Typologie des biocénoses benthiques de Méditerranée Version 2. Rapport SPN 2014 - 33, MNHN, Paris, 26 pp.

PERES J.-M., PICARD J. (1964) - Nouveau manuel de bionomie benthique de la Mer Méditerranée. *Recueil des Travaux de la Station Marine d'Endoume*, 31 (47): 1-137.

PNUE, PAM, CAR/ASP. (2006) - Classification des biocénoses benthiques marines de la région Méditerranéenne. CAR/ASP, Tunis, 13 pp.

SHEPARD F.P. (1972) - Submarine canyons. *Earth-Science Reviews* 8: 1-12.

Vasilis GEROVASILEIOU, VOULTSIADOU E.
Department of Zoology, School of Biology, Aristotle University of Thessaloniki, Greece.
E-mail: vgerovas@bio.auth.gr

MEDITERRANEAN MARINE CAVES AS BIODIVERSITY RESERVOIRS: A PRELIMINARY OVERVIEW

Abstract

Marine caves constitute a typical feature of the Mediterranean coastline, yet knowledge on their biodiversity is scattered and geographically fragmented. In order to assess the overall diversity of the Mediterranean cave biota, an overview of 307 studies was combined with data obtained from previously unexplored marine caves of the Aegean Sea. A total of 2167 taxa were recorded from 350 caves in 15 countries. Our analyses showed that research has mainly taken place in semi-submerged and shallow caves from the northern Mediterranean. Species richness varied among areas, reflecting variability in research effort and in the number of caves, which are more abundant on the rocky coasts of the northern basin. The Tyrrhenian Sea (822 taxa), Ionian Sea (696), and French coasts (650) presented the highest species richness and research effort. The biodiversity overview revealed that marine caves harbour a considerable proportion of the total Mediterranean fauna for particular phyla, especially for brachiopods, bryozoans and sponges. However, gaps of knowledge emerged regarding certain areas, groups of biota, assemblages, and cave types. It is suggested that Mediterranean marine caves constitute significant biodiversity reservoirs deserving further scientific research and conservation actions.

Key-words: Marine caves, habitat, biodiversity reservoir, biodiversity hotspot, Mediterranean Sea

Introduction

Marine cave communities are widely acknowledged for their rich biodiversity and have attracted increasing scientific interest soon after the pioneer studies, which took place in the middle of the last century (e.g. Laborel & Vacelet, 1958; Pérès & Picard, 1949). The first large-scale expedition that surveyed the Mediterranean marine cave biodiversity, the "Tyrrhenia-Expedition", was organized by Rupert Riedl in 1952, yielding 529 taxa and several publications (e.g. Russ & Rützler 1959). Later on, in his monograph "*Biologie der Meereshöhlen*", Riedl (1966) compiled all available data, reporting 905 taxa from Mediterranean marine caves, while he estimated that the total species richness might approach 2000 species. More recently, in a review of sponge diversity recorded in Mediterranean marine caves, Gerovasileiou & Voultsiadou (2012) cited 311 taxa, which represented 45.7% of the Mediterranean Porifera. The latter researchers also highlighted the upward trend in marine cave research (4 papers per year), accompanied by the addition of new records including several cave-exclusive species.

Approximately 3000 marine caves have been recorded until today on the rocky coasts of the Mediterranean Sea (Giakoumi *et al*., 2013). These ecosystems harbour a variety of sciaphilic communities, ranging from coralligenous to semi- and entirely-dark cave assemblages (Pérès & Picard, 1964), which are protected by the EU Habitats Directive (92/43/EEC) and have been included in two Action Plans by UNEP/MAP-RAC/SPA (2008; 2013).

Most researchers having worked on marine cave biota recognize in general the significance of this habitat for marine biodiversity and its conservation. However, as

Gerovasileiou & Voultsiadou (2012) pointed out, until today there is no comprehensive evaluation of marine cave biodiversity or its representativeness in the Mediterranean ecosystem. Following Riedl's work, several publications have dealt with marine cave biota from an ecological, taxonomical, or faunistic point of view; yet knowledge on their biodiversity remains limited and geographically fragmented. The aim of the present study was to: i) give a preliminary overview of the Mediterranean marine cave biodiversity, ii) examine the significance of the marine cave habitat for the entire Mediterranean ecosystem, and iii) point out gaps of knowledge deserving future research.

Materials and methods

In order to assess the overall biodiversity of Mediterranean marine caves, an overview of 307 relevant scientific studies was performed, including journal articles, monographs, conference proceedings, research project reports, and databases. Unpublished data of the authors from previously unexplored caves of the Aegean Sea were also included. All biodiversity records were incorporated into a database along with ecological (e.g. cave zone, substrate type) and spatial information. All taxa were cross-checked and taxonomically updated using the World Register of Marine Species (WoRMS). Besides species records, numerous taxa identified only to higher levels (e.g. genus, family) were included in the database but not used in our analyses, unless if they represented new records for the Mediterranean marine cave biodiversity. Soft sediment thanatocoenoses were also excluded. In order to assess research effort, examined publications were classified according to different criteria (e.g. area, taxon). The relationship between research effort (expressed in number of studies, caves, or areas surveyed) and species richness was assessed using Spearman's rank correlation. To evaluate the representativeness of cave biota to the overall Mediterranean marine biodiversity, cave species richness for each taxonomic group was calculated against the total Mediterranean species richness, based on data given by Coll *et al*. (2010). Spatial comparisons were based on the biogeographical division of the Mediterranean Sea proposed by Voultsiadou (2009) with some modifications, based on the availability of data; the following areas were examined: Alboran Sea (AL), Catalan coast (CC), Balearic Sea (BS), Sardinian Sea (SS), French coast (FC), Ligurian Sea (LS), Tyrrhenian Sea (TS), Tunisian coast (TC), North Adriatic (AN), South Adriatic (AS), Ionian Sea (IS), North Aegean (NA), South Aegean (SA), and Levantine Basin (LB).

Results

More than 350 caves were studied in 15 Mediterranean countries. Most of them were semi-submerged and/or shallow, with the majority (93%) being located in the northern Mediterranean coasts. A total of 2167 taxa, belonging to 58 major groups (Tab. 1) were recorded at different cave sectors. Species richness per taxonomic group was positively correlated to the number of respective studies (rho = 0.840, $P<0.01$, $n = 57$) and the number of surveyed areas (rho = 0.825, $P<0.01$, $n = 55$). Total marine cave species richness varied among areas (Fig. 1) and was positively correlated to the number of studies (rho = 0.696, $P<0.01$, $n = 14$) and caves explored (rho = 0.604, $P<0.05$, $n = 14$). TS, IS and FC presented the highest species richness (822, 696, and 650 taxa respectively) and the most intensive research effort, while AL was the least studied area, presenting the lowest species richness (59). However, in some areas (e.g. CC, SS, NA) species richness was disproportionally high in relation to the limited number of studies/caves. Italy,

France, and Spain were the main countries where marine cave research has taken place in the Mediterranean Sea (120, 86 and 52 studies respectively).
Not all taxonomic groups have received equal interest in the Mediterranean marine caves. Sponges are by far the most studied animal group (156 studies / 14 areas), followed by anthozoans (87 / 14), polychaetes (62 / 13), bryozoans (59 / 13), decapods (42 / 13), bivalves (42 / 11) and fishes (40 / 13). Most groups have been recorded in less than 10 studies or areas (36 and 42 groups respectively). Only a small number of studies examined bacteria, planktonic biota, and miscellaneous "small" groups like meiofaunal soft substrate animals.

Tab. 1: Research effort metrics, species richness and representativeness of the total diversity for each group recorded in Mediterranean marine caves (for abbreviations see Materials and methods).

Taxonomic group	Areas	Number of areas	Number of studies	Species richness	Proportion of Mediterranean diversity (%)
Bacteria	TS, AN	2	7	12	-
Bacillariophyceae	TS	1	1	5	0.7
Foraminifera	CC, BS, FC, SS, TS, IS, NA, SA	8	17	14	2.3
Myzozoa	IS	1	1	1	-
Ciliophora	IS	1	2	20	-
Radiozoa	IS	1	1	2	-
Phaeophyceae	BS, FC, LS, SS, TS, TC, AN, IS, NA, SA	10	19	33	12.2
Chlorophyta	CC, BS, FC, LS, SS, TS, TC, AN, AS, IS, NA, SA	12	24	27	14.2
Rhodophyta	CC, BS, FC, LS, SS, TS, TC, AN, IS, NA, SA, LB	12	31	169	25.7
Porifera	AL, CC, BS, FC, LS, SS, TS, TC, AN, AS, IS, NA, SA, LB	14	156	318	46.7
Hydrozoa	CC, BS, FC, LS, SS, TS, TC, AN, IS, LB	10	33	108	23.6
Scyphozoa	CC, BS, AN, NA	4	2	4	20
Anthozoa	AL, CC, BS, FC, LS, SS, TS, TC, AN, AS, IS, NA, SA, LB	14	87	49	29.7
Ctenophora	LS, NA	2	3	1	3.3
Platyhelminthes	TS, AN, NA	3	2	36	4
Nemertea	TS, AN, IS	3	2	9	5.2
Nematoda	unspecified	-	3	37	5.3
Rotifera	unspecified	-	1	2	3.4
Kinorhyncha	TS, AN	2	1	1	3.6
Priapulida	IS	1	1	1	20
Gastrotricha	AS, IS	2	2	16	9.7
Entoprocta	FC, AN, IS	3	4	4	21.1
Copepoda	BS, FC, SS, AN, IS	5	17	113	28
Ostracoda	FC, TS	2	4	8	1.6
Cirripedia	FC, LS, TS, AN, IS	5	13	7	17.5
Decapoda	AL, CC, BS, FC, LS, SS, TS, TC, AN, IS, NA, SA, LB	13	42	73	19.1
Mysida	CC, BS, FC, LS, SS, TS, TC, AN, AS, IS, SA	11	22	21	20.6
Thermosbaenacea	BS	1	1	1	20
Facetotecta	IS	1	1	1	-
Tanaidacea	AL, FC, TS, AN, NA	5	6	6	14
Pentastomida	IS	1	1	1	-
Isopoda	AL, FC, TS, AN, IS, NA	6	11	15	9.1
Leptostraca	BS	1	2	1	16.7
Amphipoda	AL, CC, BS, FC, LS, TS, NA	7	18	83	18.5
Cumacea	AL, FC, TS	3	6	6	6.1
Branchiopoda	IS	1	1	4	-

Tab. 1 (continued): Research effort metrics, species richness and representativeness of the total diversity for each group recorded in Mediterranean marine caves (for abbreviations see Materials and methods).

Taxonomic group	Areas	Number of areas	Number of studies	Species richness	Proportion of Mediterranean diversity (%)
Pycnogonida	FC, TS	2	3	9	20
Acari	TS	1	2	5	-
Insecta (marine)	IS	1	1	1	0.4
Oligochaeta	TS	1	4	2	-
Polychaeta	AL, CC, BS, FC, LS, SS, TS, TC, AN, IS, NA, SA, LB	13	62	261	23.3
Sipuncula	FC, TS, AN, NA	4	9	6	16.7
Echiura	BS, LS, AN, NA	4	3	1	16.7
Polyplacophora	FC, TS	2	7	7	22.6
Gastropoda	CC, BS, FC, LS, TS, TC, AN, IS, NA, SA, LB	11	37	134	8.6
Bivalvia	CC, BS, FC, LS, SS, TS, TC, AN, IS, NA, LB	11	42	90	22.5
Caudofoveata	TS	1	1	1	3.4
Cephalopoda	LS, AN, NA	3	3	3	4.6
Tardigrada	FC, TS, AS, IS	4	3	31	40.3
Bryozoa	AL, CC, BS, FC, LS, SS, TS, TC, AN, IS, NA, SA, LB	13	59	219	56.4
Brachiopoda	AL, CC, BS, FC, LS, SS, TC, AN, AS, NA, LB	11	20	9	64.3
Phoronida	NA	1	1	1	20
Chaetognatha	FC, SS, IS	3	3	5	25
Pterobranchia	FC	1	1	1	20
Echinodermata	CC, BS, FC, LS, TS, TC, AN, IS, NA, SA	10	29	34	22.1
Tunicata	CC, BS, FC, SS, TS, TC, AN, IS, NA, SA, LB	11	34	41	17.9
Pisces	CC, BS, FC, LS, SS, TS, TC, AN, AS, IS, NA, SA, LB	13	40	96	14.8
Mammalia	AL, IS, NA, SA, LB	5	-	1	4.3
Chromista				**75**	**1.7**
Plantae				**196**	**23**
Animalia				**1884**	**16.2**
Total Biota		14	**307**	**2167**	**12.9**

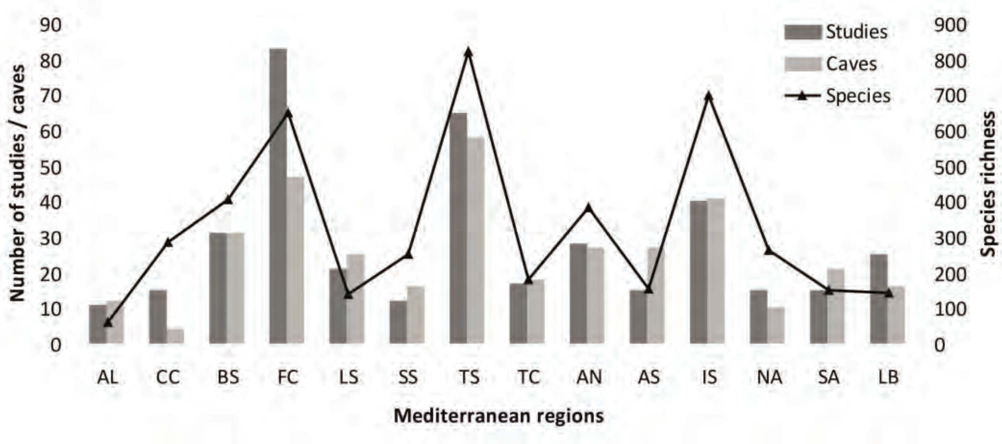


Fig. 1: Research effort compared to species richness in marine caves of different Mediterranean regions (for abbreviations see Materials and methods).

The biodiversity overview revealed that the cave environment harbours a considerable proportion of the total Mediterranean fauna for certain groups such as brachiopods, bryozoans, sponges and tardigrades (Tab. 1), as well as several protected, rare, and deep-sea species. In addition, 53 alien species have been recorded, mainly in semi-submerged caves and tunnels of the south-eastern Mediterranean basin. The semi-dark zone of the studied marine caves presented the highest species richness (1120), followed by the cave entrance (985) and the dark zone (844). However, for 510 taxa, cave zone was not specified. Macroalgae dominated in terms of species richness in the entrance (23.2% of the total diversity) while sponges dominated in the semi-dark and dark zones (19% and 22.4% of the total diversity respectively). Bryozoans and polychaetes were also among the richest groups in all zones. A total of 53 species were found in anchialine caves, mainly copepods, sponges, and bivalves. Data on the soft substrate biota were presented only in 45 studies. A total of 332 taxa were recorded in cave sediments, mainly bryozoans (on detached fragments), polychaetes, bivalves (although it was not always clear whether individuals were found dead or living), amphipods and tardigrades.

Discussion and conclusions

The results of the present overview confirmed that Mediterranean marine caves constitute significant biodiversity reservoirs of great scientific interest and conservation value. The caves surveyed to date represent only 12.3% of the Mediterranean caves recorded (Giakoumi *et al*., 2013); nevertheless, considerable representation of the total Mediterranean diversity was found for certain taxa, corroborating the findings of previous studies on the role of cave habitats for sciaphilic invertebrates (e.g. Bianchi, 2003; de Zio Grimaldi & Gallo D'Addabbo, 2001; Gerovasileiou & Voultsiadou, 2012; Gili & Ballesteros, 1991; Harmelin, 1986; Logan *et al*., 2004).

The taxa found in marine caves and their species richness varied among the different Mediterranean areas, reflecting variation in research effort, scientific priorities and interests of local researchers. However, the greatest species richness observed in the northern Mediterranean coasts could be explained by considering the latest mapping of the marine cave habitat along the Mediterranean coasts, according to which the vast majority of caves recorded (almost 97%) are located in the northern basin, which also encompasses 92.3% of the Mediterranean rocky coasts (Giakoumi *et al*., 2013). Discrepancies among species richness and intensity of research effort or habitat availability in particular areas could be attributed to differences in the breadth and depth of cave research which are difficult to quantify (see Gerovasileiou & Voultsiadou, 2012).

The literature overview undertaken revealed several problems during the data collection process such as: i) lack of spatial (coordinates) and ecological information (cave zone, depth); ii) several caves having the same toponyms (e.g. Blue Cave) or single sites with multiple caves; iii) lack of information about the cave type; iii) taxonomic inconsistencies (e.g. synonymies and possible misidentifications); iv) lacking or limited data concerning particular areas or taxa. Such problems could be addressed by the currently developing biodiversity informatics infrastructures (e.g. LifeWatch, www.lifewatch.eu), and particularly through their support to the publication of biodiversity datasets (e.g. geo-referenced, taxonomically updated species lists accompanied by relevant meta-data).

It is suggested that future marine cave research should focus on: southern and eastern Mediterranean areas (Alboran and North African coasts, Aegean and Levantine seas); unstudied groups of biota (e.g. microbial communities, meiofauna), cave assemblages and formations (e.g. soft substrate and bio-constructions); deeper (below 30 m) or peculiar cave types (anchialine caves and caves with hydrothermal springs). The adoption of modern techniques in taxonomy, using biochemical and molecular characters, is also expected to increase our knowledge on cave biodiversity by distinguishing closely related and new species. Finally, similar approaches for other habitat types in the Mediterranean Sea could assist in the assessment of regional biodiversity patterns, the identification of knowledge gaps deserving further research, and the definition of conservation priorities.

Acknowledgments
Part of this research has been co-financed by the EU Social Fund and Greek national funds through the NSRF 2007-2013 Research Funding Program: Heracleitus II, Investing in knowledge society. VG also benefited from “Alexander S. Onassis Public Benefit Foundation” fellowship for postgraduate studies.

Bibliography
BIANCHI C.N. (2003) - Flora e fauna: lineamenti generali e prospettive. *In*: Cicogna F., Bianchi C.N., Ferrari G., Forti P. (eds.), *Grotte marine: cinquant'anni di ricerca in Italia*, Ministero dell'Ambiente e della Tutela del Territorio, Rome: 137-146.
COLL M., PIRODDI C., STEENBEEK J., KASCHNER K., LASRAM F.B.R., *et al*. (2010) - The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. *PLoS ONE*, 5: e11842.
DE ZIO GRIMALDI S., GALLO D'ADDABBO M. (2001) - Further data on the Mediterranean Sea Tardigrade fauna. *Zool. Anz*., 240: 345-360.
GEROVASILEIOU V., VOULTSIADOU E. (2012) - Marine caves of the Mediterranean Sea: a sponge biodiversity reservoir within a biodiversity hotspot. *PLoS ONE*, 7: e39873.
GIAKOUMI S., SINI M., GEROVASILEIOU V., MAZOR T., BEHER J., POSSINGHAM H.P., ABDULLA A., ÇINAR M.E., DENDRINOS P., GUCU A.C., KARAMANLIDIS A.A., RODIC P., PANAYOTIDIS P., TASKIN E., JAKLIN A., VOULTSIADOU E., WEBSTER C., ZENETOS A., KATSANEVAKIS S. (2013) - Ecoregion-based conservation planning in the Mediterranean: dealing with large-scale heterogeneity. *PLoS ONE*, 8: e76449.
GILI J.M., BALLESTEROS E. (1991) - Structure of Cnidarian populations in Mediterranean sublittoral benthic communities as a result of adaptations to different environmental conditions. *Oecol. Aquat*., 10: 243-254.
HARMELIN J.G. (1986) - Patterns in the distribution of bryozoans in the Mediterranean marine caves. *Stygologia*, 2: 10-25.
LABOREL J., VACELET J. (1958) - Étude des peuplements d'une grotte sous-marine du Golfe de Marseille. *Bull. Inst. Océanogr. Monaco*, 1120: 1-20.
LOGAN A., BIANCHI C.N., MORRI C., ZIBROWIUS H. (2004) - The present-day Mediterranean brachiopod fauna diversity, life habits, biogeography and paleobiogeography. *Sci. Mar.*, 68: 163-170.
PERES J.M., PICARD J. (1949) - Notes sommaires sur le peuplement des grottes sous-marines de la région de Marseille. *C.R. Soc. Biogeogr.*, 227: 42-45.
PERES J.M., PICARD J. (1964) - Nouveau manuel de bionomie benthique de la Mer Méditerranée. *Rec. Trav. St. Mar. Endoume*, 47: 3-137.
RIEDL R. (1966) - *Biologie der Meereshöhlen*. Paul Parey, Hamburg: 636 pp.
RUSS K., RÜTZLER K. (1959) - Zur Kenntnis der Schwammfauna unterseeischer Höhlen. *Pubbl. Staz. Zool. Napoli*, 30: 756-787.
UNEP-MAP-RAC/SPA (2008) - *Action plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea*. RAC/SPA, Tunis: 21 pp.
UNEP-MAP-RAC/SPA (2013) - *Draft action plan for the conservation of dark assemblages of the Mediterranean Sea*. RAC/SPA, Tunis: 14 pp.
VOULTSIADOU E. (2009) - Reevaluating sponge diversity and distribution in the Mediterranean Sea. *Hydrobiologia*, 628: 1-12.

Carlos NAVARRO-BARRANCO, GUERRA-GARCÍA J.M., SÁNCHEZ-TOCINO L., GARCÍA-GÓMEZ J.C.
Laboratorio de Biología Marina, Universidad de Sevilla, Avda Reina Mercedes 6, 41012 Sevilla, Spain.
E-mail: carlosnavarro@us.es

UNNOTICED INHABITANTS OF MARINE CAVES: AMPHIPOD ASSEMBLAGES IN CAVES OF THE ALBORAN SEA

Abstract
Amphipod species seem to be widespread in marine cave benthic communities, both in hard and soft substrates. For many years, this fauna had attracted the attention of taxonomists, who described many new taxa. However, the ecology of caves' epifaunal and infaunal communities in general, and its amphipod fauna in particular has been often overlooked. Are these communities different from those present in open habitats? What are their abundance or diversity patterns? Can we find general and constant trends? What do marine cave amphipods feed on? Are cave environments easy to colonize? The amphipod fauna of nine different marine caves in the Alboran Sea was surveyed and more than fifty different species were identified. Species composition and structure of the communities was highly variable among caves, so that it was difficult to extract general and consistent ecological patterns. Amphipodswere one the dominant groups of mobile epifauna in all the substrates studied, both in abundance and number of species. Regarding their trophic structure, outside the caves detritivores were the dominant feeding group, while amphipods mainly played the role of carnivores inside the caves. There was a marked decrease in diversity toward the inner part of the caves; this community impoverishment should be attributed to factors such as the decrease in the trophic supply, rather to a limitation in the ability of propagules to reach the internal part of the caves. Experimental studies also pointed out the little rate of change and slow succession in epifaunal communities, which supports the actual consideration of marine caves as very sensitive habitats.

Key-words: Marine caves, Amphipoda, Mediterranean Sea, Mobile Epifauna

Introduction
Amphipods often play a key role both within the mobile epifaunal and infaunal communities in rocky reef ecosystems and marine sediments respectively. Amphipod crustaceans are one of the most relevant groups in the study of the structure of benthic assemblages because of their abundance in such ecosystems and their importance as a link in littoral trophic webs (Duffy & Hay, 2000; Taylor, 1997). Moreover, they are considered good ecological indicators and are commonly used to evaluate the environmental quality of coastal communities (Conradi *et al.,* 1997; Gómez-Gesteira & Dauvin, 2000).
In spite of the great interest that marine caves have aroused in the last decades to marine taxonomists and ecologists, most studies have focused on sessile benthic communities of hard substrate. Conversely, there is a lack of knowledge about the ecology and species composition of the mobile macrofauna associated to hard and soft bottom substrates of marine caves, which is an important handicap to properly understand these ecosystems. At the same time, understanding the ecology of the amphipod communities of marine caves could also be very helpful to increase our current knowledge about this crustacean group. Due to their distinguished features, such as isolation, deep-like conditions, marked

gradients in light, trophic supply or hydrodinamism, marine caves constitute a very suitable habitat to assess the effects of environmental factors on the fauna or explore their dispersal capabilities.

During the last years, several studies were conducted in shallow marine caves of the Mediterranean coast of Southern Spain (Navarro-Barranco *et al.*, 2013a; 2013b; 2014a; and 2014b. Previous studies highlighted the particular composition of the benthic communities in this area due to the mixing of Mediterranean and Atlantic waters and the upwelling of Mediterranean deep waters (Cebrian & Ballesteros, 2004).Moreover, the distribution and features of marine caves in the Alboran Sea still remain poorly explored (Giakoumi *et al.*, 2013).

The aim of this study was to investigate the amphipod species composition inhabiting marine caves of the Alboran Sea, as well as their abundance, distribution, trophic ecology, dispersal capability and their role in the structure of marine cave communities and conservation status.

Material and Methods

The amphipod fauna of nine marine caves was studied: Gorgonias, Cantarriján, Cerro-Gordo, Gigantes, Treinta Metros, Jarro, Raja de la Mona, Punta del Vapor and Calahonda. These caves varied greatly in topography, length and depth (ranging from 6 to more than 30 m deep). The mobile epifaunal communities inhabiting invertebrate hosts and sediments inside the cave were characterized and compared with those present in adjacent open habitats. Soft bottom samples were taken with SCUBA diving using a hand-held rectangular core of 0.025 m^2 to a depth of 10 cm. Invertebrate hosts were carefully separated from the substrate and introduced in a plastic box to avoid the loss of organisms. All samples were washed using a 0.5 mm mesh sieve and preserved in 70% ethanol. In the laboratory, all amphipod specimens were counted and identified to species level using binocular microscopes.

A colonization and succession study was conducted deploying artificial substrates following a longitudinal gradient within Cerro-Gordo cave. Collectors were retrieved from each station after 1.5, 3 and 6 months and all amphipods were identified and counted.

Finally, gut content of the dominant amphipod species inhabiting the soft bottom of marine caves and adjacent sediments in open habitats were analyzed following the methodology proposed by Bello & Cabrera (1999).

Univariate and multivariate analysis was performed in order to test differences in amphipod species composition, abundance, number of species and variability between cave and open habitats, among different caves and substrates (See Navarro-Barranco *et al.*, 2013a; 2013b; 2014a; and 2014b for a detailed description of caves topography, sampling methodology and data analysis).

Results

Fifty four different amphipod species were found into the caves, belonging to thirty six genera and nineteen different families (Tab. 1).

Tab. 1: Amphipod species list. CG = Cerro Gordo, PV = Punta del Vapor, JA = Jarro, GI = Gigantes, GO = Gorgonias, CN = Cantarrijan, CL = Calahonda, TM = Treinta Metros, RM = Raja Mona, SD = Sediment, AS =Artificial substrate, *AlC = Aldeonella calveti, PF = Pentapora fascialis, AsC = Astroides calycularis, PA = Parazoanthus axinellae, IV = Ircinia variabilis, FI = Filograna implexa, Eu = Eudendrium* sp.

Familiy	Species	Cave	Substrate
Ampeliscidae	*Ampelisca serraticaudata*	CG	SD
	Ampelisca typica	PV	SD
Amphilochiidae	*Gitana* cf *abyssicola*	CG	*Alc, PF, PA, FI*
Aoridae	*Lembos websteri*	CG, PV, JA, GI	AS, *Alc, PF, AsC, PA, IV, FI, Eu*
	Microdeutopus algicola	GO	SD
Dexaminidae	*Dexamine spiniventris*	JA	*Eu*
	Dexamine spinosa	JA	*Eu*
	Tritaeta gibbosa	CG	*IV*
Caprellidae	*Phtisica marina*	CG, PV, RM	SD, AS, A*lC, PF, IV FI, Eu*
	Pseudolirius kroyeri	PV, GO, CN, TM	SD
	Pseudoprotella phasma	CG, PV, JA, GI	AS, *PF, FI, Eu*
Corophiidae	*Apocorophium* sp.	CG	AS
	Leptocheirus bispinosus	CG	AS, *AsC, PA*
	Leptocheirus longiamnus	CG	*AsC, PA*
	Leptocheirus pectinatus	CG, RM	SD, AS
Ischyroceridae	*Ericthonius punctatus*	JA	*Eu*
	Ischyrocerusinexpectatus	CG, JA, GI	Eu
	Jassaslateryi	CG	AS
	Microjassa cumbrensis	PV, JA	*Eu*
Leucothoidae	*Leucothoe oboa*	CG	SD
	Leucothoe sp.	GO, CN	SD
	Leucothoe spinicarpa	CG	*Alc, IV, FI*
Liljeborgiidae	*Liljeborgia* sp.	CN	SD
	Liljeborgia dellavallei	CG, PV	*PF, AsC, PA, IV, Eu*
Lysianassidae	*Hippomedon massiliensis*	CG, GO	SD
	Lyssianassa sp.	CG	*Alc, AsC, PA*
Maeridae	*Elasmpus pectenicrus*	CG	*PF*
	Maera inaequipes	CG	AS, *IV*
Megaluropidae	cf *Melita* sp.	RM	SD
Nuuanuidae	*Gammarella fucicola*	CG, CN, RM	SD, AS
Oedicerotidae	*Deflexilodesgriseus*	PV, CN, CA, TM	SD
	Deflexilodesacutipes	CG	SD
	Monoculodespackardi	CG	SD, AS
	Perioculodeslongimanus	CG, PV, GO, CN.CA	SD
	Pontocratesarenarius	CG	SD
	Synchelidium haplocheles	GO	SD
	Synchelidium cf *longidigitatum*	CG	*IV*
	Synchelidium sp.	CG	AS
Pontogeniidae	*Eusiroidesdellavallei*	CN	SD
Photidae	*Gammaropsis maculata*	CG, PV, JA, GI	AS, *PF, AsC, Eu*
	Gammaropsis sp.	CG	*AsC*
	Megamphopus sp.	CG	AS
	Photislongipes	CG, PV, GO, CA	SD

Tab. 1: (continued): Amphipod species list. CG = Cerro Gordo, PV = Punta del Vapor, JA = Jarro, GI = Gigantes, GO = Gorgonias, CN = Cantarrijan, CL = Calahonda, TM = Treinta Metros, RM = Raja Mona, SD = Sediment, AS =Artificial substrate, *AlC = Aldeonella calveti, PF = Pentapora fascialis, AsC = Astroides calycularis, PA = Parazoanthus axinellae, IV = Ircinia variabilis, FI = Filograna implexa, Eu = Eudendrium* sp.

Familiy	Species	Cave	Substrate
Phoxocephalidae	*Harpinia antennaria*	TM	SD
	Harpinia ala	CG, RM	SD
	Harpinia crenulata	CG, PV, CA, TM	SD
	Harpinia pectinata	CG, GO, CN, TM	SD
	Harpinia sp.	RM	SD
	Metaphoxus fultoni	CG, GO	SD
Stenothoidae	*Stenothoe cavimana*	CG	A*sC*
	Stenothoe dollfusi	CG, PV	AS, *AlC, PA, FI, Eu*
	Stenothoe sp.	CG, PV, JA	*Eu*
	Stenothoe tergestina	CG	AS
Urothoidae	*Urothoe elegans*	CG	SD

Arthropoda was the dominant phylum (in term of abundance) over hard substrate and within it, Amphipoda was the most abundant order (Fig. 1). Even in the absence of endemic cave taxa, PERMANOVA analyses showed that amphipod assemblages inhabiting marine caves (both in artificial substrates, soft bottom and invertebrate hosts) were significantly different from those present in the exterior habitat. Marine cave communities also showed a high small-scale variability and a high degree of individuality (amphipod assemblages differed among caves). Species richness and abundance values were significantly lower toward the inner part of the caves.
Successional experiments reflected that, as it was expected, inner positions within caves were colonized later and showed a higher temporal stability. However, the dominant amphipod species were able to quickly colonize the inner part of the caves, but their abundances were much higher in open and semidark areas.

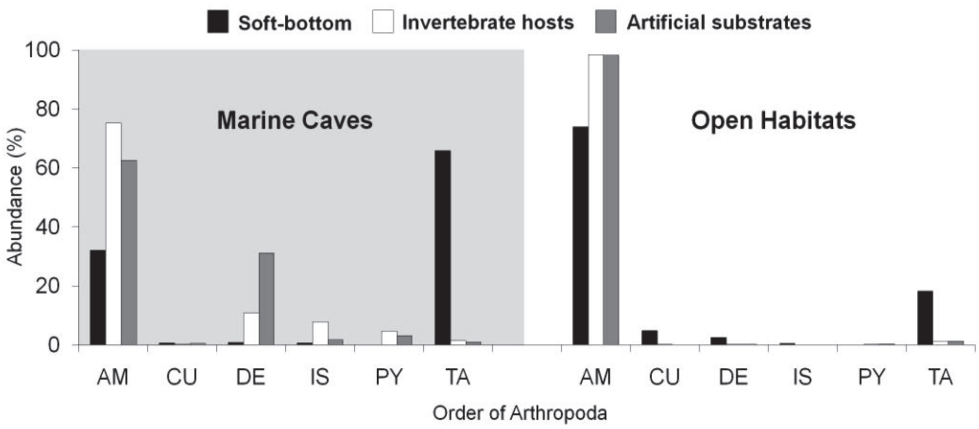


Fig. 1: Relative abundance of individuals (%) of arthopod orders inhabiting marine caves and open habitats.AM = Amphipoda, CU = Cumacea, DE = Decapoda, IS = Isopoda, PY = Pycnogonida, TA = Tanaidacea

With regard to the trophic structure of amphipods in soft bottom habitats, outside the caves detritivores were the dominant feeding group, while amphipods mainly played the role of carnivores inside the caves.

Discussion

Our studies highlighted the importance of amphipod community within marine caves habitats due to their high abundance both in hard and soft substrates. It could be surprising that no cave exclusive species were found during the studies, since marine caves have been traditionally considered as very isolated habitats with a frequent occurrence of endemic species (Harmelin *et al.*, 1985). Nevertheless, most of the species recorded in marine caves are not cave-specialized and can also be found in other habitat as well (Gerovasileiou & Voultsiadou 2012). In spite of this fact, amphipod cave assemblages have proved to be a particular community, different from those present in adjacent open habitats. These differences were mainly due to the higher species richness outside the caves and changes in the relative abundance of the species present. The impoverishment of the fauna is a common feature associated to the inner part of marine caves (Zabala *et al.*, 1989). In this sense, mobile macrofauna in general and amphipod community in particular seems to follow this trend, although it is difficult to extract general and consistent patterns due to the high variability among caves. For example, soft sedimentsin shallow marine caves showed higher densities of organisms than adjacent external sediments, probably due to the higher environmental stability into the cavities. Each marine cave has a particular combination of environmental conditions and as result, an idiosyncratic behavior and faunal composition (Bussotti *et al.*, 2006).

The factors traditionally used to explain this common impoverishment incave habitats were the decrease in the trophic supply and the low ability of propagules to reach the internal part of the caves (Harmelin *et al.*, 1985, Zabala *et al.*, 1989). The patterns of distribution observed together with colonization experiments pointed out that mobile epifaunal organisms, regardless of their development mode (direct or indirect) usually can quickly colonize the inner part of the caves, but they are not able to reach as large abundances as we observe outside. This suggests that environmental factors (such as food availability or light), rather than isolation conditions, are probably the main factors responsible forthe diversity decrease. The near absence of photosynthetic activity inside the cavities confines the presence of herbivores to illuminated areas, and the low hydrodynamism reduces the trophic supply to detritivorous species. So, cave amphipods, at least those inhabiting soft bottoms, occupy mainly the role of carnivores.

Finally, the results of our studies also highlighted the high temporal stability and low rate of development of mobile epifaunal communities, which supports the current consideration thatmarine caves arevery sensitive habitats, with a low resilience to natural and human disturbances.

Acknowledgments

Financial support of this work was provided by the Ministerio de Economía y Competitividad (Project CGL 2011-22474, internal reference 2011-707) co-financed by FEDER funds of the European Union, and by the Consejería de Economía, Innovación, Ciencia y Empleo, Junta de Andalucía (Project P11-RNM-7041**)**. This work forms part of C.N-B's Ph.D. Thesis, supported by the University of Seville (PIF Grant).

Bibliography

BELLO C.L., CABRERA M.I. (1999) - Uso de la técnica microhistológica de Cavender y Hansen en la identificación de insectos acuáticos. *Boletín Entomológico Venezolano*, 14 : 77-79.

BUSSOTTI S., TERLIZZI A., FRASCHETTI S., BELMONTE G., BOERO F. (2006) - Spatial and temporal variability of sessile bentos in shallowMediterranean marine caves. *Mar. Ecol. Prog. Ser.*, 325: 109-119

CEBRIÁN E., BALLESTEROS E. (2004) - Zonation patterns of benthic communities in an upwelling area from the western Mediterranean (La Herradura, Alboran Sea). *Sci. Mar.*, 68(1): 69-84.

CONRADI M., LÓPEZ-GONZÁLEZ P.J., GARCÍA-GÓMEZ J.C. (1997) - The amphipod community as a bioindicator in Algeciras Bay (Southern Iberian Peninsula) based on a spatio-temporal distribution. *Mar. Ecol.*, 18 (2): 97-111.

DUFFY J.E., HAY M.E. (2000) - Strong impacts of grazing amphipods on the organization of a benthic community. *Ecol. Monogr.*, 70: 237-263.

GEROVASILEIOU V., VOULTSIADOU E. (2012) - Marine caves of the Mediterranean Sea: a sponge biodiversity reservoir within a biodiversity hotspot. *PLoS One* 7 (7): e39873. doi:10.1371/journal.pone.0039873.

GIAKOUMI S., SINI M., GEROVASILEIOU V., MAZOR T., BEHER J., POSSINGHAM H.P., ABDULLA A., ÇINAR M.E., DENDRINOS P., GUCU A.C., KARAMANLIDIS A.A., RODIC P., PANAYOTIDIS P., TASKIN E., JAKLIN A., VOULTSIADOU E., WEBSTER C., ZENETOS A., KATSANEVAKIS S. (2013) - Ecoregion-Based Conservation Planning in the Mediterranean: Dealing with Large-Scale Heterogeneity. *PLoS ONE* 8 (10): e76449. doi:10.1371/journal.pone. 0076449.

GÓMEZ-GESTEIRA J.L., DAUVIN J.C. (2000) - Amphipods are good bioindicators of the impact of oil spills on soft-bottom macrobenthic communities. *Mar. Pollut. Bull.*, 40 : 1017-1027.

HARMELIN J.G., VACELET J., VASSEUR P. (1985) - Les grottes sous-marines obscures: un milieu extreme et un remàrquable biotope refuge. *Téthys*, 11 : 214-229.

NAVARRO-BARRANCO C., GUERRA-GARCÍA J.M., SÁNCHEZ-TOCINO L., GARCÍA-GÓMEZ J.C. (2014a) - Mobile epifaunal community in marine caves in comparison to open hábitats. *Aquat. Biol.*, 20: 101-109.

NAVARRO-BARRANCO C., GUERRA-GARCÍA J.M., SÁNCHEZ-TOCINO L., GARCÍA-GÓMEZ J.C. (2014b) - Amphipods- from marine cave sediments of the southern Iberian Peninsula: diversity and ecological distribution. *Sci. Mar.*, 78 (3): doi: 10.3989/scimar.00000.00

NAVARRO-BARRANCO C., GUERRA-GARCÍA J.M., SÁNCHEZ-TOCINO L., JIMÉNEZ-PRADA P., CEA S., GARCÍA-GÓMEZ J.C. (2013a) - Soft-bottom diversity patterns in marine caves; lessons from crustacean community. *J. Exp. Mar. Biol. Ecol.*, 446:22-28

NAVARRO-BARRANCO C., TIERNO DE FIGUEROA J.M., GUERRA-GARCÍA J.M., SÁNCHEZ-TOCINO L., GARCÍA-GÓMEZ J.C. (2013b) - Feeding habits of amphipods (Crustacea: Malacostraca) from shallow soft bottom communities: Comparison between marine caves and open habitats. *J. Sea. Res.*, 78: 1-7.

TAYLOR B. (1997) - The role of small mobile epifauna in subtidal rocky reef ecosystems. PhD thesis, University of Auckland

ZABALA M., RIERA T., GILI J.M., BARANGE M., LOBO A., PEÑUELAS J (1989) - Water flow, trophic depletion, and benthic macrofauna impoverishment in a submarine cave from the western Mediterranean. *Mar. Ecol.*, 10: 271-287.

Pierre-Alexandre RASTORGUEFF, BELLAN-SANTINI D., BIANCHI C.N., BUSSOTTI S., CHEVALDONNE P., GUIDETTI P., HARMELIN J.G., MONTEFALCONE M., MORRI C., PEREZ T., RUITTON S., VACELET J., PERSONNIC S.
IMBE, UMR 7263 CNRS, IRD, Aix Marseille Université, Avignon Université, Station Marine d'Endoume, Marseille, France / Department of Zoology, University of Johannesburg, South Africa
E-mail: pierre-alex.rastorgueff@gmx.fr

AN ECOSYSTEM-BASED APPROACH TO EVALUATE THE ECOLOGICAL QUALITY OF MEDITERRANEAN UNDERSEA CAVES

Abstract
A theoretical model of structure and functioning was constructed for the marine underwater cave ecosystem of the Mediterranean Sea. This model integrates almost all representative components of the cave ecosystem and gives an idea of their faunal composition, characteristics and related interactions. This model constitutes the basis of an Ecosystem-Based Quality Index (EBQI) which aims at evaluating the ecological quality of an ecosystem. This method is based on four crucial and complementary elements: i) each component was weighted in accordance with its importance in determining the structure and functioning of the cave ecosystem; ii) a suite of relevant parameters were defined to assess the ecological state of each component of the cave ecosystem; iii) these parameters were aggregated into one relevant index, the Cave EBQI (CavEBQI), to summarise the quality evaluation for each cave site; iv) each value of ecological state is accompanied by a confidence index which is a measure of its reliability. The power of such an ecosystem ecological quality assessment is that it is based on almost all its components, rather than on few species, and that it is complemented by a measure of the reliability of this evaluation. CavEBQI allows the monitoring of the ecological state of caves and the effects of disturbances over large geographic and temporal scales. Application of the same method to other ecosystems can provide an integrated view that is essential when addressing questions about protection, conservation and restoration.

Key-words: Ecosystem-based quality index; ecological quality; Marine Strategy Framework Directive; undersea caves; Mediterranean Sea.

Introduction
Changes detection in biodiversity and interpretation of their reasons within a given ecosystem are some of the main challenges for management and conservation of the marine environment. Ecological indicators are usually considered the most appropriate tools to address such questions (Dale & Beyeler, 2001; Turnhout *et al.*, 2007).
The difficulty of defining and using ecological indicators is that they must give a simplified picture of a natural system that is highly complex and dynamic, but also spatially heterogeneous and temporally fluctuating (Turnhout *et al.*, 2007). The best strategy to deal with this whole complexity is to use a suite of parameters which can be aggregated into one index that assesses the current and/or desired ecological quality of a certain system (Dale & Beyeler, 2001; Turnhout *et al.*, 2007).
Personnic *et al.* (2014) have developed a method to assess ecosystem quality based on (i) an aggregation of multiple parameters into a single index, namely the Ecosystem-

Based Quality Index (EBQI), indicating the status of an ecosystem; (ii) a confidence index which estimates the reliability of each value of the parameters and of the summarizing index. In case of a lack of reliability, the method gives insights into the identification of the cause of the flaw. This method uses a model of ecosystem functioning based on how experts think it functions under natural conditions (Dale & Beyeler, 2001). This model-based method has several advantages: (i) it allows the definition of what a 'Good Environmental Status' represents: ecosystems are fully functioning and resilient to human-induced pressures and change such as different uses of marine resources can be conducted at a sustainable level, ensuring their continuity for future generations (European Union's Marine Strategy Framework Directive 2008/56/EC); (ii) it takes into account all the components of an ecosystem as well as their interactions with each other; (iii) it indicates the relative importance of each descriptor of the ecosystem health and (iv) it allows identifying the need of prospects to better understand the structure and functioning of the ecosystem.

Underwater caves are remarkable habitats widespread throughout the Mediterranean Sea, which are listed by the European Union Habitats Directive (92/43/EEC, Habitat type 8330). However, the high aesthetic value and richness in biological peculiarities of the underwater cave community can be degraded by several threats: mechanical disturbance (deleterious water movements, SCUBA divers…), sediment deposit, water warming, red coral harvesting, urbanization and waste outflow (Chevaldonné & Lejeusne, 2003; Parravicini *et al.*, 2010; Giakoumi *et al.*, 2013).

The ecosystem-based approach is here applied to evaluate the ecological quality of the Mediterranean undersea caves ecosystem. Hence we propose (i) a model of undersea cave ecosystem composition, structure and functioning, (ii) a definition of what 'Good Environmental Status' means for undersea caves and (iii) the definition of parameters and criteria needed to evaluate the caves' status and quality.

Material and methods

<u>Model of structure and functioning of undersea caves</u>

Applying information gathered from numerous studies (references are available on demand) and our own expertise on marine cave ecosystems, we have proposed a theoretical and simplified model of structure and functioning of Mediterranean undersea caves (Fig. 1) which encompasses the following components (boxes):

- Organic matter originating from terrestrial systems (OMT) percolating through the cracks and fissures of the limestone bedrock (Rastorgueff *et al.*, 2011);
- Coastal suspended particulate organic matter (POM), which is a mix of marine phytoplankton, land-derived material and anthropogenic material brought to the sea by river runoff and sewage outflow (Rastorgueff *et al.*, 2011);
- Passive filter feeders including mostly cnidarians (box 1);
- Large (relative to the cave ecosystem) active filter feeders such as bivalve molluscs, ascidians, massive sponges, and erect or massive bryozoans (box 2) and small active filter feeders such as serpulid polychaetes, encrusting sponges and bryozoans, and brachiopods (box 3);
- Sedimentary organic matter (SOM) made of all material falling down from the water column to the cave bottom, such as organic and inorganic matter, faecal pellets and dead organisms;

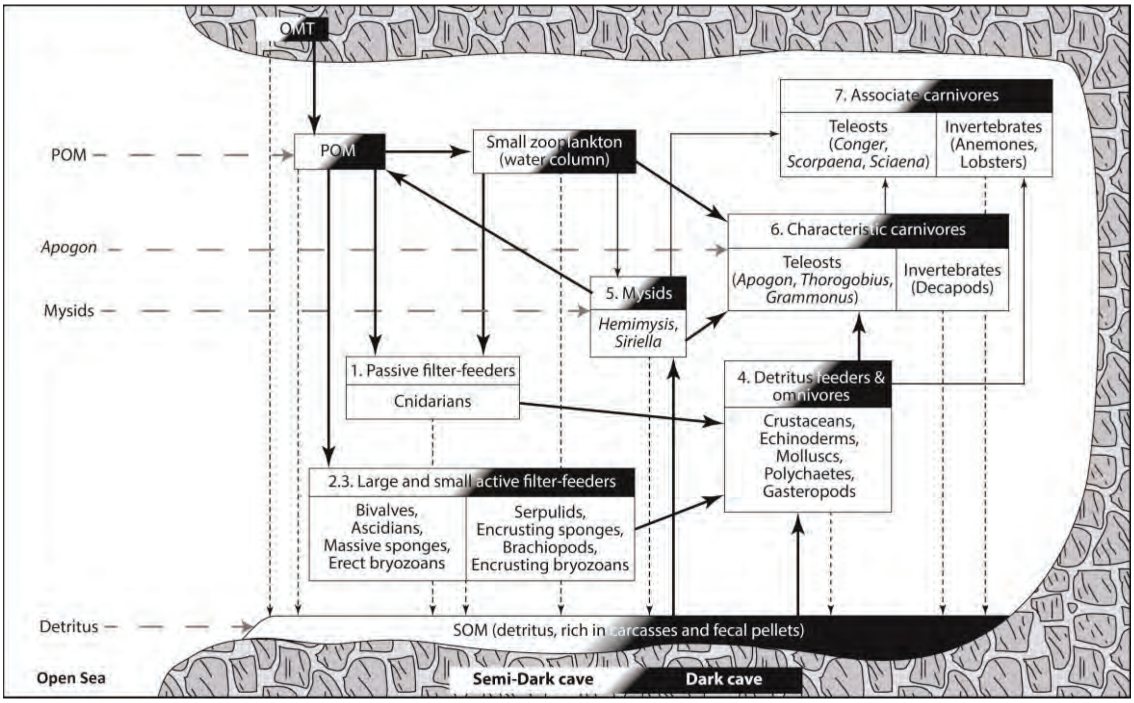


Fig. 1: Model of structure and functioning of the Mediterranean undersea cave ecosystem. Increasing thickness of black arrows, relate to the increasing intensity of organic matter fluxes. Vertical dashed arrows represent organic matter reaching the bottom of caves such as organic matter of terrestrial origin (OMT), suspended particulate organic matter (POM), fecal pellets and dead organisms. Horizontal dashed arrows represent major inputs of organic matter into caves either by advection, influx of detritus or by circadian migrations. SOM: sedimentary organic matter.

- Detritus feeders and omnivores such as decapod crustaceans, echinoderms, molluscs and polychaetes (box 4);
- Mysid crustaceans (box 5);
- Small zooplankton from the cave water column such as copepods;
- Characteristic (preferentially found in a given biotope) cave carnivores such as teleost fishes and decapod crustaceans (box 6);
- Associate (frequently found in caves but their presence is as usual in this biotope as in others) carnivores such as teleost fishes, anemones and lobsters (box 7).

<u>Methodology of ecosystem-based evaluation status of Mediterranean ecosystems</u>
The method developed by Personnic *et al.* (2014) was adapted to the undersea cave ecosystem.
For each of the components with a box number (Fig. 1), a set of relevant parameters was chosen and evaluated through a semi-quantitative scale: very bad (0), bad (1), moderate (2), good (3), and very good (4) ecological status (*S* in formula 1 below). The relative importance of each component (*W* in formula 1 below) to the functioning of the cave ecosystem was incorporated using a scale defined from lower weight (1) to higher weight (5). Consequently, the rank of each component considered was provided on a scale from 0 to 20, obtained from the product of *S* (from 0 to 4) times *W* (from 1 to 5; Personnic *et al.*, 2014).

The status of the cave ecosystem ranked from 0 (worst quality of the ecosystem) to 10 (best quality of the ecosystem) to provide the Cave Ecosystem-Based Quality Index (CavEBQI) by the formula (Personnic *et al.*, 2014):

$$(1)\ CavEQBI = [\sum_{i=1}^{n}(S_i W_i)/\sum_{i=1}^{n}(S_{max} W_i)] \times 10$$

where n is the number of components in the model of the ecosystem (for caves, $n = 8$), S_i is the ecological status of component i, W_i is the weight of component i, S_{max} is the highest possible grade for the status of the components (= 4).

Each value of the status of each component is accompanied by a Confidence Index (CI; Personnic *et al.*, 2014) which has been evaluated through a semi-quantitative scale: no quantitative field data and no suitable expert statement (0), no quantitative field data but past expert statement (1), no quantitative field data but recent expert statement (2), recent field data partially completed with expert statement (3) and available, recent and suitable field data with the recommended method (4).

The Confidence Index of the EBQI (CI_{EBQI}), which ranges from 0 (worst confidence in the value of the EBQI) to 10 (highest confidence in the value of the EBQI) is given by formula 2 (Personnic *et al.*, 2014):

$$(2)\ CI_{EQBI} = [\sum_{i=1}^{n}(CI_i W_i)/\sum_{i=1}^{n}(CI_{max} W_i)] \times 10$$

where n is the number of components in the model of the ecosystem (for caves, $n = 8$), CI_i is the Confidence Index of the component i, W_i is the weight of the component i, CI_{max} is the highest possible grade of the Confidence Index of the components (= 4).

Results

Considered components of the cave ecosystem model and respective evaluation criteria are represented in Table 1.

Discussion

The proposed model of structure and functioning of Mediterranean undersea caves presented in this study gives a picture that is quite close to *in situ* observations of this ecosystem. However, this picture is incomplete and requires more work to better understand this ecosystem, especially by taking into account macro- and meiofauna, small crustaceans and fauna from the sedimentary cave floor. Future studies should also take into account the intrinsic high heterogeneity of natural systems such as undersea caves.

Nevertheless, the proposed model was useful to develop an ecosystem-based method of evaluation of the ecological quality of each cave site (CavEBQI). This evaluation integrates most of the components of the cave ecosystem allowing a robust evaluation of the quality of each site.

This method opens perspectives on studying impact of disturbance on large geographic and temporal scales by giving a standardized tool to monitor cave ecosystem states over long time periods and large spatial extent.

In addition, this integrated approach of marine cave ecosystems opportunely combined with interactions with other ecosystems such as *Posidonia oceanica* meadows, for which an EQBI already exists (Personnic *et al.*, 2014), could give a new view of the functioning of the marine realm. In fact this latter is not a suite of isolated ecosystems and should rather be considered as a underwater seascape, composed of many interacting pieces. This is an aspect of major importance for addressing and resolving questions about conservation, protection and restoration of biodiversity.

Tab. 1: Cave ecosystem model components (see Fig. 1) and parameters used to evaluate the ecological quality (from 0, very bad to 4, very good) of undersea cave habitats.

Box / Weight	Components of the cave ecosystem model	Parameter	Status 0	Status 1	Status 2	Status 3	Status 4
1 / 5	Passive filter feeders (*e.g. Parazoanthus axinellae*, *Corallium rubrum*, *Caryophyllia inornata*, *Leptopsammia pruvoti*, *Hoplangia durotrix*, *Phyllangia americana mouchezii*, *Eudendrium racemosum*, *Eunicella cavolini*, *Paramuricea clavata*, *Halecium beanii*)	Cover (%)	0 %	0-25 %	25-50 %	50-75%	>75 %
2 / 3	Large active filter feeders (*e.g. Petrosia ficiformis*, *Aplysina cavernicola*, *Agelas oroides*, *Haliclona mucosa*, *Diplastrella bistellata*, *Reniera fulva*, *Celleporina mangnevillana*, *Adeonella calveti*, *Reteporella mediterranea*, *Schizomavella* spp., *Dentiporella sardonica*, *Lima hians*, *Lithophaga lithophaga*, *Pycnodonta floribunda*, *Protula* sp., *Pyura* spp., *Aplidium fuscum*)	Cover (%)	0 %	0-25 %	25-50 %	50-75%	>75 %
3 / 2	Small active filter feeders (*e.g. Petrobiona massiliana*, *Discodermia polymorpha*, *Dendroxea lenis*, *Puellina pedunculata*, *P. radiata*, *Onychocella marioni*, *Ellisina gautieri*)	Cover (%)	0 %	0-25 %	25-50 %	50-75%	>75 %
1,2,3 / 2	Sessile filter feeders	Volumetric stratification (0, no stratification; 1, millimetre; 2, centimetre; 3, decimetre)	0	1		2	3
4 / 3	Detritus feeders and omnivores (e.g. *Herbstia condyliata*, *Galathea strigosa*, *Scyllarus arctus*, *Scyllarides latus*)	Species richness Density (# individuals /5 min /species)	0 0	1 1-2	2 3-4	3-5 5-10	>5 >10
5 / 4	Cave-dwelling mysids (*Siriella gracilipes*, *Hemimysis speluncola*, *Hemimysis margalefi*, *Hemimysis lamornae mediterranea*, *Harmelinella mariannae*)	Semi-quantitative abundance	0		1		Swarm
6 / 3	Characteristic carnivores (*Apogon imberbis*, *Thorogobius ephippiatus*, *Scorpaena notata*, *Grammonus ater*, *Gammogobius steinitzi*, *Palaemon serratus*, *Stenopus spinosus*, *Lysmata seticaudata*, *Lysmata nilita*, *Plesionika narval*)	Teleost species richness Decapod species richness	0 0	1 1	2 2	3 3	4 4-5
7 / 1	Associate carnivores (*Conger conger*, *Phycis phycis*, *Palinurus elephas*, *Homarus gammarus*, *Scyllarides latus*, *Arachnanthus oligopodus*, *Cerianthus membranaceus*)	Teleost species richness Decapod species richness Anemone semi-quantitative abundance	0 0 0	1 1 	1 2 1-2	2 2 	2 3 >2

Bibliography

CHEVALDONNÉ P., LEJEUSNE C. (2003) - Regional warming-induced species shift in north-west Mediterranean marine caves. *Ecol. Lett.*, 6: 371-379.

DALE V.H., BEYELER S.C. (2001) - Challenges in the development and use of ecological indicators. *Ecol. Indic.*, 1: 3-10.

GIAKOUMI S., SINI M., GEROVASILEIOU V., MAZOR T., BEHER J., POSSINGHAM H.P., ABDULLA A., ÇINAR M.E., DENDRINOS P., GUCU A.C., KARAMANLIDIS A.A., RODIC P., PANAYOTIDIS P., TASKIN E., JAKLIN A., VOULTSIADOU E., WEBSTER C., ZENETOS A., KATSANEVAKIS S. (2013) - Ecoregion-based conservation planning in the Mediterranean: dealing with large-scale heterogeneity. *PLoS ONE*, 8: e76449.

PARRAVICINI V., GUIDETTI P., MORRI C., MONTEFALCONE M., DONATO M., BIANCHI, C.N. (2010) - Consequences of sea water temperature anomalies on a Mediterranean submarine cave ecosystem. *Estuar. Coast. Shelf. S.*, 86: 276-282.

PERSONNIC S., BOUDOURESQUE C.-F., ASTRUCH P., BALLESTEROS E., BELLAN-SANTINI D., BONHOMME P., BOTHA D., FEUNTEUNE E., HARMELIN-VIVIEN M., PERGENT G., PERGENT-MARTINI C., PASTOR J., POGGIALE J.-C., RENAUD F., THIBAUT T., RUITTON S. (2014) - An ecosystem-based approach to evaluate the status of a Mediterranean ecosystem, the *Posidonia oceanica* seagrass meadow. *PloS ONE*, 9(6): e98994.

RASTORGUEFF P.-A., HARMELIN-VIVIEN M., RICHARD P., CHEVALDONNÉ P. (2011) - Feeding strategies and resource partitioning mitigate the effects of oligotrophy for marine cave mysids. *Mar. Ecol. Prog. Ser.*, 440: 163-176.

TURNHOUT E., HISSCHEMOLLER M., EIJSACKERS H. (2007) - Ecological indicators: Between the two fires of science and policy. *Ecol. Indic.*, 7: 215-228.

****

POSTERS

****

Michela ANGIOLILLO, BAVESTRELLO G., BO M., CAU A., CAU A., GIUSTI M., SALVATI E., TUNESI L., CANESE S.
ISPRA, Via Brancati 60, 00144 Roma, ITALY
E-mail: michela.angiolillo@isprambiente.it

DISTRIBUTION OF THE DEEP-DWELLING GORGONIAN *VIMINELLA FLAGELLUM* IN THE ITALIAN WESTERN MEDITERRANEAN SEA BY MEANS OF MULTI-YEAR ROV SURVEYS

Abstract

The whip-like gorgonian Viminella flagellum (Alcyonacea, Ellisellidae) is an Atlantic-Mediterranean species living in temperate and subtropical waters. Past knowledge about species occurrence in the Mediterranean Sea was limited to the surrounding of Gibraltar Strait and the Balearic Sea. A multi-year ROV video surveys allowed updating the distribution of this species in the Italian waters and obtaining information about its occurrence, abundance and associated species. V. flagellum dwelled in rocky environments at 100-250 m depth, from the Ligurian Sea to the Sicily Channel. It may form very dense monospecific meadows or show a sparse distribution associated with highly diversified coral benthic assemblages, forming a so called "coral garden". The availability of appropriate technical devices allowed us to obtain more specific information about this species and its distribution. The high species richness of the assemblages hosting V. flagellum, together with their vulnerability to human activities, should motivate the adoption of conservation measure for these deep environments.

Key-words: ROV-imaging; Geographical distribution, Structuring species, Mediterranean deep corals.

Introduction

Viminella flagellum (Johnson, 1863) is an Atlantic-Mediterranean whip-like gorgonian, commonly characterized by unbranched colonies up to 3 m high (Carpine & Grasshoff, 1975). It dwells in temperate and subtropical waters on rocky substrata arising from detritic bottoms, associated to other gorgonians. It is generally distributed along the Eastern Atlantic coasts at 350-1000m depth, while in the Mediterranean Sea, it was recorded at 90-200m depth. Its distribution was considered limited to the western basin, to the immediate surroundings of the Gibraltar Strait and the Balearic Sea, with the exception of the western coast of Corsica. In 2010, *V. flagellum* was discovered also in the Sicily Channel (Italy) (Giusti *et al.*, 2012). This study aims to update the information about the geographical distribution of *V. flagellum*, with a description of its habitats and associated species, observed through multi-year ROV video survey explorations (2010-2013) along the Italian coasts.

Materials and methods

The data were collected during 12 ROV surveys, aimed to characterize the Mediterranean deep rocky coral assemblages, between 40 and 450 m depth. The cruises were carried out onboard the R/V *Astrea* (ISPRA) along the coast of six Italian regions, between 2010 and 2013. The ROV "Pollux III" hosted an underwater acoustic tracking position system, HD photo and video cameras, a 3 jaw grabber to take samples and three parallel laser beams to for image scaling. HD photo, acquired each 10 sec, were analyzed and *Viminella* colony density (colonies m^{-2}) and co-occurrence with other habitat-forming taxa was described. Moreover, signs of human impact were assessed.

Results

V. flagellum colonies resulted widely distributed along the Italian coasts, from the Ligurian Sea to the Sicily Channel (Fig. 1A). Specimens may form dense monospecific meadows with high densities (60 col m^{-2}; Fig. 1B) on the less inclined substrata in the upper part of the continental slope. Instead, along the vertical slope it was recorded with few specimens (Fig. 1C). *V. flagellum* was also recorded in highly diversified coral benthic assemblages mainly composed of arborescent gorgonians (*Paramuricea clavata*, *P. macrospina*, *Eunicella cavolinii*, *Corallium rubrum*, *Callogorgia verticillata*, *Swiftia pallida*, *Villogorgia bebrycoides*, Fig. 1D), the scleractinians *Dendrophyllia cornigera*, the alcyonacean *Alcyonium* sp., antipatharians (*Antipathella subpinnata*, *Antipathes dichotoma* and *Parantipathes larix*) and sponges (*Pachastrella monilifera* and *Poecillastra compressa*, Fig. 1C). The populations were made of both adult (> 1 m high) and small (20-30 cm high) colonies. Some specimens of the larger branched colonies can host epibionts. Colonies presented two phenotypes, yellow and white, randomly distributed. The human impact was mainly characterized by lost fishing lines.

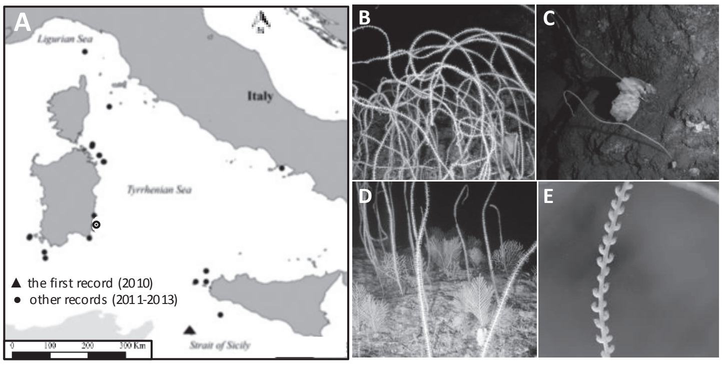


Fig. 1: A) Map of the geographical distribution of *V. flagellum* in the Italian Seas; B) *Viminella* meadow; C) *V. flagellum* and *P. compressa*; D) Coral garden; E) A *V. flagellum* sample.

Discussion and conclusions

The updated distribution of *V. flagellum* shows the wide occurrence of this species mainly along the western side of the Italian waters, where this gorgonian frequently forms dense meadows. These records highlight the importance of appropriate technical devices to obtain more precise description on natural populations of anthozoans and on their real distribution. Large benthic cnidarians can play an important ecological role since they create complex three-dimensional habitats, enhancing high diversity levels. Several Mediterranean deep coral assemblages are endangered by fishing activities, mainly if they host important target species for commercial fisheries. In the *Viminella* assemblages, very few lost lines were entangled on the specimens, probably due to the unbranched morphology of the colonies, which may reduce their catch-ability by nets and lines. However, the importance of this species in structuring habitats, should motivate the adoption of specific conservation measures, contributing to the creation of a future network of deep marine protected areas in the Mediterranean Sea.

Bibliography

CARPINE C., GRASSHOFF M. (1975) - Les gorgonaires de la Méditerranée. *Bull. Inst. Océanogr.*, 71: 1-140.

GIUSTI M., BO M., BAVESTRELLO G., ANGIOLILLO M., SALVATI E., CANESE S. (2012) - Record of *Viminella flagellum* (Alcyonacea, Ellisellidae) in Italian waters (Mediterranean Sea). *Mar. Biod. Rec.*, 5: e34.

Simonepietro CANESE, BAVA S.
ISPRA - Via V. Brancati, 60, Rome – Italy.
E-mail: simonepietro.canese@isprambiente.it

THE DECLINE OF TOP PREDATORS IN DEEP CORAL REEFS

Abstract
During seven years of ROV exploration of mesophotic and dark habitats conducted in more than 500 sites around Italy we have had the opportunity to observe the presence and the behaviour of deep groupers (Polyprion americanus, Epinephelus caninus and Hyporthodus haifensis) and sharks (Hexanchus griseus). Interviews conducted in the Ligurian Sea with fishermen give us the possibilities to estimate, on the basis of log books and pictures of significative catches, the relative historical abundance of these species. Since the end of 70's these large groupers and sharks were so abundant that a single fisherman could catch, with a long line armed of 70 hooks, more than 800 kg of fishes, comprise 20 large Polyprion and 3 Hexancus. In only10 fishing expeditions where captured of 125 large groupers weighed between 20 and 37 kg. After only two years of fishing activities, the groupers disappeared from seamounts and the mainly target was constituted only by large Blackspot seabream (Pagellus bogaraveo). Nowadays the professional fishing activity abandoned these targets due to a collapse of resource, but recreational activities that can utilize expensive and sophisticated equipment continue to target these species probably causing the drop of population at unrecoverable levels.

Key-words: Giant groupers, sharks, deep habitat, rov, fishing impact.

Introduction
In the last few years mesophotic and dark habitats are gaining more attention due to several studies conducted by means of remotely operated vehicles (ROV); these research highlighted the presence of true coral forests composed mainly by gorgonian and black corals (Bo *et al*., in press; Bo *et al*., 2012). These environments host numerous large predators like sharks (*Hexanchus griseus*), and giants groupers (*Polyprion americanus*, *Epinephelus caninus* and *Hyporthodus haifensis*), species that represents some of the less studied large vertebrates in the Mediterranean Sea. The presence of these animals assessed by ROV seems to be very rare in comparison with the few information recorded by fishermen that fished these species up to the middle of '70. All these species are characterized by long life span, late sexual maturity, furthermore giant groupers are known to form sexual aggregation in determinate areas, make these species very vulnerable by fishing activities. Nowadays this species are no more profitable for professional fishing, but they are still appealing for recreational fishing that, using sophisticated and expansive equipments, considers them as an attractive fishing trophy, probably causing the drop of population at unrecoverable levels.

Materials and methods
The presence of groupers and sharks was annotated during 560 transects conducted by ROV in the period 2008 - 2014, in the bathymetric range between 50 and 500 meters. In total ROV transects account for more than 800 hours of observation and 400 linear kilometres travelled on rocky habitats. Historic fishing data were collected from three fishermen in the Liguria sea that in the 70's fished groupers. From interviews, log books, photographs and short movies, we assessed species identity and quantity.

Results

We record a total of 25 *E. caninus*, 3 *P. americanus*, 5 *H. Haifensis* and 6 *H. griseus*; three encounters of *E. caninus* and one of *H. haifensis*,. *E. caninus* was always observed on top of seamounts or around shipwreck at depth between 100 and 150 meters where were present gorgonians gardens of *Paramuricea clavata* and *Eunicella Cavolinii* or forests of black coral *Antipathella subpinnata, Antipathes dicotoma and Parantipathes larix*. The few sighting of *H.haifensis* occurred in deeper environment between 150 and 250 meters, in habitats characterized by presence of black coral (*Leiopathes glaberrima*). *P. americanus* was always observed near white corals banks (*Madrepora oculata* and *Lophelia pertusa*). *H. griseus* were observed along large depth range from 50 to 500 meters. Historic data suggests that in the middle of 70's these species were very abundant in fact using a long line with only 70 hooks, a fisherman was able to capture 20 *P. americanus* and 3 *H. griseus*, which weight was 450 kg and 350 kg respectively. In two following seasons the fishermen make 10 fishing trip to seamounts, capturing 125 large groupers of weight between 20 and 37 kg. After these two years of fishing activities, the groupers disappeared and the main target remain only large Blackspot seabream (*Pagellus bogaraveo*).

Discussion and conclusions

Deep groupers and sharks are very vulnerable species with a long longevity, late sexual maturation, delimited home range and aggregation spawning, furthermore deep waters species are also still poorly studied. As happened in others country, (McClenachan, 2009) these species has been severely overfished, but in the Mediterranean Sea, differently from what happened in the USA, no active conservation measure was planned to preserve these population except for the banning adopted in France. Nowadays this populations appear very scarce if confronted with historic data. Professional activities have abandoned these fishing targets, but seamounts are still frequented by recreational fishermen, that loose on the seafloor large quantities of fishing line (Bo *et al*., 2014). We stress the scientific and stakeholders community to adopt a precautionary approach to preserve these species, limiting the fishing pressure and establishing offshore marine protected areas also for the conservation of these species.

Acknowledgments

Rov data were collected in the framework of 32 oceanographic campaign, conducted by R/V ASTREA with the participation of several research Institute: University of Genova, University of Pisa, University of Napoli Parthenope, University of Bologna, CNR Ismar Bologna, University Politecnica delle Marche, Ancona; University of Cagliari; University of Messina; University of Malta.

Bibliography

AZZURRO E., ANDALORO F., MARINO G. (2000) - Presenza della cernia di Haïfa, *Epinephelus haifensis* (Serranidae: Epinephelinae), nel Mediterraneo Centrale. *Biol. Mar. Medit*. 7: 786-789.

BO M., BAVESTRELLO G., ANGIOLILLO M., CALCAGNILE L., CANESE S., CANNAS R., CAU AL., D'ELIA M., D'ORIANO F., FOLLESA M.C., QUARTA G., CAU A. Persistence of pristine deep coral forests in the Mediterranean Sea (SW Sardinia). *Plos-One*, in press.

BO M., BAVA S., CANESE S., ANGIOLILLO M., CATTANEO-VIETTI R., BAVESTRELLO G. (2014) - Fishing impact on deep Mediterranean rocky habitats as revealed by ROV investigation. *Biol. Conserv.*, 171: 167-176.

BO M., CANESE S., SPAGGIARI C., PUSCEDDU A., BERTOLINO M., ANGIOLILLO M., GIUSTI M., E. SALVATI, GRECO S., BAVESTRELLO G. (2012).- Deep coral oases in the South Tyrrhenian Sea. *Plos-One* 7(11): e49870. doi:10.1371/journal.pone.0049870.

MCCLENACHAN L. (2009) - Historical declines of goliath grouper (*Epinephelus itajara*) populations of South Florida, USA. *Endangered Species Res*. 7:175–181. doi:10.3354/esr00167

Vasilis GEROVASILEIOU, KOUTSOUBAS D., VOULTSIADOU E.
Department of Zoology, School of Biology, Aristotle University of Thessaloniki
E-mail: vgerovas@bio.auth.gr

SPATIAL HETEROGENEITY OF BENTHIC COMMUNITIES IN A MARINE CAVE OFF LESVOS ISLAND (AEGEAN SEA)

Abstract
Spatial heterogeneity of benthic communities was surveyed in a marine cave off Lesvos Island (Aegean Sea, Eastern Mediterranean). Quadrats were photographed along 3 transects: one along the cave ceiling and two along the opposing vertical walls. Analyses revealed a rich fauna of 64 taxa belonging to 9 taxonomic groups. Sponges were the dominant group in terms of species richness, followed by bryozoans and cnidarians. Species richness and biotic coverage decreased towards the interior. Three distinct assemblages were identified: the coralligenous entrance where encrusting rhodophytes, sponges, and anthozoans prevailed, the middle semi-dark zone dominated by sponges, and the dark interior dominated by serpulids. Topographic features of the cave had a significant effect on the structuring of the community, highlighting the role of cave topography in the observed patterns.

Key-words: Marine caves, sessile benthos, spatial heterogeneity, zonation, Aegean Sea

Introduction

Scientific interest on sciaphilic hard substrate communities has increased over the last years due to their rich diversity and conservation value. However, marine caves remain poorly explored and available data on the diversity and structure of their communities mainly concern shallow caves from the north-western Mediterranean. Marine caves are characterized by profound environmental gradients, reflecting individual topographic features (Riedl, 1966). Nevertheless, few studies have surveyed quantitatively marine cave communities (e.g. Martí *et al*., 2004) while the role of topography in their spatial distribution has not been thoroughly examined. The aim of the study was to investigate spatial heterogeneity of benthos in a marine cave of the Eastern Mediterranean.

Materials and methods

Agios Vasilios cave is located at a depth of 23-40 m off Lesvos Island (Aegean Sea). Benthic communities were surveyed with 25 x 25 cm photoquadrats along 3 distinct transects: one along the ceiling and two along the opposing vertical walls of the cave (3 replicates at 5 m intervals). Biotic cover percentage was calculated with photoQuad. Statistical analysis was undertaken with Primer v6. A two-way PERMANOVA was performed on fourth root transformed coverage data, based on Bray-Curtis similarity index, for two factors (Distance from entrance, fixed with 5 levels – 0, 5, 10, 15, 20 m; and Position, fixed with 3 levels – cave ceiling, left wall, and right wall).

Results

Photoquadrat analysis revealed 64 taxa belonging to 9 taxonomic groups. Sponges were the dominant group in terms of species richness (36 species), followed by bryozoans (8) and cnidarians (7). Species richness decreased towards the interior, while cave walls presented lower species richness than the ceiling. Biotic coverage also decreased from 100% in the entrance to 10% in the interior. Multivariate resemblance analysis of community structure revealed 3 groups of stations (Fig. 1), representing the following assemblages: i) the coralligenous entrance dominated by encrusting red algae, sponges (e.g. *Spirastrella cunctatrix*) and scleractinians (*Madracis pharensis* and *Hoplangia durotrix*); ii) the middle semi-dark zone where sponges prevailed (e.g. *Dendroxea lenis*, *Plakina bowerbankii*, *Timea unistellata*); iii) the dark interior dominated by Serpulidae. Samples from the intermediate ceiling station were grouped with the dark zone due to the locally dimmer conditions related to micro-topography. PERMANOVA results showed that Distance and Position as well as their interaction had a significant effect on the community structure (P < 0.01 in all cases).

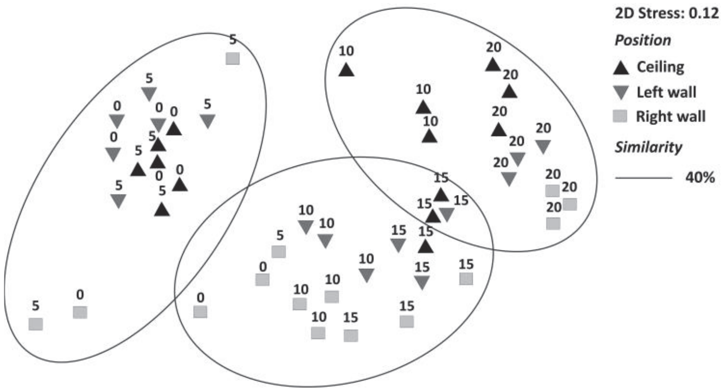


Fig. 1: Resemblance of cave assemblages demonstrated in MDS plot. Numbers indicate distance from cave entrance.

Discussion and conclusions

Patterns of diversity and biotic coverage for the surveyed cave were in accordance with those described from the western Mediterranean (Martí *et al*., 2004). However, this study extends the limited quantitative knowledge regarding the community structure of Mediterranean marine caves to the lower infralittotal zone. Our results corroborate the hypothesis that cave topography (and related environmental gradients; see Gerovasileiou *et al*., 2013 and references therein) can largely affect community structure. Further ecological research in marine caves from different areas, with distinct topographic features, is expected to increase our understanding of these ecosystems.

Acknowledgments

The authors would like to thank M. Sini for her help during fieldwork and Ch. Dimitriadis for assistance in statistical analysis. This research has been co-financed by the EU and Greek national funds through the Research Funding Program: Heracleitus II, Investing in knowledge society. VG also benefited from "Alexander S. Onassis Public Benefit Foundation" fellowship.

Bibliography

GEROVASILEIOU V., TRYGONIS V., SINI M., KOUTSOUBAS D., VOULTSIADOU E. (2013) - Three-dimensional mapping of marine caves using a handheld echosounder. *Mar Ecol-Prog Ser*, 486: 13-22.

MARTÍ R., URIZ M.J., BALLESTEROS E., TURÓN X. (2004) - Benthic assemblages in two Mediterranean caves: species diversity and coverage as a function of abiotic parameters and geographic distance. *J. Mar. Biol. Ass. U.K.*, 84: 557-572.

RIEDL R. (1966) - *Biologie der Meereshöhlen*. Paul Parey, Hamburg: 636 pp.

Adrien GOUJARD, FOURT M.
GIS Posidonie, OSU Pythéas, Aix Marseille Université, Campus de Luminy, TPR1, case 901, 13288, Marseille, France.
E-mail: adrien.goujard@univ-amu.fr

THE INFORMATION SYSTEM ZOODEX, A TOOL FOR THE TREATMENT OF IMAGE DATA

Abstract
The exploration of dark deepwater zones has until recently been mainly undertaken on the basis of blind sample collection (grabs, dredges, trawls, etc.). Since the sixties, direct observation by diving saucer or submarine has been developed in the Mediterranean. Currently, relatively inaccessible deepwater zones down to 1 000 m depth are increasingly being explored by Remotely Operated Vehicles (ROV) or submarines and the recording of images of the explored sea bottom has become widespread. But processing the data and correlating them is often complex and takes up a great deal of storage space. During the MedSeaCan and CorSeaCan campaigns, carried out by the "Agence des aires marines protégées", the information system ZOODEX (ZOOlogical Data Exploitation system) was developed for the purpose of optimising biological analysis on images in a systematic and homogeneous way, banking all the data, facilitating their interconnection, consulting and retrieving the information.

Key-words: database, data storage, imagery, submarine canyons, Mediterranean Sea.

Introduction
The exploration campaigns MedSeaCan and CorSeaCan (2008-2012), carried out by the "Agence des aires marines protégées" (French MPA Agency), generated a large amount of heterogeneous and complementary data: low and high definition videos, low and high definition photographs, observation records, samples, GIS (Geographic Information System) layers, geophysical data. The aim of the data processing is to enable biological and ecological analysis and to provide the means to extract from them the selected data. To achieve that, the ZOODEX information system (Fourt & Goujard, 2013) was developed by GIS Posidonie.

Materials and methods
The ZOODEX system was originally designed to process the underwater images from the MedSeaCan and CorSeaCan campaigns. At the core of the system, an Access data base (Microsoft Office 2010) was designed for the purpose of integrating, processing, consulting and extracting information. The system is coupled with a GIS to allow the geolocalisation of the observations (Fourt & Goujard, 2012). The exploration campaigns involved 287 dives, or 550 hours of LD video footage, 18 hours of HD video footage, 21 900 photos and 18 850 events observed in real time. During the derushing of the footage, unique events containing various variables are created chronologically. These variables concern the identification of a species, the number of individuals, the nature of the substrate, the presence of a particular facies, qualification of the bioturbation, of the biodiversity, the presence of waste, of plankton, of euphausiaceans, the collection of a sample, comments, traces left by trawling, etc., and also the time, depth and GPS position of the event. By means of the interconnection of the data, each event is linked to a dive, a video sequence and one or several photographs (where available), which offers the possibility of illustrating the events. A data input form has been specially designed to make the derushing process more user-friendly (Fig. 1).

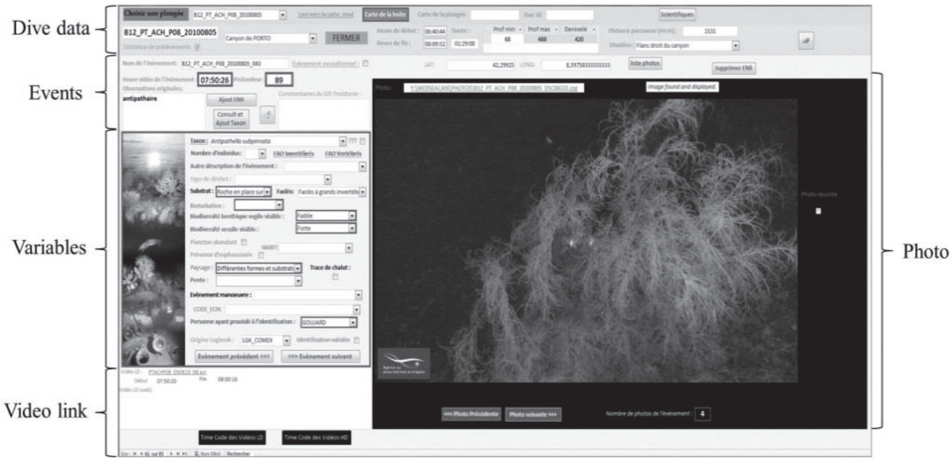


Fig. 1 : ZOODEX tool: input form for the treatment of image data (Fourt & Goujard, 2013).

Results

At the end of processing, 26 500 events had been created. From the database, unique events were catalogued in a logbook, that is a chronological listing of all the events of a dive. Each event is characterised by its variables and its GPS position, which provides a basis for mapping them along the dive route. In addition, on the basis of species identification, performed with the support of specialists and the samples collected, an image database of deepwater species was developed. Finally, several inputs are possible at several scales for extraction or consultation of the data: by taxon, by geographical localisation (dive, canyon), by depth, etc.

Discussion and conclusions

The ZOODEX information system is designed for the systematic and homogeneous processing of image data, in particular along a dive route, the banking of the full set of data, the consultation and retrieval of the information. In addition, it is a tool that facilitates the reference state and the monitoring of a site, enabling temporal and spatial comparisons. Finally, the architecture of the database is modulable according to the specific requirements of the study and may be adapted for different explorations and biological monitoring operations.

Acknowledgments

We thank the “Agence des aires marines protégées” for financing the data processing of the MedSeaCan and CorSeaCan campaigns and for enabling us to develop the ZOODEX system. We are also grateful for the work of the following specialists for the identification of species: P. Chevaldonnée, T. Perez, J. Vacelet, H. Zibrowius, S. Sartoretto, S. von Boletzky, C. Froglia, H. Galea, S. Iglesias, T. Molotsova, and for the expert assessment of the substrates: J. Mascle.

Bibliography

FOURT M., GOUJARD A. (2013). Système d’information ZOODEX. ZOOlogical Data Exploitation system. Partenariat Agence des aires marines protégées – GIS Posidonie, en collaboration avec l’équipe scientifique.

FOURT M., GOUJARD A. (2012) - Rapport final de la campagne MEDSEACAN (Têtes des canyons méditerranéens continentaux) novembre 2008 – avril 2010. Partenariat Agence des aires marines protégées – GIS Posidonie. GIS Posidonie publ. 218 p + annexes.

Vesna MAČIĆ, PANOU A., BUNDONE L., VARDA D.
Institute for Marine Biology, Dobrota b.b. 85330 Kotor, Montenegro
E-Mail: vmacic@ibmk.org

CONTRIBUTION TO THE KNOWLEDGE OF RARE AND ENDANGERED HABITATS - MARINE CAVES (MONTENEGRO, SOUTH EAST ADRIATIC COAST)

Abstract
Marine caves are considered as a biodiversity hotspot and they are listed in Annex I of the EU Habitats Directive as an important and endangered habitat. The Montenegrin coast (about 300km in the South-East Adriatic Sea) mainly consists of a variety of rocks, among them vast karst areas. Although the karstic nature of the wider area is well known, marine caves along the country's coastline have never been studied systematically.
In September 2013, we systematically surveyed the marine caves with an entrance above sea level in the northern part of Montenegro (cape Arza to cape Platamuni, ca. 40km). We registered a total of 20 marine caves. Only few had a relatively deep submerged area (up to 30m depth) while most of them were a few meters deep. Some of them had a small pebble or sandy beach and in some of them cave rock formations were found. Here, two characteristic caves are presented in detail. Besides marine caves we registered 24 holes which were less than 5m long but still important for some rare and endangered species. During the survey, 7 marine protected species were registered and also 2 species of protected terrestrial plants, 5 species of protected birds and 1 mammal (bat). A part of the surveyed area belongs to the future MPA Platamuni, planned to be established by the responsible Montenegrin authorities. Our results will contribute to the better protection and management of endangered marine and coastal species and habitats. Furthermore, they will substantially contribute to the creation of the urgently needed Marine Caves' Register in Montenegro.

Key-words: marine caves, conservation, protected habitat, Adriatic Sea, Montenegro

Introduction
Marine caves are an important and endangered habitat listed in Annex I of the EU Habitat Directive (1992). They are also protected by the Montenegrin law on nature protection (Sl. list, 2013). Over two-thirds of the territory of Montenegro belongs to the karst formation of the south-eastern Dinarides with various and specific rocky forms. Data on marine caves in Montenegro are very scarce and, at present, there is no Marine Caves' Register (although it is planned by law). For all above reasons we surveyed the marine caves in the area from cape Arza, peninsula of Luštica, to cape Platamuni, peninsula of Donji Grbalj (ca. 40 km) in order to (a) contribute to the knowledge of this important, but poorly studied habitat, (b) to create the basis for the urgently needed Cave Register and (c) to ensure a better management of this rare, endangered and protected habitat.

Materials and methods
The survey was performed from cape Arza down to cape Platamuni (ca. 40km), in September 2013. For all registered caves/holes longer than 5m the following basic data were noted: location name, geographic coordinates, dimensions (in meters), exposition, morphological characteristics, date of survey, and typical living organisms in the cave

and in front of it. During the postprocessing of the collected data all locations were mapped by Quantum GIS software (2013).

Results

In the surveyed area we registered 20 marine caves one of which had an underwater entrance. Only few marine caves had a relatively deep submerged area (up to 30m depth below the sea level (b.s.l.)), while most of them were only a few meters deep. In some caves there was a small pebble or sandy beach and in others cave rock formations were found.
The best known cave, frequently visited by the broad public, is Plava špilja (Blue Cave). This cave is 60m long and 46 m wide, with two entrances, one exposed to the south-west (4m x 2m) and the other to the south-east (9m x 6m). Both entrances are partially submerged. Inside the cave there is one single chamber (few m b.s.l. and 25m high above the sea level (a.s.l.)). Inflow of fresh water is evident. On the vertical walls close to the entrances many sessile organisms were registered, especially in the western part of the cave. The most abundant were various species of sponges.
The biggest cave in the area of the future MPA Platamuni is Krekavica cave. The entrance in this cave is exposed to the south, very large and a.s.l. it is 15m large and 8m high. Above the entrance and on both sides of the cave there is a very high vertical cliff. The submerged part of the entrance is also very large and up to 30m deep. The vertical walls in this cave are overgrown by an immense quantity and diversity of organisms: it is probably the richest cave in the Montenegrin part of the Adriatic Sea.
Besides the marine caves we also registered 24 holes less than 5m long, but still important as potential habitat for the highly endangered monk seal or for some other rare and endangered species. In the surveyed area, the following 7 marine protected species (Sl. list 2006) were registered inside or around the caves: *Lithophyllum byssoides*, *Cystoseira amentacea*, *Posidonia oceanica*, *Cymodocea nodosa*, *Pinna nobilis*, *Cladocora caespitosa* and *Lithophaga lithophaga.* Additionnally, 2 species of protected terrestrial plants were noted, namely *Euphorbia dendroides* and *Limonium angustifolium*, 5 species of protected birds, namely *Ardeola ralloides*, *Alcedo athis*, *Phalacrocorax aristotelis*, *Acciptier gentilis* and *Corvus corax*, and one protected bat species (*Miniopterus schreibersii*).

Conclusions

Our data on marine caves in Montenegro will be used for the urgently needed creation of a Caves' Register and will substantially contribute to implement more efficient protection measures of this endangered habitat and the marine environment in general.

Acknowledgements

The authors wish to thank Jugopetrol AD Kotor, Montenegro, who financed this project and Ms Emanuela Rossi for determination of bat species.

Bibliography

EU HABITAT DIRECTIVE (92/43/EEC) - Available at: Council Directive on the conservation of natural habitats and of wild fauna and flora. Available at: http://www. central2013.eu/ fileadmin/user_upload/Downloads/Document_Centre/OP_Resources/HABITAT_DIRECTIVE_ 92-43-EEC.pdf

SLUŽBENI LIST BR.76/06 (2006) - Riješenje o stavljanju pod zaštitu pojedinih biljnih i životinjskih vrsta. Sl. list RCG br. 76/06, od 12. decembra 2006. godine

SLUŽBENI LIST BR. 62/13 (2013) - Zakon o zaštiti prirode. Sl. list RCG od 31.12.2013. g.

Chryssi MYTILINEOU, SMITH C.J., PAPADOPOULOU K.N., CHONDROMATIDOU V.
Hellenic Centre for Marine Research, Institute of Marine Biological Resources and Inland Waters, 46.7 km Athens-Sounio, P.O. BOX 712, 19013, Anavissos, Attica, Greece
E-mail: chryssi@hcmr.gr

THE IMPACT OF ANTHROPOGENIC ACTIVITIES ON COLD WATER CORALS IN THE EASTERN IONIAN SEA FROM ROV OBSERVATIONS

Abstract
Information related to cold water corals (CWC) abundance, bathymetry and health were collected using observations from ROV video transects. Sampling was carried out off the coasts of Cephalonia Island in the E. Ionian Sea at depths ranging between 300 and 850 m in June and October 2010. Eight species of corals, Antipathes dichotoma, Leiopathes glaberrima, Parantipathes larix, Isidella elongata, Swiftia pallida, Desmophyllum dianthus, Funiculina quadrangularis and Pennatula phosphorea were reported. The depth distribution of CWC ranged between 300 and 810 m depth. Most of the corals were live. However, in many cases, I. elongata and L. glaberrima were impacted most probably from fishing activities. Most of the corals were found off the south-western Cephalonian coast, which implies the presence of a moderate concentration CWC area, the only such known area in the Eastern Ionian deep waters. It should therefore be given a high level of protection.

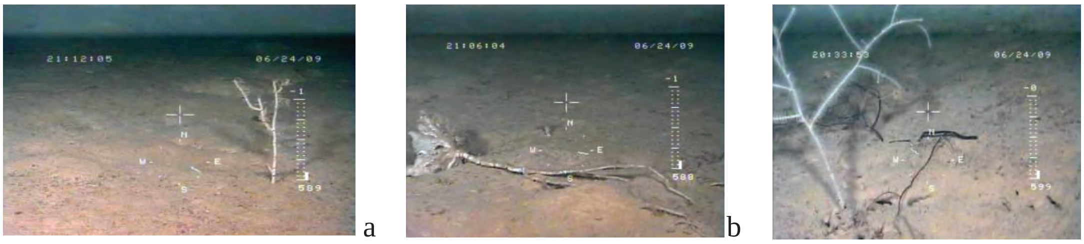
Key-words: deep corals, impact, *Leiopathes glaberrima, Isidella elongata*, Mediterranean

Introduction
Cold water corals (CWC) are now recognized as important bodies of deep water ecosystems (Freiwald and Roberts, 2005), because they provide habitat allowing opportunities for food, shelter, spawning and reproduction for different species. The effects of fishing (mainly trawlers) on CWC have been recorded as a major threat to them (Roberts, 2002; Watling, 2005). Their slow growth rate results in recovery times from tens to hundreds of years; this characterizes them as vulnerable to anthropogenic activities organisms. Few studies on CWC in Greek waters have been realized (Vafidis *et al.*, 2006; Smith *et al*., 2009; Mytilineou *et al*., 2014) to date. The present work examined the presence and distribution of CWC, the depth in which they live and their condition in the Ionian Sea in order to contribute to their protection.

Material and methods
The material came from ROV video transects carried out in the frame work of CoralFISH project off the coasts of Cephalonia Island in the E. Ionian Sea at depths ranging between 300 and 850 m in June and October 2010. A total of 8 ROV dives were made with approximately 25 hours of video recordings. Corals were identified to the lowest possible taxonomic level and their size and health condition, the depth and substrate of their presence, and the presence of litter were reported.

Results
Eight species of corals (722 specimens) were identified; *Antipathes dichotoma* (9), *Leiopathes glaberrima* (15), *Parantipathes larix* (1), *Isidella elongata* (20), *Swiftia pallida* (157), other Plexauridae (8), *Desmophyllum dianthus* (41), other Scleractinia (50),

Funiculina quadrangularis (396) and *Pennatula phosphorea and Pennatula sp.* (25). Most of the corals were found off the south-western Cephalonian coast. *I. elongata*, *Funiculina quadrangularis* and *Pennatula sp.* occurred at depths deeper than 700 m, whereas the other species did not exceed this limit. More than 50% of *I. elongata* and *L. glaberrima* were dead or severely damaged (Fig.1), whereas only 4% of *Pennatula sp*. and less than 1% of *F. quadrangularis* were affected. From them 30% were close or related to anthropogenic litter (fishing gears, ceramics, ropes etc) (Fig.2).



a b c

Fig. 1: Damaged *I. elongata* (a, b) and *L. glaberrima* rubbles close to alive A. dichotoma (c)

a b

Fig. 2: Ghost long lines (a) and nets (b) entangled on corals and rocks

Discussion

Given the lack of basic information on CWC in Greek waters and the difficulties of investigation and sampling related to the ecosystems of deep waters, the use of ROV offered knowledge about the presence and health condition of CWC in the E. Ionian. *I. elongata* and *L. glaberrima* seem to be more vulnerable to anthropogenic impact than other coral species. The presence of a moderate density CWC area, the only known in the E. Ionian Sea, implies the necessity for more research and protection.

Bibliography

FREIWALD A., ROBERTS M. (2005) - Cold-water corals and Ecosystems. *Springer-Verlag*, Berlin Heidelberg.

MYTILINEOU CH., SMITH C.J., ANASTASOPOULOU A., PAPADOPOULOU K., CHRISTIDIS G., BEKAS P., KAVADAS S., DOKOS J. (2014) - New cold-water coral occurrences in the eastern Ionian sea: results from experimental long line fishing. *Deep Sea Research II* 99: 146-157.

ROBERTS M.C. (2002) - Deep impact: the rising toll of fishing in the deep sea. *Trends Ecol. Evol.* 17 (5): 242-245.

SMITH C., SAKELLARIOU D., MCCOY F., WACHSMANN S. (2009) - Deep coral environments south of Crete. *Proc. 9th Symp. Oceanogr. & Fish*., Vol. I: 665-668.

VAFIDIS D., MYTILINEOU CH., MASTROTOTARO F., D'ONGHIA G. (2006) - First records of *Leiopathes glaberrima* (Esper, 1792) and *Isidella elongata* (Esper, 1788) (Cnidaria:Anthozoa) in the Ionian Sea. *Proc 10th ICZEGAR*, Patra, Greece: 220.

WATLING L. (2005). The global destruction of bottom habitats by mobile fishing gear. *In:* Crowder, L. & Norse, E.A (eds). *Marine Conservation biology,* Island Press.

Antonietta ROSSO, DI MARTINO E., SANFILIPPO R., FRASCHETTI S.
Dept of Biological, Geological and Environmental Science, University of Catania – Corso Italia 57, 95129, Catania, Italy.
E-mail: rosso@unict.it

BRYOZOANS FROM SHALLOW-WATER SUBMARINE CAVES OF ITALIAN MARINE PROTECTED AREAS

Abstract
Bryozoans from 42 samples collected from 10 shallow-water submarine caves in 3 Italian Marine Protected Areas in Sicily (Plemmirio: PL; Pelagian Islands: PEL) and Sardinia (Capo Caccia: CC) have been investigated. A total of 113 species was identified, including 90 Cheilostomes, 22 Cyclostomes and 1 Ctenostome. Only 25, usually infrequent species, are shared by all the areas but not by all the caves. Other species, relatively frequent and abundant, are restricted to all the caves in a single area. In contrast, most species, often with a few or single colonies, are restricted to single areas/caves, and even to single sites. Main compositional affinities have been observed for the PL-CC and PL-PEL couples of areas. Conversely, PEL and CC areas show the lowest affinity. Results seem related to setting and features of caves, and possibly also to their geographical location in relation to the areal distribution of species.

Key-words: Bryozoans, Submarine caves, Species distribution, Recent, Mediterranean.

Introduction
Bryozoans from Mediterranean submarine caves have been investigated mostly from the western basin (Harmelin, 2000; Rosso et al., 2012; 2013). Communities include a few typical cave-dwellers and numerous sciaphilic species with different ecological requirements (Harmelin, 1969; Rosso et al., 2013). Species composition differs between caves. Cave features, depth, morphology, hydrodynamic energy (and related oxygen/food/larval supply), confinement, attenuation in light, and colonisation history shape communities (Harmelin, 1969; 1997; 2000; Rosso et al., 2012). This paper gives first insights on bryozoan communities from 10 submarine caves with different features, located in the central Mediterranean.

Materials and Methods
Materials come from 10 submarine caves located in 3 Italian Marine Protected Areas (MPAs). The 3 caves from the Plemmirio MPA (PL, SE Sicily, Ionian Sea) are 35-65m long and have relatively small openings at 20m depth, and blind ends. Further 3 caves are located in the Capo Caccia MPA area (CC, NW Sardinia, Provencal-Balearic Sea). They are 30-195m long, have single or double openings at 3-12m depth, and subaerial end chambers. Further 4 caves were sampled at Lampedusa, Pelagian Islands MPA (PEL, Sicily Strait). All of these cavities are tunnels (11 to 30m long), with deeper (from 12 to 20m) and shallower (from 5 to 12m) openings. A total of 63 samples was collected (PL: 32; PEL: 17; CC: 16). Most samples (49) derive from wall and ceiling hard surfaces, whereas 14 come from soft sediments locally present on the floor.

Results
A total of 113 species was identified. Cheilostomes prevail with 90 species (29 anascans and 61 ascophorans) whereas Cyclostomes (22 species) and Ctenostomes (1species) are

subordinate. The PL AMP shows the most diversified communities (72 species; 35-50 species per cave), followed by the CC AMP (66 species; 29-50 species per cave) and the PEL AMP (53 species; 19-36 species per cave). Only 25 species are shared by all the areas; most of them are infrequent, or frequent in only one of the three areas and only some are locally abundant. Further 29 species are shared by two of the three areas, with 13 species shared by the PEL-PL and by the CC-PL MPAs, and only 3 species shared by the CC-PEL MPAs. Several species are restricted to single areas where they are shared by all sampled caves, are relatively frequent and abundant, and often show high coverages. Nevertheless, most species, often represented by 1 or a few colonies are restricted to single caves and even to single sites within a cave. The highest number of species localised in a single area, pertains to the CC AMP (25 species), followed by the PL AMP (22 species) and the PEL AMP (12 species). But more than half of them (31species) had single occurrences, and further 6 species were found only twice.

Discussion and conclusions

Size and number of investigated samples was enough to assess the biodiversity of single cave communities (Rosso et al., 2012) and results allow to state that the composition of bryozoan communities is different between the investigated caves, as expected. The communities of the CC MPA caves (with over than 25% of the species shared by all caves and only 33% present in a single cave) show the greatest homogeneity. In contrast, bryozoan communities from the PL and PEL MPAs differ more markedly, because 48% and 40% of their species are present in single caves, respectively. The main affinities between areas can be observed for the PL-CC and PL-PEL couples of MPAs. These affinities are mainly related to the sharing of sciaphylic (PL-CC MPAs) and generalist species, including photophilic taxa typical of the relatively lit PEL communities and of cave entrances in the PL area (PL-PEL MPAs). Conversely, PEL and CC areas show the lowest affinity. These results seem to be related to cave's setting and features (blind caves/tunnels, depth/dimensions of entrances, light) and possibly to their geographical location and the areal distribution of some species.

Acknowledgemts

Paper in the frame of the CoNISMa 3 AMP project, partly supported also by Catania University FIR grants. Catania Palaeontological Group, paper contribution n. 396.

Bibliography

HARMELIN J.-G. (1969) - Bryozoaires des grottes sous-marines obscures de la région Marseillaise: faunistique et écologie. *Téthys*, 1(3): 793-806.

HARMELIN J.-G. (1997) - Diversity of bryozoans in a Mediterranean sublittoral cave with bathyal-like conditions: role of dispersal processes and local factors. *Mar. Ecol. Prog. Ser.*, 153: 139-152.

HARMELIN J.-G. (2000) - Ecology of cave and cavity dwelling bryozoans. In: Herrera Cubilla A., Jackson J.B.C. (eds), *Proc. 11th IBA Conf. 1998, Smithsonian Res. Inst. Panama*: 38-55.

ROSSO A., DI MARTINO E., SANFILIPPO R., DI MARTINO V. (2012) - Bryozoan Communities and Thanatocoenoses from Submarine Caves in the Plemmirio Marine Protected Area (SE Sicily). In: Ernst A., Schäfer P., Scholz J. (eds), Bryozoan Studies 2010. *Proc. 15th IBA Conf. 2010,*Springer, Berlin, Heidelberg, 143: 251-269.

ROSSO A., SANFILIPPO R., TADDEI RUGGIERO E., DI MARTINO E. (2013) - Serpuloidean, bryozoan and brachiopod faunas from submarine caves in Sicily. *Boll. Soc. Paleont. It.*, 52(3): 167-176.

Antonietta ROSSO, SANFILIPPO R., MASTROTOTARO F.
Dept of Biological, Geological and Environmental Science, University of Catania – Corso Italia 57, 95129, Catania, Italy.
E-mail: rosso@unict.it

BRYOZOAN AND SERPULID DISTRIBUTION PATTERN ON A DEEP-WATER SLAB (BARI CANYON, ADRIATIC SEA)

Abstract
The distribution of bryozoans and serpulids colonising a large carbonate slab from the Bari Canyon (280 m) has been investigated. The two relatively platy opposite larger faces of the slab are remarkably different: one is mud-covered, whereas the other one is mud-free, and colonised by encrusting organisms. Bryozoans and serpulids are present on both surfaces with a comparable number of species but the number of specimens is relatively higher on the mud-free surface than on the opposite one. Interestingly, a few species are selectively present on one face only and, even species shared by both surfaces, show a polarity for their abundance. In particular, flexible erect bryozoans are restricted to the mud-covered surface. Sediment smothering is suggested as the main cause for this polarity.

Key-words: Encrusters, Polarity, Deep-sea, Recent, Mediterranean.

Introduction
Bryozoans and serpulids from deep sectors of the Mediterranean are still poorly known. Most information deals with communities associated to cold water corals (Mastrototaro et al., 2010). Data become scantier for the Adriatic and for communities directly colonising rocky substrata and hardgrounds, whose knowledge is restricted to information reported in Toscano and Raspini (2005) and Rosso et al. (2010). In this context, the present study gives first insights on species composition and distribution pattern of the epilithobiont community living on a hard slab from the Bari Canyon.

Materials and methods
The studied slab, about 25x30x7 cm wide, comes from the Bari Canyon, from where it was sampled through a Van Veen grab, at station 1B1, from a site at 280 m depth, at the coordinates 41°17.4859 N and 17°09.2288 E, during the MINERVA UNO cruise, in 2012. The area is characterized by steep slopes with exposed hard surfaces, blocks and hardground slabs, locally masked by thin-to-thick sediment covers (Sanfilippo et al., 2013). In order to identify bryozoan colonies and serpulid specimens and to assess their distribution, the slab was analysed under a stereomicroscope. Selected bryozoan fragments were picked and observed uncoated through a Low Vacuum SEM.

Results
The slab shows a differentiation of the two relatively platy opposite larger faces: one side is visibly covered with mud whereas the other one is mud-free and shows wide surfaces coloured owing to the obvious presence of alive organisms. A total of 11 bryozoan species (9 genera and 10 families) have been recognized, as well as 6 serpulid species belonging to 5 genera. These taxonomic groups are present on both larger faces with a relatively similar number of species on the mud-free surface (9 bryozoans in 7 genera and 6 families, and 4 serpulids belonging to 4 genera) on the mud-free surface, and on the

mud-coated surface (8 bryozoans in 8 genera and 7 families, and 4 serpulids in 4 genera). Nevertheless, the number of specimens is higher on the mud-free surface (31 bryozoan colonies and 81 serpulid tubes) and lowers significantly on the mud-coated surface (20 bryozoans and 16 serpulids) for both groups but mostly for the latter. Further differences relate to community composition. Besides bryozoans and serpulids, the community of the mud-free surface is more diversified including sponges, cnidarians, the brachiopod *Novocrania anomala* and the foraminifer *Cornuspiramia adherens*, whereas the mud-covered surface hosts rare terebellids and *C. adherens* nets. Both surfaces share the serpulid *Filogranula gracilis* and the bryozoans *Escharina vulgaris*, *Puellina (Glabrilaria) pedunculata* and *Gregarinidra gregaria*. Except for E. *vulgaris* and *Herentia hyndmanni*, most species show different abundances on the two sides. Further species, such as the serpulid *Filograna* sp. and a few bryozoans are restricted to the mud-covered side, whereas *Puellina* spp. bryozoan colonies and the serpulid *Metavermilia multicristata* occur only on the mud-free surface.

Discussion and conclusions

The nearly exclusive presence of the bryozoans *Crisia* and *Scrupocellaria delilii* on the mud-covered surface could be related to their growth morphology consisting of tufts of erect flexible branches, allowing colonies to elevate from their substrate and to shade off the sediment particles. Analogously, the serpulids *Filograna* sp. and probably also *F. gracilis* (the most abundant species on the mud-covered surface, although less abundant than on the opposite side) seem relatively tolerant to siltation (Sanfilippo et al., 2013). The occurrence (or the dominance) of further (all encrusting) bryozoan species on only one of these surfaces cannot confidently be traced, in the absence of any knowledge about their ecological requirements. Present observation documents a polarity of epilithobiont's distribution pattern in deep-water environments. Although different causes could concur to produce polarity on these hard substrata, a possible driving process seems to be the presence/absence of sediment smothering in spite of light/shadow, as happens for differently oriented hard surfaces in shallow-water habitats.

Acknowledgemts

Samples were available through the CNR-CoNISMa Project RITMARE-La Ricerca ITaliana per il MARE. Catania Palaeontological Group, paper contribution n. 395.

Bibliography

MASTROTOTARO F., D'ONGHIA G., CORRIERO G., MATARRESE A., MAIORANO P., PANETTA P., GHERARDI M., LONGO C., ROSSO A., SCIUTO F., SANFILIPPO R., GRAVILI C., BOERO F, TAVIANI M., TURSI A. (2010) - Biodiversity of the white coral bank off Cape Santa Maria di Leuca (Mediterranean Sea): An update. *DSR II*, 57 (5-6): 412-430.

ROSSO A., VERTINO A., DI GERONIMO I., SANFILIPPO R., SCIUTO F., DI GERONIMO R., VIOLANTI D., CORSELLI C., TAVIANI M., MASTROTOTARO F., TURSI A. (2010) - Hard and soft-bottom thanatofacies from the Santa Maria di Leuca deep-water coral province, Mediterranean. *DSR II*, 57 (5-6): 360-379.

SANFILIPPO R., VERTINO A., ROSSO A., BEUCK L., FREIWALD A., TAVIANI M. (2013) - *Serpula* aggregates and their role in deep-sea coral communities in the southern Adriatic Sea. *Facies*, 59(4): 663-677.

TOSCANO F., RASPINI A. (2005) – Epilithozoan fauna associated with ferromanganese croustgrounds on the continental slope segment between Capri and Li Galli Islands (Bay of Salerno, Northern Tyhrrenian Sea, Italy). *Facies*, 50: 427-441.

RECOMMENDATIONS

****

RECOMMANDATIONS

RECOMMENDATIONS OF THE 1st MEDITERRANEAN SYMPOSIUM ON THE CONSERVATION OF DARK HABITATS

The first Mediterranean symposium on dark habitats took place in Portoroz on 31st October 2014.

The first 2 sessions were devoted to deep habitats, largely focussing on canyons, rocky banks and escarpments. A lot of attention was given to describing the spatial distribution of biodiversity mostly from the western Mediterranean basin. The data gathered has already helped some countries to revise their typology of assemblages. It was clear to all that this initiative should be transferred to other Mediterranean countries, in agreement with international initiatives currently undertaken.

The main impact documented by participants was the accumulation of marine litter, most particularly lost fishing gear and plastics. The participation of stakeholders and decision-makers to deep exploration seems a good idea to increase awareness about the damage caused by such human activities. Outreach / educative actions targeted towards the general public and especially towards recreational and professional fishermen could enhance environmental awareness.

Many efforts were made to georeference data and feed interactive databases. This effort should be supported in the long term. Environmental (e.g. temperature, currents, etc.) data are missing from the depth range where most these studies were carried out (50-500 m). MPAs beyond national jurisdiction are still too few to ensure poorly resilient deep-sea communities can persist in the future.

The session on caves gathered contributions from different parts of the Med. Many efforts were made on gathering existing information on the distribution of caves, our degree of knowledge and how to evaluate the ecological quality status, through their functional components. It was stressed that they are a significant reservoir of biodiversity and that they too are poorly resilient. However, although within the reach of recreational divers, human impact on caves other than global warming and pollution is believed to still be marginal. Possible impacts would have to be evaluated. Meanwhile we need to improve our basic knowledge on connectivity among cave populations, their biodiversity and functioning of their communities.

RECOMMANDATIONS DU 1er SYMPOSIUM MEDITERRANEEN SUR LA CONSERVATION DES HABITATS OBSCURS

Le premier symposium méditerranéen sur les habitats obscurs a eu lieu à Portoroz, le 31 octobre 2014.

Les deux premières séances ont été consacrées aux habitats profonds, mettant principalement l'accent sur les canyons, les rives rocheuses et les escarpements. L'attention s'est portée essentiellement sur la description de la répartition spatiale de la biodiversité, en particulier dans le bassin occidental de la Méditerranée. Les données recueillies ont déjà permis à certains pays de réviser leur typologie des assemblages. Il est apparu clairement à tous que cette initiative devait être transférée à d'autres pays méditerranéens, conformément aux initiatives internationales qui sont menées à l'heure actuelle.

Le principal impact documenté par les participants concerne l'accumulation de déchets en mer, en particulier les engins de pêche et les plastiques perdus. La participation des parties prenantes et des décideurs à une exploration en profondeur semble être une bonne idée afin d'améliorer la prise de conscience des dommages provoqués par ces activités humaines. Des actions de sensibilisation / d'éducation visant le grand public et tout particulièrement les pêcheurs de loisirs et professionnels, permettraient d'améliorer la sensibilisation à l'environnement.

De nombreux efforts ont été déployés afin de géoréférencer les données et d'alimenter les bases de données interactives. Ces efforts devraient être maintenus sur le long terme. Les données environnementales (notamment sur la température, les courants, etc.) ne sont pas disponibles pour la fourchette de profondeur dans laquelle la majorité de ces études a été effectuée (50-500 m). Les AMP hors des limites de la juridiction nationale sont encore trop rares pour s'assurer que les communautés en eaux profondes faiblement résistantes puissent continuer à exister à l'avenir.

La séance relative aux grottes a permis de rassembler des contributions de différentes parties de la Méditerranée. De nombreux efforts ont été déployés afin de recueillir les informations existantes sur la répartition des grottes, notre degré de connaissance et la façon d'évaluer l'état de la qualité écologique, par le biais de leurs composants fonctionnels. Il a été souligné qu'elles représentaient un réservoir de biodiversité significatif et qu'elles étaient trop peu résistantes. Toutefois, même si celles-ci sont accessibles aux plongeurs de loisirs, l'impact humain sur les grottes, en dehors du réchauffement climatique et de la pollution, est considéré comme marginal. Les impacts possibles devront être évalués. Entre-temps, nous devons améliorer nos connaissances élémentaires de la connectivité entre les populations des grottes, de même que leur biodiversité et le fonctionnement de leurs communautés.

SPREAKERS LIST / LISTE DES ORATEURS

Ricardo AGUILAR
Oceana, Plaza España, Leganitos 47, 28013 Madrid, Spain
E-mail: raguilar@oceana.org

Michela ANGIOLILLO
Italian National Institute for Environmental Protection and Research (ISPRA), Via Brancati 60, 00144 Roma, Italy
E-mail: michela.angiolillo@isprambiente.it

Marzia BO
Dipartimento di Scienze della Terra, della Vita, dell'Ambiente, Università di Genova, Corso Europa 26, 16132 Genova, Italia
E-mail: marzia.bo@unige.it

Simonepietro CANESE
Italian National Institute for Environmental Protection and Research (ISPRA), Via Brancati 60, 00144 Roma, Italy
E-mail: simonepietro.canese@isprambiente.it

Martina CANESSA
DiSTAV, Dipartimento di Scienze della Terra, dell'Ambiente e della Vita, Università di Genova, Corso Europa 26, 16132 Genova, Italy
E-mail: tittamenta@hotmail.it

Boris DANIEL
Agence des aires marines protégées - Antenne Méditerranée - 26, rue de la République, 13001 Marseille- France
E-mail: boris.daniel@aires-marines.fr

Maïa FOURT
Institut Méditerranéen de Biodiversité et Ecologie Marine et Continentale (IMBE), UMR 7263 CNRS, IRD, Aix Marseille Université, Avignon Université, Station Marine d'Endoume, Marseille, France
E-mail: maia.fourt@univ-amu.fr

Vasilis GEROVASILEIOU
Department of Zoology, School of Biology, Aristotle University of Thessaloniki, Greece
E-mail: bill_ger@yahoo.com
vgerovas@bio.auth.gr

Vesna MAČIĆ
Institute for Marine Biology, Dobrota b.b. 85330 Kotor, Montenegro
E-mail: vmacic@ibmk.org

Carlos NAVARRO-BARRANCO
Laboratorio de Biología Marina, Universidad de Sevilla, Avda Reina Mercedes 6, 41012 Sevilla, Spain
E-mail: carlosnavarro@us.es

K.-Nadia PAPADOPOULOU
Hellenic Centre for Marine Research, Institute of Marine Biological Resources and Inland Waters, 46.7 km Athens-Sounio, P.O. Box 712, 19013, Anavissos, Attica, Greece
E-mail: nadiapap@hcmr.gr

Pierre Alexandre RASTORGUEFF
IMBE, UMR 7263 CNRS, IRD, Aix Marseille Université, Avignon Université, Station Marine d'Endoume, Marseille, France / Department of Zoology, University of Johannesburg, South Africa
E-mail: pierre-alex.rastorgueff@gmx.fr

Antonietta ROSSO
Department of Biological, Geological and Environmental Science, University of Catania, Corso Italia 57, 95129, Catania, Italy
E-mail: rosso@unict.it

SCIENTIFIC COMMITTEE MEMBERS / MEMBRES DU COMITÉ SCIENTIFIQUE

Ricardo AGUILAR
Oceana, Plaza España, Leganitos 47, 28013 Madrid, Spain
E-mail: raguilar@oceana.org

Yelda AKTAN TURAN
Istanbul University, Fisheries Faculty, Ordu Caddesi n° 200, 31170 Laleli Istanbul, Turkey
E-mail: yaktan@istanbul.edu.tr

Didier AURELLE
Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE), CNRS UMR 7263, Aix-Marseille Université, Station Marine d'Endoume, Chemin de la Batterie des Lions, 13007, Marseille, France
E-mail: didier.aurelle@imbe.fr

Enrique BALLESTEROS
Centre d'Estudis Avançats de Blanes, CEAB-CSIC, Carrer d'acces a la cala Sant Francesc, 14, Blanes (Girona). E-17300 Catalunya, Spain
E-mail: kike@ceab.csic.es

Hoceine BAZAIRI
Faculté des Sciences, Université Mohammed V-Agdal, 4 Avenue Ibn Battouta, B.P. 1014 RP, Rabat, Maroc
E-mail: hoceinbazairi@yahoo.fr
bazairi@fsr.ac.ma

Carlo Nike BIANCHI
DiSTAV, Dipartimento di Scienze della Terra, dell'Ambiente e della Vita, Università di Genova, Corso Europa 26, 16132 Genova, Italy
E-mail : nbianchi@dipteris.unige.it

Charles François BOUDOURESQUE
Aix-Marseille University and Toulon University, Mediterranean Institute of Oceanography (MIO), CNRS/IRD UM 110, University campus of Luminy, 13288 Marseille cedex 9, France.
E-mail: charles.boudouresque@mio.osupytheas.fr

Pierre CHEVALDONNE
Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE), CNRS UMR 7263, Aix-Marseille Université, Station Marine d'Endoume, Chemin de la Batterie des Lions, 13007, Marseille, France
E-mail: pierre.chevaldonne@imbe.fr

Joaquim GARRABOU
Mediterranean Institute of Oceanography (MIO) UM 110, CNRS/INSU, IRD, Aix-Marseille Université, Université du Sud Toulon-Var, Marseille, France / Institut de Ciències del Mar (ICM), CSIC, Barcelona, Spain
E-mail: garrabou@icm.csic.es

Vasilis GEROVASILEIOU
Department of Zoology, School of Biology, Aristotle University of Thessaloniki, Greece
E-mail: bill_ger@yahoo.com
vgerovas@bio.auth.gr

Habib LANGAR
Département de Biologie, Faculté des Sciences Mathématiques, Physiques et Naturelles de Tunis, Campus Universitaire Tunis El Manar, 2092 Tunis, Tunisie
E-mail : habib.langar@gmail.com

Gérard PERGENT
Equipe « Ecosystèmes Littoraux », FRES 3041, Université de Corse, 20250 Corte, France
E-mail: pergent@univ-corse.fr

Christine PERGENT-MARTINI
Equipe « Ecosystèmes Littoraux », FRES 3041, Université de Corse, 20250 Corte, France
E-mail: pmartini@univ-corse.fr

Leonardo TUNESI
3rd Dept. CRA15 "Marine Habitats and Biodiversity Protection", ISPRA - Italian National Institute for Environmental Protection and Research, Via Vitaliano Brancati, 60, 00144 Roma - Italy
E-mail: leonardo.tunesi@isprambiente.it

ORGANISING COMMITTEE MEMBERS / MEMBRES DU COMITÉ D'ORGANISATION

Khalil ATTIA
Director
UNEP/MAP/Regional Activity Centre for Specially Protected Areas
Boulevard du Leader Yasser Arafet, B.P. 337 – 1080, Tunis Cedex, Tunisie
E-mail: director@rac-spa.org

Naziha BEN MOUSSA
Administrative Assistant
UNEP/MAP/Regional Activity Centre for Specially Protected Areas
Boulevard du Leader Yasser Arafet, B.P. 337 – 1080, Tunis Cedex, Tunisie
E-mail: naziha.benmoussa@rac-spa.org

Cyrine BOUAFIF
Phd Student
Département de Biologie, Faculté des Sciences Mathématiques, Physiques et Naturelles de Tunis, Campus Universitaire Tunis El Manar, 2092 Tunis, Tunisie
E-mail: bouafif.cyrine@gmail.com

Tina CENTRIH
Researcher
Institute of the Republic of Slovenia for Nature Conservation, Regional Unit Piran, Trg Etbina Kristana 1, 6310 Izola, R Slovenija
E-mail: tina.centrih@zrsvn.si

Imtinen KEFI
Financial Officer
UNEP/MAP/Regional Activity Centre for Specially Protected Areas
Boulevard du Leader Yasser Arafet, B.P. 337 – 1080, Tunis Cedex, Tunisie
E-mail: imtinen.kefi@rac-spa.org

Atef OUERGHI
Ecosystems Conservation Programme Officer/ MedKeyHabitats Project Officer
UNEP/MAP/Regional Activity Centre for Specially Protected Areas
Boulevard du Leader Yasser Arafet, B.P. 337 – 1080, Tunis Cedex, Tunisie
Email: atef.ouerghi@rac-spa.org

Habib LANGAR
Professor
Département de Biologie, Faculté des Sciences Mathématiques, Physiques et Naturelles de Tunis, Campus Universitaire Tunis El Manar, 2092 Tunis, Tunisie
E-mail : habib.langar@gmail.com

Yassine Ramzi SGHAIER
MedKeyHabitats Technical Assistant Officer
UNEP/MAP/Regional Activity Centre for Specially Protected Areas
Boulevard du Leader Yasser Arafet, B.P. 337 – 1080, Tunis Cedex, Tunisie
E-mail: Yassineramzi.sghaier@rac-spa.org

Robert TURK
Slovenian SPA Focal Point
Institute of the Republic of Slovenia for Nature Conservation, Regional Unit Piran, Trg Etbina Kristana 1, 6310 Izola, R Slovenija
E-mail: robert.turk@zrsvn.si