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A GUIDE ON ENVIRONMENTAL MONITORING OF ROCKY SEABEDS IN MEDITERRANEAN MARINE PROTECTED AREAS AND SURROUNDING ZONES

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Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem

MedPartnership

Together for the Mediterranean Sea

A GUIDE ON ENVIRONMENTAL MONITORING OF ROCKY SEABEDS IN MEDITERRANEAN MARINE PROTECTED AREAS AND SURROUNDING ZONES.

A guide on the identification and monitoring of disturbance-sensitive, benthic (rocky seabeds), sessile target species for scientific, professional and recreational divers, academics working in the area, specialized businesses and public authorities connected to the environment and all involved actors in the management, impact assessment, monitoring and conservation of coastal environment.

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A guide on environmental monitoring of rocky seabeds in Mediterranean Marine Protected Areas and surrounding zones.

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Dedicated to Liliana

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PRESENTATION OF THE GUIDE

Marine Protected Areas are increasingly becoming an important management tool to conserve the marine biodiversity and to protect natural resources, globally.

Monitoring is an essential component of resource management by providing science-based information to guide key management decisions like prioritizing conservation strategies, proper allocation of resources, and ultimately, whether or not these marine protected areas are meeting their intended objectives.

At Mediterranean level, the monitoring of habitats and species does not seem to be a common practice in Marine Protected Areas and its surrounding areas. Therefore, The Contracting Parties to the Barcelona Convention are currently working to implement an Ecosystem Approach in the Region with the ultimate objective of achieving the Good Ecological Status (GES) of the Mediterranean Sea. They act for establishing a new monitoring program in line with the Ecosystem Approach. This will enable for the first time a quantitative monitoring of the status of the Mediterranean Sea on a regional basis, covering biodiversity and non-indigenous species. Mediterranean countries are however in need of diverse technical tools, including guides, to assist that process.

The present guide is intended to provide technical guidance to all actors at different levels in developing site-based monitoring plans to complement existing management plans or in developing new ones. It aims to set up a methodological tool for environmental and ecological monitoring of Marine Protected Areas and for littoral seabeds of surrounding areas, given their role as buffer zones between Marine Protected Areas and more distant anthropized zones.

Furthermore, it will enable promoting the creation of a network of underwater sentinel stations to act as an environmental monitoring and warning system helping to detect changes in the littoral ecosystem and the seascape it forms with its fauna and flora.

Finally, this methodological tool aims to standardize monitoring across rocky seabeds in Marine Protected Areas by providing guidance on monitoring objectives, sampling design, indicators, and methodology. It was developed for Marine Protected Areas managers, including conservation officers and researchers who collect monitoring data but also for an ample collection of divers, both recreational and professionally certified, as well as any stakeholder enthusiastic about underwater wildlife and wishing to contribute towards its environmental monitoring and conservation.

Phot. 1: the Strait of Gibraltar, location where the majority of the observations presented in this guide were made. In the background, the African continent and the Moroccan mountain Jebel Musa, trademark landscape of the southern littoral border of the Strait.

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As this guide gathers information from observations and results published since 1990, it has benefited from projects financed by Public Tenders (DGICYT PB87 0397, DGICYT PB89 0081, DGICYT PB95 0235, DGESIC PB98-0532, REN2000-1602/GLO, REN2001-1956-C17-02/GLO and CGL2006-05182/BOS), the private company *Compañía Española de Petróleos* (CEPSA S.A.), the Ceuta Port Authority, the Algeciras Port Authority, the Ceuta Regional Assembly, OBIMASA, EGMASA and CMAYOT. Accordingly, I would like to express my sincere thanks to Marina Hércules and her President, José Manuel Ávila, for granting use of their infrastructure to carry out research and diving activities around Ceuta.

The contribution of my close colleague Alexandre Roi González Aranda has been both commendable and noteworthy, particularly in terms of revising the bibliography and drafting explanatory drawings, and without his immeasurable assistance this work would not have been published in 2015. So I offer my deepest thanks to Alexandre and would also like to extend that to Liliana Olaya, Aurora Ruíz, Inés Martínez and Juanjo Díaz for their collaboration with data compilation and to María Altamirano, Julio de la Rosa, Ignacio Bárbara, Ricardo Bermejo and Ignacio Hernández (macroalgae), José Luis Carballo (sponges), Pablo López and César Megina (cnidarians), Carlos López (bryozoans), Santi Naranjo, Alfonso Ramos and Xavi Turón (ascidians) for their taxonomical advice regarding conflictive species.

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The members of the diving clubs and centers that have joined the first Underwater Environmental Surveillance Network to apply the environmental monitoring methodology proposed by the present guide deserve a special mention. And also to Gabrial García and David Manso from the data management company IT3 Cloud, for their invaluable help in developing the environmental warning software for target-species and a website to manage the data. The appendix of this book is dedicated to those individuals and their respective clubs and centers

Also, I express my warm appreciation to Fabio Badalamenti and his research group (CNR-IAMCs Headquarters di Castellammare del Golfo, Sicily, Italy: Marco Torri, Dr. Luigi Musco, Dr. Thomas Vega, Dr. Carlo Pipitone, Dr. Giovanni D'Anna and Dr. Michele Gristina). In 2014 they installed the first underwater sentinel stations on the Italian coast (at different points of the island of Sicily), following the line of work contained in this work and in close cooperation with local dive centers and the Marine Biological Laboratory of the University of Seville.

Furthermore, I gratefully acknowledge the support provided by the Strait of Gibraltar Natural Park (an integral part of the Mediterranean Intercontinental Biosphere Reserve), the Campo de Gibraltar UNESCO Center, the Institute of Gibraltarian Studies, the Institute of Ceutan Studies, the Museum of Gibraltar and the University of Seville's Research Services and their Research Foundation (FIUS).

To the "International Academy of Underwater Sciences and Techniques", UNESCO, CMAS and MAGRAMA, I deeply appreciate their support and recognition to the practical results of research reflected in this work, applied to the monitoring and conservation of the marine environment.

I would like to give a special thanks to the aquatic complex Nemo 33 in Brussels (the Guinness world record as the deepest diving pool pit in the world), where its General Director showed me their innovative facilities, with the invaluable collaboration of the great friend and collaborator Jorge Bayo. I deeply believe that based on the model developed in this book, these facilities would be an ideal location for placing an artificial simulator guard-station, with coloured grids that would include reproductions of benthic marine organisms. This simple set up would contribute to learning underwater photography in artificial systems and would stimulate Nemo's 33 many users to participate in underwater environmental monitoring in coastal areas around the world, where they enjoy their diving holidays. Finally, it would be an additional attraction proposed by this splendid facility, promoting environmental education and marine environment preservation.

I am grateful to the Andalusian Federation of Underwater Activities, especially to Manual Crespo and Pepe Daza, for their continuous efforts to promote and consolidate diving in Andalusia.

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1 PREFACE

1.1. Background

The origins of the present work stem from the international workshop "Climate change impact indicators on marine biodiversity in the Mediterranean MPAs" (23rd - 24th October 2012, IUCN Centre for Mediterranean Cooperation). This meeting introduced the author to a provisional method for underwater environmental monitoring of Marine Protected Areas (MPAs) which was based on benthic bioindicators and designed to detect significant changes in the benthic system biota, whether they are caused by local effects or those of a geographically larger character (global warming).

Members of the Regional Activity Centre for Specially Protected Areas (RAC/SPA) who participated in the workshop decided to support the publication aforementioned method, after it had been sufficiently tested, and the preparation of a complete guide to environmental bioindicators to assist in its application.

This guide has been elaborated within the framework of the "Regional Project for the Development of a Mediterranean Marine and Coastal Protected Areas (MPAs) Network through the boosting of Mediterranean MPAs Creation and Management (MedMPAnet Project)", implemented in the framework of the UNEP/MAP-GEF MedPartnership, with the financial support of the European Commission (EC), the Spanish Agency for International Cooperation and Development (Agencia Española de Cooperación Internacional para el Desarrollo, AECID) and the French Global Environment Facility (Fonds Français pour l´Environnement Mondial, FFEM).

Consequently, they are promoting and financing the publication of this guide in French and English. In a parallel effort, the Andalusian Regional Council's Department of Environment and Land Planning (Consejería de Medio Ambiente y Ordenación del Territorio, CMAOT) decided to promote the online publication of the Spanish version.

The final phase of data collection included contributions from both the European MedPAN-North Project and a Cooperation Agreement signed in May 2013 by the Seville Port Authority, Aquagestión Sur (the Seville aquarium) and the University of Seville, in the context of which an environmental monitoring program based on soft substrate (infauna) benthic indicators is already underway in the Guadalquivir estuary. Under the terms of the Cooperation Agreement, another program will begin in 2015 concentrating on sessile bioindicators that shall be monitored in permanent quadrats located in underwater sentinel stations in zones around the river mouth; the aim being to test the present method in fluctuating systems as opposed to the structured, stable and highly biodiverse systems for which it was preferentially conceived.

Work presented in this guide continues on from a previous publication (García-Gómez, 2007), some portions of which are reused in their entirety and some with modifications or expansions. Obviously, the main difference is this publication incorporates the methodological tool (environmental action and monitoring protocol for observing target species in permanent quadrats fixed to the substrate at underwater sentinel stations), refined and tested in close collaboration with recreational diving clubs and centers, plus a conveniently presented guide to the indicator species which help to implement the protocol. For its publication, nevertheless, we have awaited the results from the scientific analysis of the target species coverage using a 10-year temporal data series, obtained from a sentinel station in the Strait of Gibraltar located in unpolluted, stable and biodiverse waters (García-Gómez *et al.*, publication under way). This information proved to be vital when testing the expectations for the method proposed in this guide.

The aforementioned precursory publication (García-Gómez, 2007) arose from an INTERREG IIIC MedPAN Project developed from 2005 to 2007. The project aimed to create a Management Network for Mediterranean Marine Protected Areas responsible for developing management tools to assist in the daily tasks required to manage protected spaces while also promoting public involvement. Prior research within the framework of a preceding project, the MedPAN North Project which was supported by the RAC/SPA and CMAOT, yielded advances in terms of data collection and helped to fine-tune the monitoring method.

The information presented in this work and in its predecessor (García-Gómez, 2007) is the fruit of an intense, continual scientific and technical research program developed over more than 20 years in the south of the Iberian Peninsula, specifically in the coastal waters of Andalusia and Ceuta. In this regard, the Strait of Gibraltar, a delimiting zone for the distribution of many species, does not form an absolute barrier but rather an area of gradient where there is a progressive decrease or increase, in function of gradual environmental changes, in the numbers of many species located on either side of the graded zone.

It is worth noting that the Lusitania (temperate-cold), Mauritania (warm) and the Mediterranean biogeographical provinces all converge in this single geographical enclave connecting the

Atlantic Ocean and Mediterranean Sea (García-Gómez *et al*., 1997; García-Gómez, 2002), and secondly that, the similarities and differences between this enclave's biota and the biota present in other biogeographical areas have been addressed in various scientific publications (López de la Cuadra and García-Gómez, 1994; Carballo *et al.*, 1997; Naranjo *et al.,* 1998). It has, therefore, provided an ideal natural location to investigate the processes of change occurring in the littoral biota which are non-attributable to human influence. On a different scale, this has subsequently served in the comparison of marine biota responses to varying degrees of contamination, where we observe pollution-sensitive species progressively disappearing (or numerically decreasing) as the environmental conditions alter, i.e., as we approach the focal point of the impact.

In the context of marine bioindicators, and within the geographical area comprising the south of the Iberian Peninsula and the Strait of Gibraltar, several scientific studies have investigated specific zoological groups, such as Poriferas (Carballo *et al.*, 1994, 1996), polychaetes (Sánchez-Moyano *et al*., 2002; Guerra-García and García-Gómez, 2004b), crustaceans (Conradi *et al*., 1997, 2000; Alfonso *et al*., 1998; Sánchez-Moyano and García-Gómez, 1998; Guerra-García and García-Gómez, 2001, 2004a), molluscs (Sánchez-Moyano *et al*., 2000a; Espinosa *et al*., 2007), Ascidiacea (Naranjo *et al*., 1996, 1998) or benthic filter feeders (Carballo and Naranjo, 2002).

Other publications have contributed in the integrated study of different zoological groups, with the aim of identifying the community structures of endobenthic macrofauna in sediments and other types of substrate in order to quantify their capacity as bioindicators (Estacio *et al*., 1997, 1999; Sánchez-Moyano *et al*., 2000b, 2003; Fa *et al*. 2003; Guerra-García *et al*., 2003a, b, c; Guerra-García and García-Gómez, 2005a, b, 2006). The value of soft substrate benthic bioindicators in coastal water environmental monitoring programs has been confirmed by recent subject-specific studies (Sánchez-Moyano *et al*., 2005a, b). Research into the macrofauna and macroflora of the intertidal zone, which took environmental gradients into consideration, has also been published (Guerra-García *et al*., 2006).

1.2. Objectives and justification

The main aim of this publication is to develop a methodological tool for environmental and ecological monitoring of Mediterranean Marine Protected Areas (MPAs) and the littoral seabeds of their surrounding areas, which are included because they act as buffer zones between MPAs and more distant anthropized zones. A parallel objective is to promote the creation of a network of underwater sentinel stations to act as an environmental monitoring and warning system helping to detect changes in the littoral ecosystem and the seascape it forms with its fauna and flora. On one hand, these changes could be of a natural or anthropogenic origin, and on the other hand, they may be due to local causes or as a result of Global Warming.

Therefore, it was considered a basic requisite to include **essential biological factors** and offer clues about **how to detect threats to and impacts on the littoral marine environment**, placing special emphasize on the monitoring of **sensitive species** (which can only survive in high-quality environments and tend to disappear when they deteriorate) that are preselected (**target species**) and monitored in **permanent quadrats**. The quadrats are installed in underwater **sentinel stations** located on pristine seabeds of high environmental stability, preferably at depths of between 25 and 35 metres. Periodic monitoring of these target species will help to detect short-term environmental impacts, if any occur, as well as gradual, long-term changes resulting from Global Warming.

Monitoring **sensitive target species** in areas that they typically inhabit can be effective in determining the presence of anthropogenic disturbances (although disturbances of a natural origin may also exist), based on the balance, decline or disappearance of their populations. In contrast, and principally to avoid the error of preselecting them as target species (i.e., sensitive), we also include descriptions of **tolerant species** (highly adaptive to different environmental conditions). These can survive in both high-quality and disturbed environments, hence they are not particularly sensitive to environmental changes and are not likely to disappear from areas which they originally inhabit. Another situation involves zones initially void of tolerant species but which are eventually inhabited by them because of a deterioration in the area's environmental quality, providing a further source of valuable information. And so a further objective that has emerged from this point is to elaborate a complete **identification guide** to assist in the recognition and selection of appropriate species.

Both the diversity of benthic species and the structural complexity of the observed communities progressively increase in the bathymetric range of 0 to -35 meters. This is a consequence of a gradual increase in the environmental stability and a moderate decrease in light. As such, the "biological sources of information" that could prove to be the most useful in terms

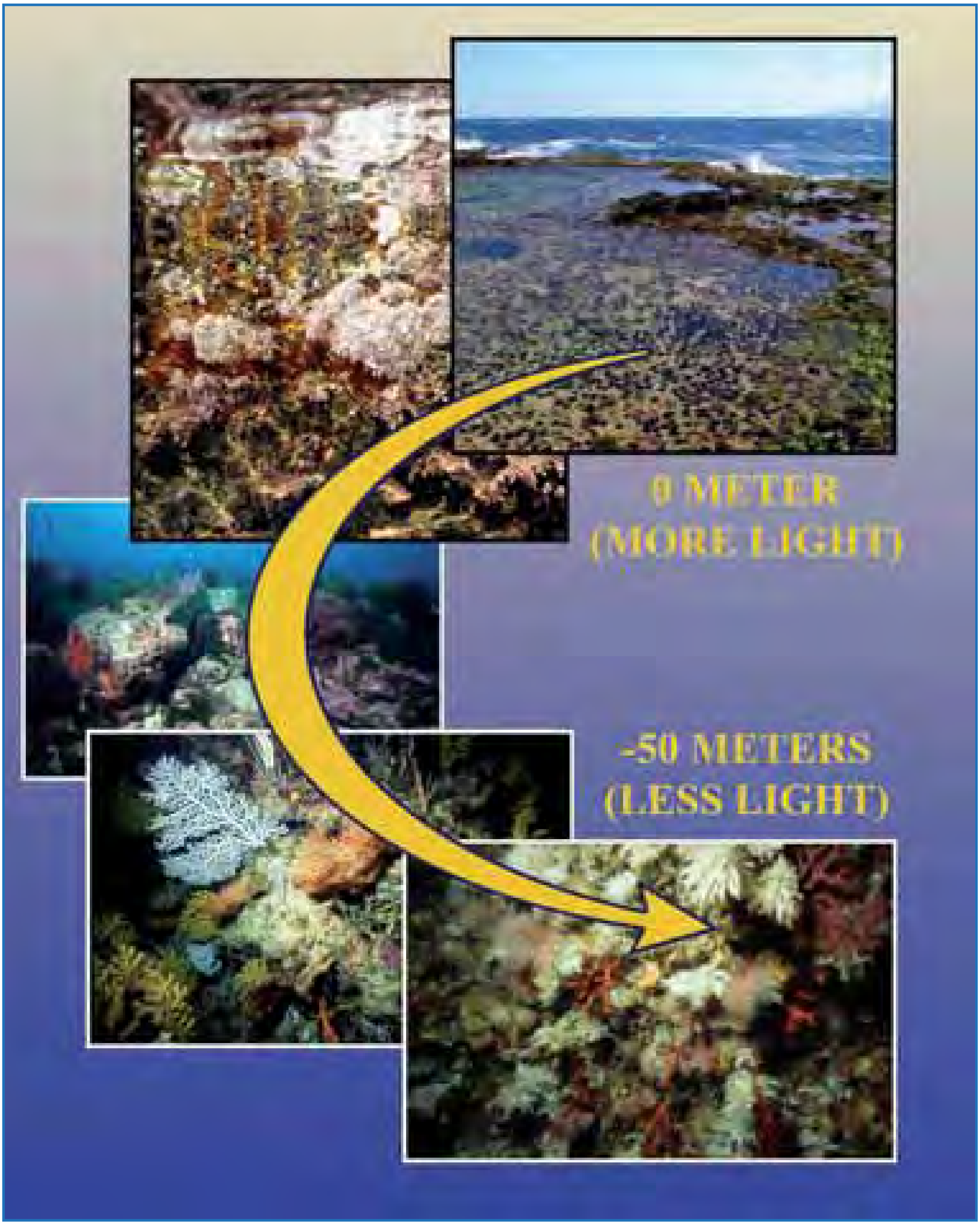


Fig. 1

of surveillance and monitoring also increase in number (**fig. 1**).

The proposed method is not intended to concentrate on the system's biodiversity (nor even that of specific zoological or botanical groups), but rather to focus on the target species sensitive to environmental changes or disturbances and that fulfil the criteria set out below. They would act as permanent sentinels (or seasonal sentinels, but sensitive to disturbances) whose sensitivity affords a reliable indication of the ecosystem's health and, therefore, they would warn of serious threats and identify the impacts affecting local biodiversity. This would abolish the need for expensive periodic monitoring programs that measure biodiversity in its entirety (for example, centered on the study of communities of species). A second disadvantage of these traditional programs is the use of invasive sampling techniques, i.e., specimen collection, that result in samples which are only available to the initial group of scientists because the material is partly or fully destroyed while being analyzed. This severely hinders the exchange and verification of specimens by other members of the scientific community.

It is important to highlight that the species we designate here as indicators have been chosen according to a hypothesis based on a "broad response profile" that is supported by *in situ* observations and generally reinforced with information from specialized literature. However, in controlled environments, there is a general lack of complete studies for these species in terms of tolerance or sensitivity to the different physico-chemical parameters that condition important changes in their natural habitats. Therefore, future advances in scientific research in this field will enable the corresponding adjustments to be made so that more accurate predictions can be presented about whether or not a given species would be a suitable ecological indicator and under which environmental conditions (in particular, which physico-chemical parameters).

A primary objective in the development of the aforementioned methodological tool was to draft an **environmental monitoring protocol** for divers, but which will also prove to be useful for the public authorities responsible for the monitoring and conservation of our littoral zones. Given that the monitored species are "framed" by permanent quadrats fixed to the substrate, the application of the method will generate long temporal data series about the evolution of sensitive target species thus warning of significant changes or imbalances in the sublittoral benthos. This will be achieved by either simply comparing "after" images with those of a zero or initial state (on a local scale), or by a more complex approach that involves the use of repeated measures statistical techniques (Lanyon and Marsh, 1995).

A secondary objective of this publication, as explained in **Chapter 4.1**, is to help meet the implementation demands of the EU Water Framework Directive 2000/60/EC (WFD), particularly in the context of sessile macroinvertebrates.

Although the said tool is designed to detect disturbances in biologically structured, stable (in terms of structure-degradation) and ecologically pristine systems, it can also be used to evaluate the degree of recovery of disturbed littoral systems once the source(s) of impact (in terms of structure-degradation) has been eliminated or mitigated. (**figs. 2 and 3**).

The guide also has a didactic purpose as it aims for divers who care for the marine environment to develop their observational skills, to receive appropriate training in the detection of potentially significant anomalous processes, and to encourage their voluntary collaboration with the competent authorities by reporting any signs of environmental changes or disturbances occurring in the marine environment. As such, the authorities can subsequently validate the findings and, if necessary, take the appropriate preventive or corrective actions.

1.3. Target audience or, who is this guide written for?

The guide has been prepared to include a broad social projection (participative tool) and generate collaborative commitments to the environmental monitoring of Mediterranean Marine Protected Areas and their neighboring littoral zones. Therefore, it is essentially directed towards diving clubs and centers, in other words, an ample collection of divers (both recreational and professionally certified), as well as scientists, environmental technicians, businesses and authorities involved in environmental studies of coastlines, university students learning about the marine sciences, marine biology or the environmental sciences, and, in general, towards any members of the public who are enthusiastic about underwater wildlife and wish to assist in its environmental monitoring and conservation **(photo 2)**.

The present guide has also been conceived to encourage the various Environmental Authorities (whether local, national or Mediterranean), with the support of academic and professional research institutes (such as the University of Seville, Spain), to stimulate a new wave of environmental volunteering within diving clubs and centers, promoting environmental monitoring networks that operate with low expenditures and aim to generate large temporal data series (whose general absence from environmental studies enormously hinders the detection or prediction of trends in the evolution of marine ecosystems). All of the

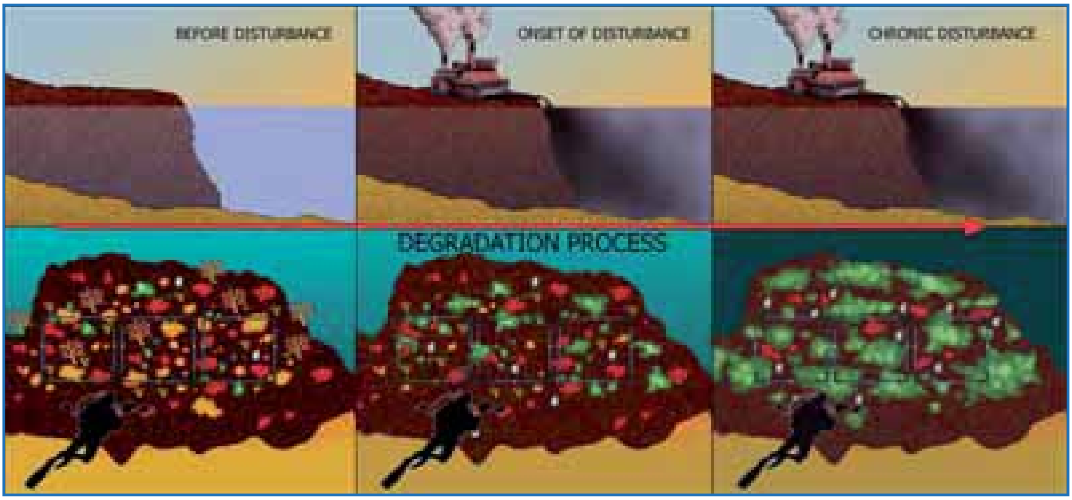


Fig. 2

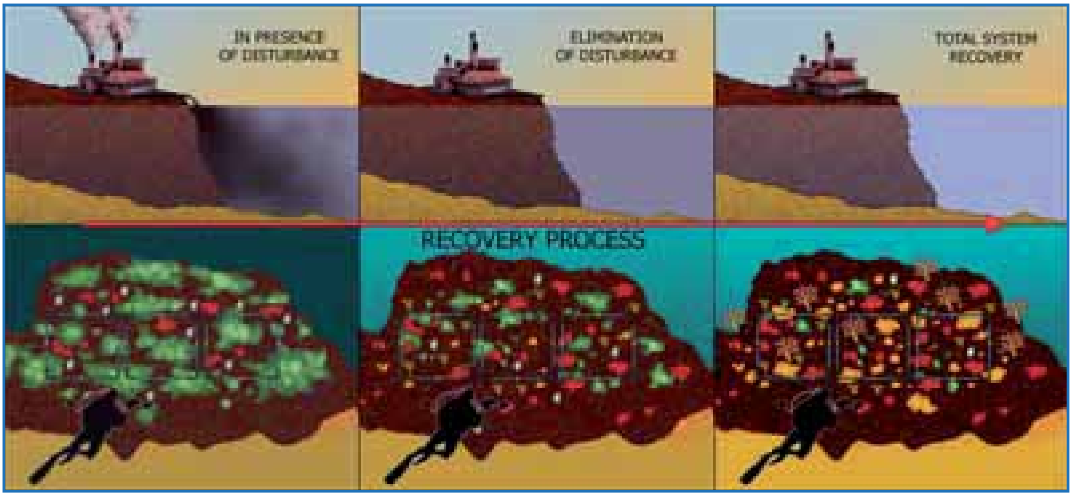


Fig. 3

above derives from a method based on the analysis of photographs taken periodically; a technique that is non-invasive, prevails with time (as many copies as desired can be made of the photographic series) and, in the future, aspires to online management by scientific teams who are participating in environmental monitoring networks that use identical or similar target species but in different geographical zones.

Phot. 2

2 DETECTION OF UNDERWATER IMPACTS, A COMPLEX QUESTION

Seawater is almost nine hundred times denser than air. This means it is physically impossible to make external observations of any negative changes in the ecosystem derived from physico-chemical disturbances occurring in the water (either of a natural or anthropogenic origin). Therefore, in contrast to a burning forest (which can be seen from kilometers away, thus facilitating rapid responses in attempts to extinguish the fire), shallow coastal seabeds can environmentally fade, sicken or collapse just a few meters away from the observer, even while you take a pleasant swim in waters up to your waist. The sea, due to its physical nature, tends to conceal itself; this significantly hinders the externalization of just how many environmental problems it may be experiencing. As a result of this severe disadvantage with respect to terrestrial ecosystems, the sea requires special attention and the full involvement of several social groups.

Furthermore, and unlike toxic gases which dissipate rapidly into the air, water-borne pollutants dissipate very slowly through seawater. Thus, the aquatic environment provides an important physical barrier to dispersion processes, which tends to maximize local impacts and minimize those of a broader scale. Nevertheless, while anthropogenic emissions (e.g., urban waste) occurring in specific coastal areas may have primarily local implications, if they are close together their combined impact could affect more extensive geographical areas leading to changes of a larger, more global scale, for example, related to Global Warming (e.g., an increase in water temperature or acidity).

Occasionally it can be difficult to discern which of the detected changes or impacts are of a **natural origin** and which have an **anthropogenic origin**. For example a storm could provoke a massive silting over of species by violently displacing aggregates (a natural disturbance), contributing to a dramatically altered seascape in contrast to the previous situation of prosperity and environmental stability. If there is no periodic monitoring of the phenomenon, then any future environmental controls designed to detect significant changes in the benthic system would not be able to establish the causes with any degree of certainty. Furthermore, many species with a short life-cycle disappear from their typical zone in certain periods of the year only to reappear in their corresponding seasons. In such cases, absences during these periods are normal and should not be attributed to any anthropogenic events that may happen to occur simultaneously.

One of the main environmental problems facing European coasts, which also concerns any Marine

Protected Areas that are close to zones of elevated human pressure, derives from the untreated or insufficiently treated urban effluent of coastal cities. Particularly in summer when the number of tourists significantly swells the population density of coastal cities, causing a large increase in the total volume of pollutants (mainly organic) discharged into the littoral system. Least not we forget the periodic influx of agrochemicals that provoke unwanted mass fertilization and, therefore, eutrophication in littoral waters. Neither should we overlook the contamination produced by industry or maritime navigation (the Mediterranean is one of the busiest seas in the world in terms of maritime traffic), nor the impacts derived from civil engineering works or related aggregate extraction activities, nor any of the other possible causes of disturbance (**photo 3)**.

On one hand, there are isolated yet severe impacts that cause short-term damage to a large proportion of the affected biota (especially the sensitive species). On the other hand, there are more subtle impacts that only become apparent in the long-term, for example, those derived from a small volume of persistent organic pollution in a coastal area which can produce an initial and almost imperceptible seed of contamination that develops into a serious mid- or long-term environmental impact with unforeseeable implications. Initially, one would only be aware that something was happening but, with the passing of time, noticeable changes would probably occur in the community's structure.

In another setting, physico-chemical monitoring of the waters is insufficient to prevent or detect either short- or long-term impacts in the littoral environment. Long temporal data series as well as short-term data collection would be required to form hypotheses about significant impacts on the biota (particularly when trying to detect mid- or long-term changes). For example, samples taken in areas close to estuaries during the flood tide (when clean, renewed water is entering) may give normal analytical results and yet there could be damage occurring to the biota which can only be detected by analyzing affected waters in samples taken from the ebbtide (due to the flow of pollutants discharged into the river). Another factor is the lack of knowledge about certain pollutants' influence on the biota in function of their concentration per unit volume and particularly their prevalence in the medium. This often means that communities of organisms do not present any signs of impact (at least not at a fatal level), yet analysis of the column of water reveals pollutant concentrations above the normal or tolerable environmental thresholds.

Therefore, given that any "internal changes" occurring in the sea are impossible to detect from the land and their underwater detection is severely limited (given the poor visibility and low accessibility), there is an apparent need to improve existing detection, monitoring and evaluation methods. This constitutes a continuous challenge: firstly, to advance with new proposals regarding the design of low- or moderately-priced, inclusive, environmental monitoring protocols and methods that can be implemented in geographically adjacent or distant zones; and secondly, to analyze (integrally but continuously over time) the results obtained from the application of such proposals. Hence the present guide intends to add impetus to the preparation of a new underwater environmental monitoring and impact detection method, based on the monitoring of indicator target species (sensitive or stenoic) framed by permanent quadrats located in underwater sentinel stations. The method will be subject to future improvements with the collaboration of all those who wish to be involved in perfecting it.

Phot. 3

3 BENTHOS VERSUS PLANKTON AND NEKTON - WHY IS BENTHOS BETTER?

Accidental or recurrent discharge of an agent that disturbs the marine environment causes immediate physico-chemical changes to the properties of the water as well as having short-, mid- and/or long-term effects on the biota. **Plankton** (the collective of organisms that drift with sea currents as they are unable to swim against them) does not comprise a very useful portion of the marine biota in terms of collating information for localized evaluations of potential disturbances that may affect littoral organisms. This is because some species in the plankton group are generally small, have a short life-cycle, always drift with currents (so they do not remain in the locally affected area) and have a high reproductive capacity which allows them to repopulate quickly. **Nekton** includes organisms (mainly fish) that are highly mobile, with the ability to relocate and seek out better conditions, so even though they are large and easily observed in water they do not make suitable indicators.

Benthos refers to all organisms that exist in close connection with the seabed. They may live very close to the substrate but without actually contacting it (**suprabenthic**), on and in close physical contact with the substrate (**epibenthic**) or physically within it (**endobenthic**). Furthermore, they can be classed as being attached to the substrate (**sessile**) or moving over it (**vagile**). Some authors apply the term **nektobenthos** to fishes that actively move along the seabed, indifferent to whether or not they occasionally settle on it.

Additionally, the water column (the par excellence environment for plankton and nekton) offers very few opportunities for evolutionary diversification and, therefore, for speciation (due to its high degree of homogeneity). However, the opposite is true for the substrate's rocky habitats, whose spatial heterogeneity and greater stability present more possibilities for evolution and, subsequently, speciation. This difference is very apparent when diving from the surface down to the seabed, as the low degree of diversity can be observed in the column of water that is contrasted by the sudden increase in life upon reaching the rocky seabed. There are numerous species constantly struggling for space among the plethora of biological specimens carpeting the rocky substrate, some of which can be employed as a powerful tool for gathering environmental information.

Benthos is, in light of the above, the marine biota compartment that **offers the largest amount of high-quality data to meet the objectives of this guide**. In fact, benthic organisms, particularly those that live fixed to the substrate (**sessile**) throughout adulthood, or those that move very slowly and are intrinsically sedentary, have no capacity to escape from environmental changes which may occur in their habitat and so remain in the affected area throughout the entire duration of the event (**photos 4 and 5**). Therefore, if and when these changes occur, they either survive them, with evident signs of stress and a partial reduction in numbers, or they present their overall disappearance from the system. This makes them ideal **bioindicators** in terms of lethal and sub-lethal effects because they act as permanent or periodic "sentinels" (in the case of the latter, if they are not perennial and have an annual or sub-annual life-cycle, they can only offer environmental data during certain months of the year) of the ecological quality of the waters they inhabit and significantly contribute to environmental monitoring of littoral waters. That is why these organisms, especially the larger sensitive species (which can be found and recognized more easily, thus encouraging divers to monitor them), form the best option for use as a target species - because of their vulnerability to potential environmental changes that could occur in their habitat. Correspondingly, the fauna which provide the largest quantity of information for environmental observations of our coastal seabeds are adult sessile macroinvertebrates (Sponges, Cnidaria, Bryozoa…) and the benthic tunicates (Ascidiacea). Macroalgae represent the most useful flora, particularly perennial species.

Soft substrates are associated with less epibenthic diversity because they offer less stability and are more uniform than hard substrates, as such, they almost always develop with the appearance of underwater deserts. Nevertheless, they form the habitat where **marine phanerogam meadows** establish, evolutionary treasures that must be conserved as they play an important role in the ecology of our coasts. Divers who wish to be involved in environmental monitoring of our coasts and frequently dive over soft seabeds should pay special attention to the meadows described herein (particularly *Posidonia oceanica* and *Cymodocea nodosa*) because they are very visible, easy to locate and, in general, sensitive to environmental disturbances and pollution (especially that of an organic character derived from untreated urban wastewater).

Phot. 4

Phot. 5

4 ENVIRONMENTAL BIOINDICATORS AND THE BENTHOS, A RICH VEIN OF INFORMATION

Although environmental disturbances are essentially of a physical or chemical nature, they can directly or indirectly trigger other changes of a biological character. Whether through indirect actions, i.e., the cascade effect, environmental changes in the system (e.g., a temperature increase) open the possibility for new exotic species to introduce themselves which could develop into invaders, displacing indigenous species and destroying part of the ecosystem. Or alternatively via direct actions, when such actions affect the local biota at different levels of intensity, depending on the individual sensitivity of each species that forms the said biota. The disturbances can also cause measurable quantitative and qualitative fluctuations in the structure of the community and in its populations.

Not only do marine species, comprised of different genetic and functional units as they are, demonstrate different responses according to the variety and nature of the changes (depending on their sensitivity), but so do the individuals in function of population distributions (e.g., whether narrow or broad, and whether juveniles or adults), which further complicates the matter. Using the human species as an example can help further explain this last statement, since people can display a variable level of tolerance to different types of biological attack or respond differently to the same medical treatment. As doctors say, "there are no diseases, only ill people".

The aforementioned demonstrates the complexity of the problem and means we can appreciate the insufficient scope of numerous environmental monitoring programs that do not consider the organisms direct response to the possible changes affecting their environment. In absence of the information that can be extracted from marine biota, such programs cannot, therefore, contribute to a full environmental diagnosis since the biota offers a direct perception of its own environment and also reacts to it with specific signals, such as changes in appearance (effects on the phenotype), decreased populations or a net loss of species in function of their sensitivity to the environmental changes.

4.1. The concept of bioindicators and their emerging role

There are several definitions for the term bioindicator (or biological indicator) put forward in the scientific literature. They include: Iserentant and De Sloover (1976) who considered a bioindicator to be any organism or biological system used to identify a change in the ecosystem; Lebrun (1981) interpreted it to be any qualitative or quantitative parameter (measured at the level of individuals, populations or communities) that is likely to indicate particular living conditions corresponding to a given state, a natural variation or an environmental disturbance; and Blandin (1986) defined bioindicators as those organisms, certain combinations of them or complete biological communities that, with reference to biochemical, cytological, physiological, ethological or ecological variables, afford a practical and accurate characterization of the state of an ecosystem or an eco-complex while also providing an early warning of possible changes, whether natural or anthropogenic. Similarly, the term 'eco-complex' was defined by Blandin and Lamotte (1985) as a localized collective of interdependent ecosystems that have been shaped by a common ecological and anthropological history.

The use of bioindicators is a newly emerging line of environmental research since, as we have already mentioned, physico-chemical monitoring of the littoral zone (i.e., the traditional analysis of water or sediment samples) has proven insufficient in terms of identifying, detecting and/or preventing the changes that affect the species composition and structure of the marine ecosystem. Therefore, implementation of Water Framework Directive (WFD) 2000/60/EC of the European Parliament and Council (23 October, 2000) places special emphasis on the management of bioindicators (in order to assess the state of coastal ecosystems and the quality of their waters).

Although the WFD includes invertebrates among the bioindicators which should be monitored, in actual fact the values for environmental monitoring checks developed and recommended by a section of the scientific community have selectively focused on the infauna (invertebrates living among soft substrates, such as sand and muds) while ignoring the invertebrates that live attached to rocky substrates (probably due to sampling difficulties arising from their hardness and spatial heterogeneity) and which can provide very important environmental information, as we demonstrate in the present guide. For this reason, the SBPQ (Sessil Bioindicators Permantent Quadrats) method proposed in this guide (which leans heavily toward rock-dwelling invertebrates) can, after being suitably adapted, make future contributions to covering this gap in the WFD (reference values and environmental quality thresholds need to be established).

4.2. The benthos, a large catalog of indicator species

We have already discussed the advantages benthos holds over plankton and nekton in terms of developing an environmental monitoring protocol that is akin to our present proposal. Nevertheless, it is important to note that while the benthos includes **several species with excellent characteristics to act as bioindicators**, it excludes many others; whether because they can move and escape adverse environmental conditions, because they are very small or simply because of their high adaptive plasticity meaning they do not reveal any responses to either significant (but not drastic) or gradual changes that may occur in the littoral system.

4.3. Tolerant vs. sensitive species, the point of departure

As already stated, environmental changes occurring in the water column that blankets coastal seabeds can influence the benthic biota, causing phenotypic signals of stress, decreased abundance or net loss of biodiversity (sensitive species), among other impacts.

The multitude of species that pass their adult lives attached to the substrate (sessile) and, therefore, cannot escape from environmental changes in their surroundings, may produce a variety of responses to different environmental disturbances. There are those that disappear or exhibit net losses in abundance (**sensitive or stenoic species**), those that can survive and prevail normally without displaying external signs of impact (t**olerant or eurioic species**), and also those that, without any decrease in abundance, can present morphological abnormalities (unusual appearance, reduced growth, stains that are indicative of diseases caused by micro-organisms, etc.) There is also the possibility that none of these predicted responses occur and the species can tolerate the contamination from toxic substances, as long as it remains within moderate thresholds that do not lead to death or produce external signs of impact over a period of time. This type of focus, however, exceeds the scope of the present work.

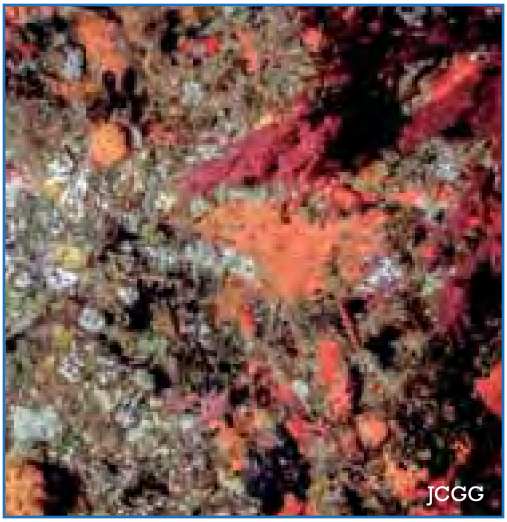
The spirit of this guide, which centers on the periodic environmental monitoring of (rocky substrate) benthic communities over time, focuses on **sensitive indicator species** and within this group the **target species** which, through their absence/presence or changes in abundance, can provide relevant environmental information that we must know how to interpret. As such, in a blue world reluctant to uncover its secrets and in which aerial photography or satellite imagery prove to be ineffective tools for monitoring its evolution (unlike they are on earth), it is recommended to capture "**zero or initial" states**, in pristine sites with structured, stable environments (whose benthic communities, whether climax or pre-climax, hardly fluctuate with the passage of time) that are threatened by different vectors due to their proximity to anthropized zones. The aim is to monitor the temporal evolution of such **target species** and, very importantly, to record the "before" and "after" situations corresponding to any environmental impacts that may occur either suddenly (accidentally) or slowly but more permanently (due to more global and "softer" causes).

The monitoring tool we propose is, at the very least, an **underwater environmental warning protocol** that will enable the detection of both short- and mid-to-long-term changes in the benthic system. The protocol described below specifically relates to the **temporal evolution of the coverage of sensitive target species framed by permanent quadrats** (fixed to the substrate), which allows short-, mid- or long-term losses, stabilization or gains to be clearly quantified. It is designed to foster the creation of large and long-term temporal data series and follows the philosophy of BACI methods (Before/After, Control/Impact) (Green, 1979; Underwood, 1992). The SBPQ method includes a non-invasive sampling and data collection technique, plus it means that important changes can be detected by the naked eye (as comparisons are made with images superimposed over the same permanent quadrats, although cross-referencing with data from other sentinel stations in the same network is encouraged). However, a more scientific approach is required to verify whether or not the changes are significant, for that we recommend that the temporal coverage matrices for the selected taxa are processed by professionals using repeated measures statistical analysis (Lanyon and Marsh, 1995), so that the periodical observations are focused on the evolution of the target species in the permanent quadrats. The selected species are generally of such a size that they can be identified *in situ*, thus the observer can recognize them with relative ease. We have avoided, therefore, the inclusion of physically small species that are impossible or extremely difficult to identify while diving or even in periodical photographs of the permanent quadrats.

Tolerant or eurioic species possess a broad ecological valence and high adaptive plasticity (**photo 6**). They are found in both stressed and uncontaminated environments, plus they not only tolerate moderately or severely disturbed situations but can also become **transgressive or invasive** species if there is an abnormal increase in their numbers (displacing other, more sensitive species). Hence they can be used as **indicators of environmental stress or contamination**. Contrastingly, the **sensitive or stenoic** species have a narrow ecological valence, limited capacity to adapt to different habitats and, therefore, target waters of a high environmental quality. They are unable to adapt when conditions worsen (or they adapt very precariously). Consequently they are potentially regressive and also the species which provide the greatest amount of information in underwater environmental monitoring controls when implemented according to the action protocol explained below **(photo 7).**

It should be clarified that a species sensitivity can be either directly (the given species cannot tolerate the new environmental conditions) or indirectly related to a disruptive factor. As an example of this point; a vagile predatory species (capable of moving over the substrate) could tolerate the presence of a certain degree of pollution that, in itself, would not eliminate it from the system but could lethally affect its prey. Of course, as its prey disappears so will the predator due to a lack of food (this could be the case with certain species of nudibranchs that specifically prey on sponges, if the sponges disappear because they cannot tolerate the new conditions, caused by increasing organic contamination, for example). Therefore, the predatory species in our example is not directly sensitive to the disturbance being contemplated but it is, however, indirectly related as it would be seriously affected by the lack of prey, leading to its inevitable disappearance from the altered system (García-Gómez, 2007).

Phot. 6



Phot. 7

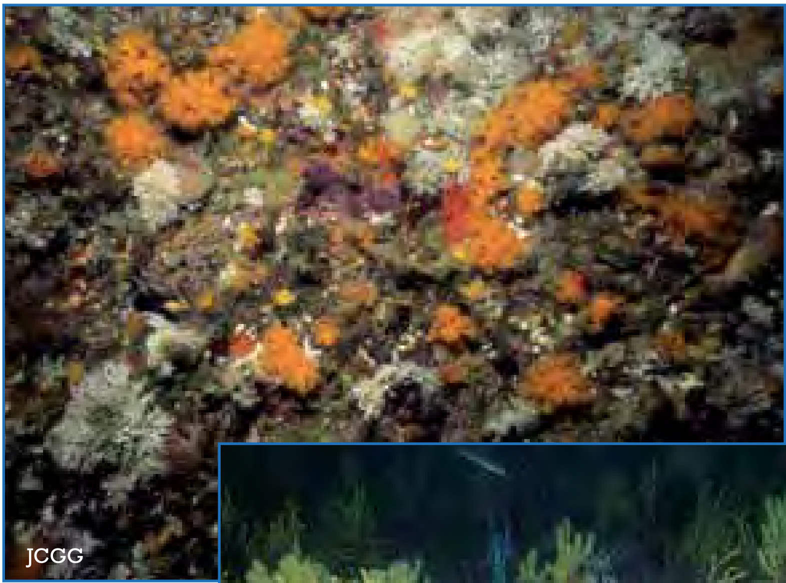
5 TARGET SPECIES SELECTION: IMMOBILITY (SESSILE SPECIES), LARGE SIZE AND ABUNDANCE, THE KEY ASPECTS

Divers who wish to be involved in the monitoring of our coastal seabeds have to overcome some significant difficulties. The first being that the dives themselves are always very limited, so they must be very well organized in order to extract the maximum benefit from each of them. Secondly, vivid colors (such as red and orange) fade at just a few meters depth until they are lost to the domination of blue (the wavelength in the spectrum of visible light that penetrates the furthest into water), thus it is impossible to distinguish the eye-catching colors exhibited by the organisms inhabiting our rocky seabeds, particularly in shady areas or below a certain depth. And thirdly, partly due to the aforementioned, it can be very difficult to identify the species which can be used as bioindicators in the monitoring of our littoral environments, so it is important to be trained to do it correctly. These points give rise to the motive for publishing this guide to indicator species. Divers should familiarize themselves with it before selecting an appropriate target species that will define the location of the monitoring quadrats and, hence, that of the underwater sentinel station where the quadrats will be installed.

5.1. Criteria for selecting the most suitable rock-dwelling sessile bioindicators

Sessile bioindicators in adulthood make up the selected group of organisms from which we must choose the **target species** for the implementation of the environmental monitoring protocol detailed in this guide. Nevertheless, **not all of the group's species are sessile** (it could also include tolerant species) nor do they all have the correct characteristics to be monitored by the coverage analysis technique used in the environmental monitoring protocol proposed by the present guide (for example, because they do not possess "agility" in their response to impacts, or because they are so small so they cannot be captured in photographs or disappear in poor resolution).

Starting from the basis of our ability to identify a **benthic species as a sensitive indicator**, it could be selected as the **target species** for purposes of periodic monitoring via images as long as it fulfils these three basic requisites: **1) Stationary** on the seabed (i.e., the species must be **sessile**, because it is **attached** to the substrate throughout adulthood, thus permitting its presence/absence within the quadrats to be periodically measured while eliminating the possibility of escape or displacement); **2)** To be **moderate or large in size**, so that the diver may easily discover and recognize it *in situ*, and so it appears in high resolution in the periodic photographs of the quadrats being monitored; and **3)** It



Phot. 8

Phot. 9

should be **abundant** (or common, but never rare), as this not only implies its firm and non-accidental presence in the habitat that it is to represent, but also so that its possible disappearance or notable population decrease at a local level is directly related to significant environmental changes in its habitat. In **photos 8 and 9**, presented as examples, the orange *Astroides calycularis* and yellow gorgonian *Paramuricea clavata* corals, both sensitive species, comply with the three premises presented above.

A further advantage is if they enjoy a **long life** (e.g., the gorgonian *Paramuricea clavata* can live for several years) and are **continuously present throughout the year**, since the same individuals or colonies can, with their presence, provide

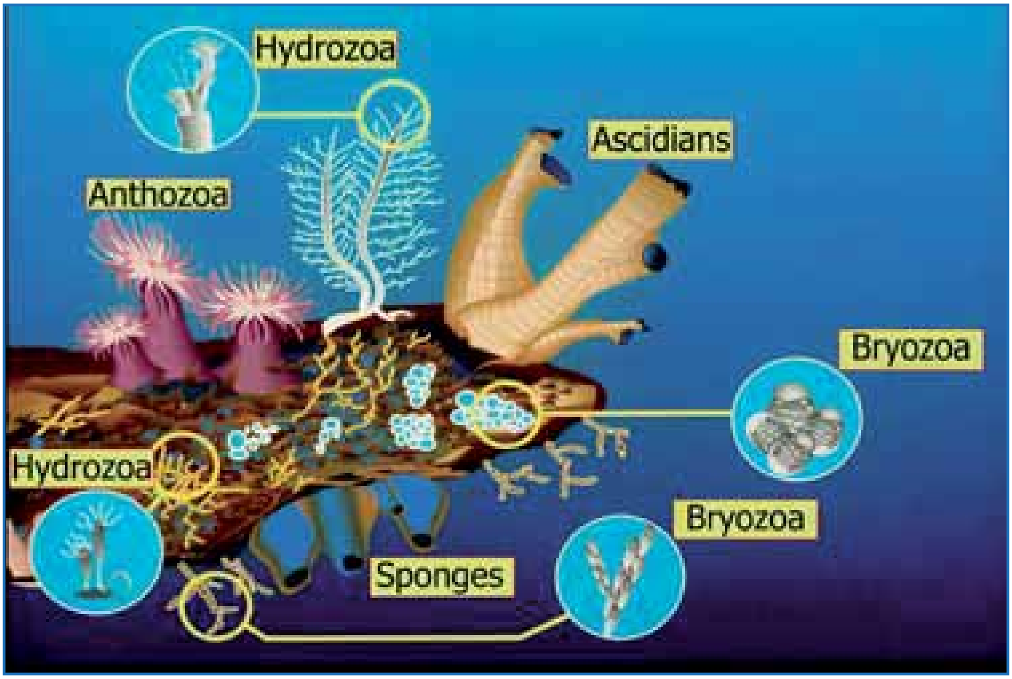


Fig. 4

evidence of unchanging long-term conditions and in any period of the year. It should also be highlighted that a species distributed throughout the entire Mediterranean may not only (naturally) be absent from certain geographical areas, but it could be abundant in one zone and transitory or rare in others. Therefore, where a species' presence is transitory or rare, it should not be used as a bioindicator. Hence the concept of abundance we put across here has strong local connotations because the effective monitoring of rocky or restricted marine areas, which are neither broad nor extensive, arises from the essence of this guide.

In relation to the above, the fauna capable of providing the greatest number of sensitive indicator species for monitoring of our littoral seabeds are the **sponges**, the benthic **cnidarians** (**Anthozoa** and **Hydrozoa**), the **ascidians** and, to a lesser degree, the **Bryozoa** (**fig. 4**). Some sessile species (or even vagile, but strictly sedentary, such as certain species of marine gastropods) among the molluscs and annelids can also be designated as sensitive indicators. Among the flora, many of the **macroalgae** attached to rocks comprise sensitive species and can also contribute to effective monitoring of the ecosystem's evolution and to the evaluation of any changes occurring within it. Perennial flora life can offer valuable information throughout the entire year, while seasonal flora must be monitored in their periods of maximum development and, therefore, maximum coverage in order to produce the images necessary for analysis in accordance with the premises of the present SBPQ method.

The sensitive species that fulfil the requisites established above, including both macroalgae as well as macroinvertebrates and tunicates (ascidians) which live attached to the substrate, particularly the colonial species (**figs. 5 and 6, photos 10 and 11**), usually belong to one of three main morphological configurations (among which other intermediate types can be categorized): **1) laminar** or **flattened**, such as many of the sponges, colonial ascidians and bryozoans that carpet rocky surfaces. These species follow a "compulsive" strategy of covering the entire substrate (as such, they are programed to grow rapidly in a plane towards the edges, in as many directions of the colonized surface as possible, and to avoid growing upwards); **2) massive**, for example many of the sponges, corals and ascidians. These may adopt a spherical appearance or that of an irregular cross-section (thus they exploit a three-dimensional space and grow in all possible directions); and **3) erect** or **arborescent**, such as the form exhibited by the gorgonians. Species that take this configuration only need a minimum amount of rocky surface to erect a complex structure with hundreds of polyps or zooids that "branch out" above their competition for the substrate (similar to a leafless tree canopy, while their branches tend to be planar so they may place them perpendicular to the current and optimize food capture), thus minimizing the effect of competition for the substrate.

Among the macroalgae, those of an erect configuration are the most frequent (greatest number of species) and the ones presenting the largest size range (from small species standing at little height above the substrate to the giant laminarias). Laminar forms are also typical in well-lit and moderately shaded zones, encrusting calcareous algae are particularly representative of this group. The massive configuration is the rarest formation and clear examples of the globular shape can be observed in specific species, such as *Codium bursa*, *Colpomenia sinuosa* and *Lithophyllum byssoides*. Among the macroinvertebrates that are "prisoners" of the substrate, all three configurations are common as long as the ecosystem is mature and well-structured, the strong competition for space displaces the laminar morphotype species in favor of the massive and erect forms which assume the majority of

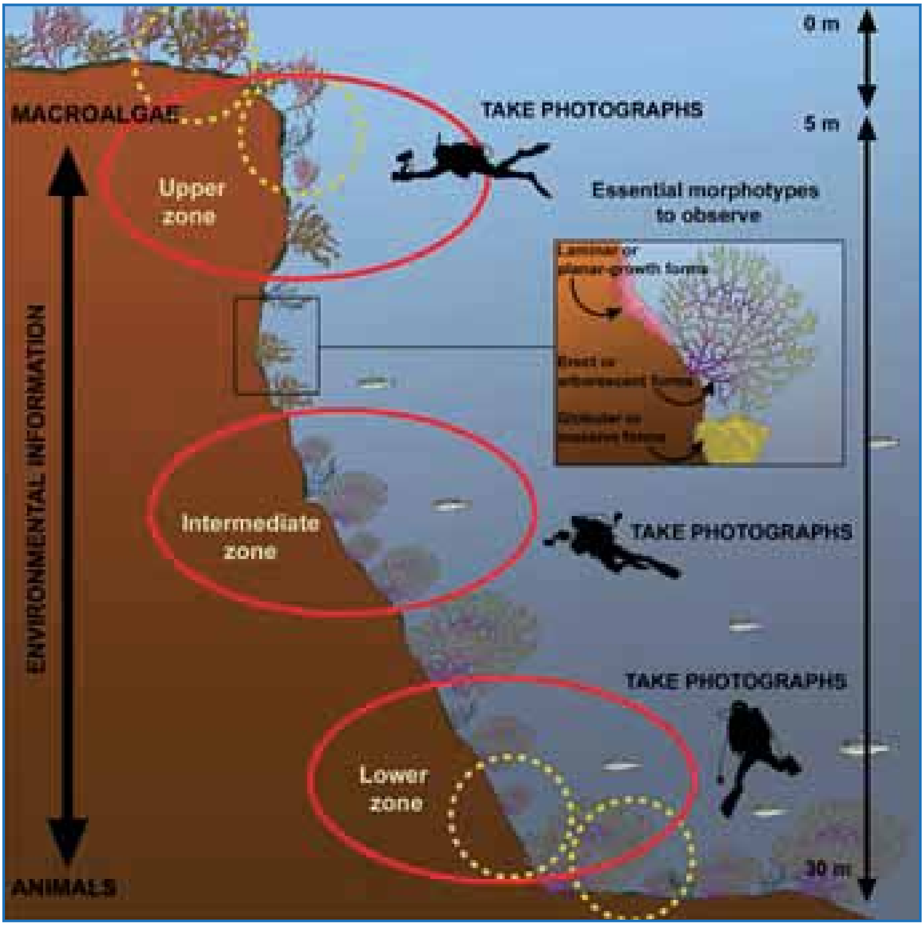


Fig. 5

useful coverage of the rock surfaces available.

Alternatively, one should also consider that in environmental monitoring which uses images of the sentinel stations' quadrats, the eventual disappearance of sensitive indicator species could be accompanied by the intrusion of new species that did not previously inhabit the area being monitored. This could reinforce the hypothesis of an environmental disturbance, whether due to physico-chemical changes in the media or because the new species could be considered an **invasive species** (which would also represent a disturbance, although the pre-existing physico-chemical parameters of the water column remain unchanged).

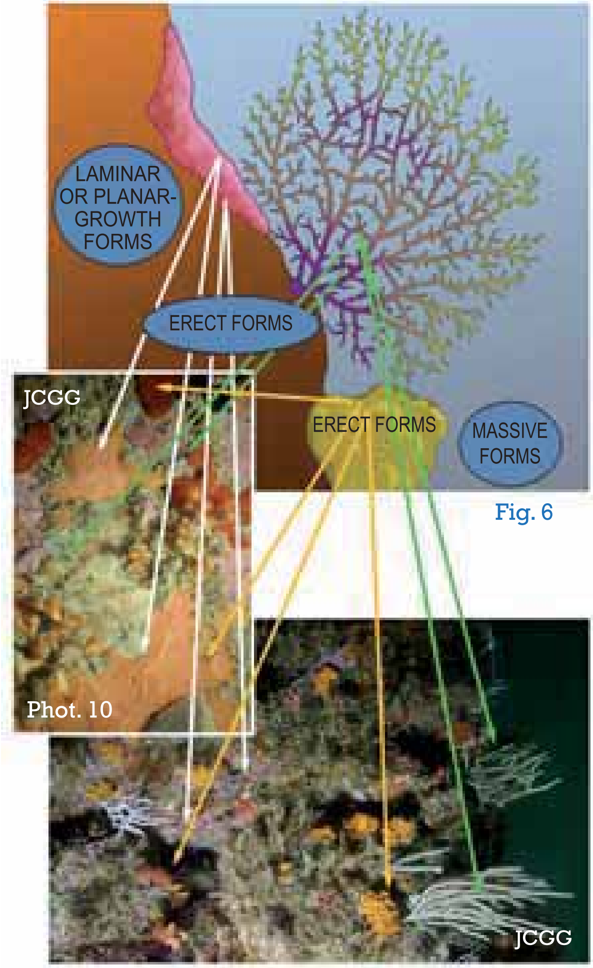


Fig. 6

Phot. 10

Phot. 11

5.2. Marine phanerogam meadows

The marine phanerogams, particularly *Posidonia oceanica* and *Cymodocea nodosa*, can also provide ideal target species for the implementation of underwater monitoring controls (in addition to the these two species, there are three other eligible species found in the Mediterranean: *Zostera noltii*, *Zostera marina* and *Halophila stipulacea,* the latter, with origins in the Red Sea, is only established in the Eastern Mediterranean). They can form dense meadows over soft substrates, while *P. oceanica* can also inhabit rocky zones. It is a good idea to become familiar with the peripheral borders of the meadows because they can provide indications of their environmental stability, progression or regression in function of whether the borders have remained stationary, advanced or retreated (the use of light-weight sampling quadrats can facilitate this measurement, see the example in **photo 12**). In this respect, the borders located at the ends

Phot. 12

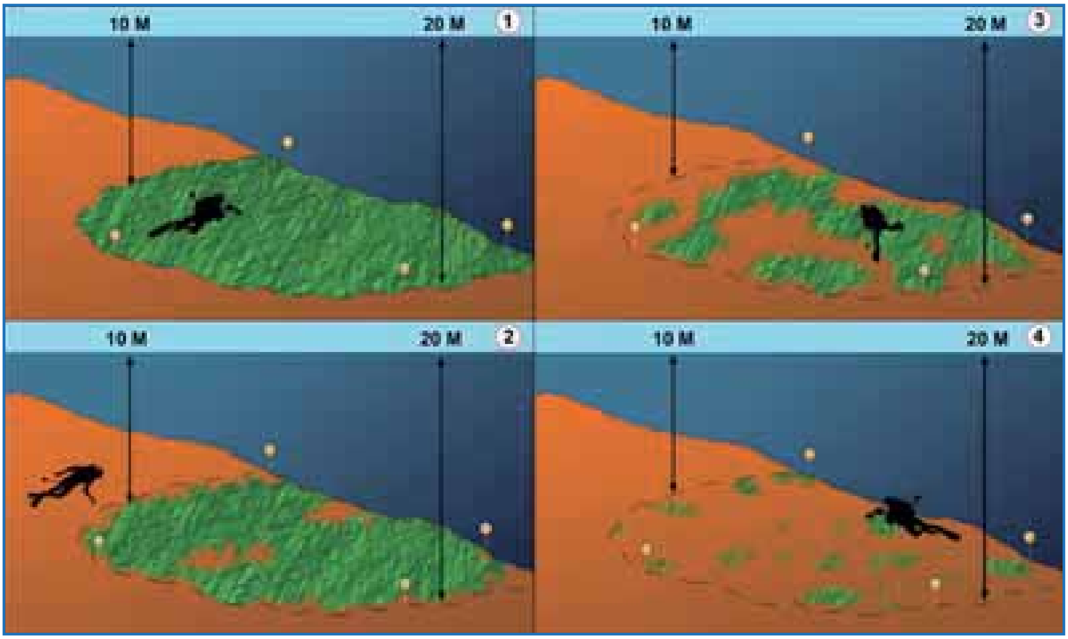


Fig. 7

and furthest from the coastline, as well as those at lesser and greater depths, offer excellent information. **Figure 7** shows a hypothetical case of a meadow regressing until it totally disappears.

As they are primarily associated with soft substrates, they do not form ideal species for their adaption to the underwater environmental monitoring protocol presented in this guide. Nevertheless, regarding its use in coastal strip environmental monitoring programs, the deepest border of the meadows is especially relevant; if the water column becomes progressively more turbid as a result of a small yet continuous source of organic pollution (e.g., from wastewater discharges), the frontier will retreat to shallower depths where the light suits the plant's requirements for photosynthesis. For example, if the deepest border initially marked by a diver was at 20 meters, then in the next control it is measured at 15 meters, the retreat could be caused by an increase in turbidity derived from a persistent pollution event akin to the one cited earlier (**fig. 8, photo 13**). It may help to mark each border, with not only the exact bathymetric measurement (which can be read with a bathometer placed on the substrate), but also by placing small, colored cork buoys (preferably less then 10 cm in diameter, with a short cord so they remain close to the seabed and are less likely to be lost), or metal stakes, preferably aluminum, also colored, solidly and vertically buried in the soft substrate, so that the colored part emerges at least 50 cm above the seabed to divers find them (**photo 14**).


JCGG

Phot. 13

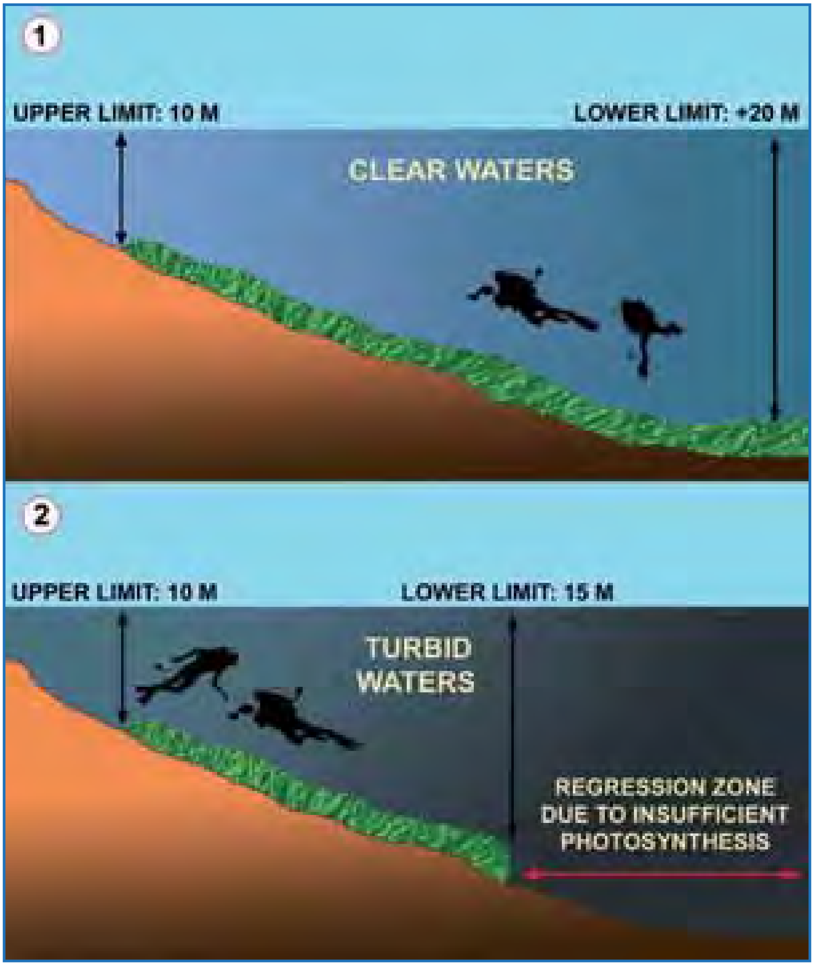

1
UPPER LIMIT: 10 M
LOWER LIMIT: +20 M
CLEAR WATERS
2
UPPER LIMIT: 10 M
LOWER LIMIT: 15 M
TURBID WATERS
REGRESSION ZONE DUE TO INSUFFICIENT PHOTOSYNTHESIS

Fig. 8

Phot. 14

6 COMPLEMENTARY BIOINDICATORS

6.1. Invasive species

Allochthonous species are flora or fauna that, due to anthropogenic actions, have been introduced into areas outside their natural distribution range. As they compete for local resources (space, nutrients) these species can become a direct threat to autochthonous ones and may even displace them completely, thus constituting an agent of change. In such cases they are called **invasive species.** According to Boudouresque and Verlaque (2002), the most telling factor for distinguishing invasive from allochthonous species is that their invasive potential may be proven in other parts of the world.

The following characteristics are primarily responsible for making these species such competitive and highly proliferative organisms:

- **Broad ecological amplitude**: they easily colonize environments with very different characteristics, tolerating a broad range of environmental conditions.

- **High vegetative propagation capacity**: they multiply very efficiently without resorting to sexual reproduction.

- **Effective predator defense mechanisms**: they possess substances or structures that are indigestible or toxic upon ingestion.

Invasive species represent one of the greatest threats to the biodiversity and balance of autochthonous ecosystems. Starting with the progressive displacement of their competitors, i.e., native species, they can eventually transform the entire biological community (Abrams, 1996; Walker and Kendrick, 1998), causing complex structural and functional changes in the host ecosystem (Galil, 2007 and 2009).

The number of introduced species has increased notably across the world in recent decades, due to factors such as the disruption of natural frontiers, aquaculture, trafficking of exotic species and, above all, an increase in international transport. Several invasive, sessile benthic species, both fauna and flora, have been introduced into the Mediterranean from different geographical areas. In fact the Mediterranean is home to more introduced species than any other sea; it holds over 700 invasive species, around 50% of which are currently well established (Zenetos *et al*., 2005).

It is expensive, and sometimes even impossible, to control and eradicate a well-established invasive species. The best way to avoid these problems is through prevention, by identifying potentially invasive species and impeding their establishment. Early detection can be a decisive factor in their eradication by helping to stop their spread. Divers involved in coastal environmental monitoring should, therefore, receive appropriate training in how to detect invasive species.

Listed below are the main invasive, sessile species that should be taken into consideration for identification while diving (Otero *et al.*, 2013):

Algae
- *Acrothamnion preissii*
- *Asparagopsis armata*
- *Asparagopsis taxiformis*
- *Caulerpa racemosa var. cylindracea* **(photo 15)**
- *Caulerpa taxifolia*
- *Codium fragile sp. fragile*
- *Lophocladia lallemandii*
- *Stypopodium schimperii*
- *Womersleyella setacea*

Angiosperms
- *Halophila stipulacea*

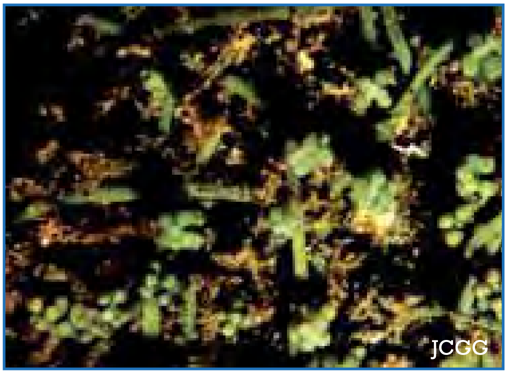
Cnidarians
- *Oculina patagonica* **(photo 16)**

Ascidians
- *Herdmania momus*
- *Microcosmus squamiger*

Molluscs
- *Arcuatula (Musculista) senhousia*
- *Brachidontes pharaonis*
- *Chama pacifica*
- *Crassostrea gigas*
- *Limnoperna (Xenostrobus) escurris*
- *Pinctada imbricata radiata*
- *Spondylus spinosus*

Strictly speaking the molluscs *Venerupis (Ruditapes) philippinarum* and *Crepidula fornicata* are sedentary and not truly sessile in adult stages, but they should also be included for the present purposes.

Images of these aforementioned species (*Asparagopsis armata, A. taxiformis* and *Microcosmus squamiger* are defined as tolerant species in the present guide) can be found at the following website:



Phot. 15

Phot. 16

https://portals.iucn.org/library/efiles/edocs/2013-008-Es.pdf

It is also important to mention the non-invasive allochthonous species. These do not tend to have a negative impact on the ecosystems where they are introduced, but they can offer valuable environmental information. For example, if their distribution area augments it could be a sign of possible changes in the system (e.g., a gradual temperature increase brought about by global warming), or simply that humans have transported the species to a new site (e.g., in ships bilge water).

It is important to detect if these allochthonous species, whether invasive or not, are able to introduce themselves into stable and diverse ecosystems, displacing one or several of the indigenous species in the process. To this end, the fixed quadrats monitoring system not only facilitates detection of these species but also quantifies their presence and estimates the negative impacts affecting other organisms (such as a decline in coverage of the most sensitive species).

Furthermore, and not only during the quadrat monitoring and photographing process but during any dive whatsoever, it is very important to pay attention to the general environment in order to detect any of the aforementioned allochthonous species as early as possible. These actions can be implemented within already established technical or scientific programs, or even as part of different altruistic environmental initiatives, such as the FEDAS Marine Monitoring Network - a Spanish data exchange network concerned with information on invasive species, pollution, waste or unusual species, which is rapidly communicated to the relevant authorities so they may apply the appropriate measures.

6.2. Sensitive vagile species

Independent of the sessile target species whose selection is prescriptive for the correct application of the environmental monitoring plan proposed in this guide, other non-sessile, non-target benthic species also exist which can help to consolidate the observations (Cranston *et al.,* 1996; Whitfield and Elliott, 2002; Azzurro *et al.,* 2010; Greenstreet *et al.,* 2012).

These can move slowly over the substrate, for example, certain echinoderms or several species of small crustaceans and molluscs (included among the latter are some species of nudibranchs that, despite their small size, can be detected thanks to their brilliant colors or contrasting liveries), or they may be very mobile but have sedentary habits, such as some nectobenthic fish or others associated with the seabed (*Anthias anthias*, *Apogon imberbis*, *Thalassoma pavo*). Of the fish, the Labridae family (of which there are numerous species in European waters) is one of the most informative in terms of environmental data because its adult representatives, which require clean and rejuvenated waters, are generally sedentary or do not tend to move very far from their established habitats (García-Gómez., 2007). We have included in this guide some of the aforementioned species as an example of non-sessile fauna that can also provide valuable environmental information, thus they may serve to reinforce an environmental and ecological diagnosis of a marine habitat subjected to an ecological monitoring program.

There are also sensitive species of commercial interest, such as certain fish (grouper, golden grouper, brown meagre, etc.) or crustaceans (American spiny lobster, European common lobster), but their absence from zones where they were previously abundant does not necessarily mean that they have fled due to changes in the environmental conditions of their habitat, but have been extracted by surface or underwater fishing. Therefore, for the given reasons, **it may not be advisable to include these types of fauna in environmental monitoring guides** whose objective is to contribute to the detection of changes in the system that are **unrelated to catches** (although we have considered mechanical destruction resulting from poor fishing practices). However, periodically monitoring the evolution of species of commercial interest is certainly relevant to the evaluation of the "**reserve effect**" in protected areas (Claudet *et al.,* 2006).

6.3. Sessile species with fragile calcareous skeletons

There are also sessile species with calcareous skeletons that due to the size and fragility of their calcareous structures can, independent of whether they are sensitive or tolerant species, help to monitor the mechanical impacts affecting our coastal seabeds (Sala *et al.*, 1996; Lloret *et al.*, 2006). Taking some colonial corals (*Dendrophyllia ramea*, *Astroides calycularis*), (**photo 17**), polychaete worms (*Salmacina dysteri*) and bryozoans (*Pentapora fascialis*, *Myriapora truncata*), (**photo 18**), as examples. Since their eye-catching formations are easy to recognize during a routine dive thanks to their size and colorfulness, and as these colonies break easily in the face of abrasive action from drag nets, anchors or inexperienced divers, such species can be monitored in terms of checking their losses or the destruction of their very stable, highly-structured habitats, which also comprise very beautiful seascapes. For example, divers who are insufficiently trained to respect the seabed frequently kneel on it (to take photographs or carry out some observations, alternatively because they are incorrectly ballasted or have poor control over their buoyancy compensator). If signs of this type of damage are observed in zones where the bottom communities are biodiverse and highly structured they should be reported to the competent authorities. Accordingly, underwater photography also proves very useful when verifying before and after scenarios.

Phot. 17

Phot. 18

7 GEOGRAPHICAL ENVIRONMENT, ZONING AND BIOSTRATA

This guide has been prepared so that its methodological tool can be applied to coastal waters in the **Mediterranean Sea,** including the **Strait of Gibraltar** and **its neighboring zones**, while bearing in mind that the sensitive indicator species that form part of the guide are not distributed homogeneously and so may be absent in numerous littoral zones of these waters. This guide could be used, with respect to its approach, not only in the Marine Protected Areas, but also throughout the Mediterranean basin. The Mediterranean countries can contribute to its development with the future provision of other sensitive species that are common or abundant in their specific coastal zones.

As benthic organisms and, in our case, the choice of target species are both connected to the rocky substrate of the littoral strip it is often convenient to classify the different zones of this area into four categories: **supralittoral** (extreme environment that only has access to the sea through splashes of waves), **midlittoral** (also called **intertidal** or tidal), **infralittoral** (from the lower tidal limit down to the maximum depth in which marine phanerogams and photophilic algae can develop) and **circalittoral** (from the lower limit of the infralittoral zone down to the depths where multicellular autotrophic algae capable of tolerating low-level light conditions can survive). The bathymetric limits between the infralittoral and circalittoral depend on the turbidity of the waters, which subsequently has a significant effect on the penetrative capacity of the macroalgae and marine phanerogams. Mediterranean benthic communities extend from the supralittoral zone (the most illuminated and susceptible to drying out) down to the lower limit of the circalittoral, and from here down to the deepest, darkest depths characterized by extreme pressure (the Mediterranean has an average depth of 1,500 meters, less than half the average depth of 3,800 meters cited for the world's oceans).

Of the mentioned zones, the **infralittoral** is the one that divers enjoy the most and, within this area, we have established the maximum diving depth for the elaboration of the environmental monitoring protocol proposed in this guide to be **35 meters**. Algae dominate in the well-lit surfaces of the shallower depths, representing the majority of coverage of the biological settlements. As we descend into deeper depths and the incident light diminishes, algae numbers progressively decline in favor of fauna dominance, which become ever more abundant and species-rich. Consequently, erect and massive forms of algae dominate in the illuminated enclaves of shallow waters (**photo 19**), while sponges and colonial animals (anthozoans, bryozoans, ascidians) dominate in deeper waters (**photo 20**). However, it is worth noting that sciaphilic algae also tend to be well represented in deeper waters (they prefer shaded, low-light environments) by different encrusting calcareous species which bind and contribute to a large part of the community's bioarchitectonic structure.

To gain a graphical understanding of these points, we shall briefly describe the **biostrata or spatial structural levels** that, in the Mediterranean, can be found in well-lit zones with total macroalgae predominance and those which would exist in highly-structured, semi-shaded zones predominantly inhabited by animals. With respect to

Fot. 19

the former, we can highlight **three biological strata** (**fig.9**), with encrusting laminar forms, such as *Lithophyllum incrustans* and *Mesophyllum alternans* (stratum **1**), massive forms (*Codium bursa*) and those with a discrete

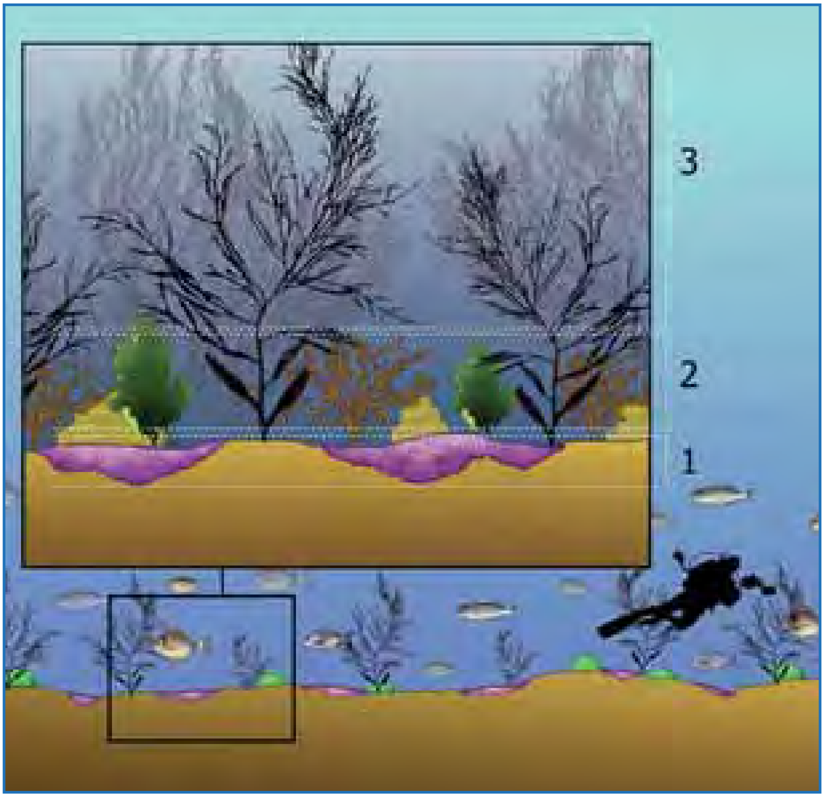


Fig. 9

erect configuration (*Dictyopteris membranacea*) (stratum **2**), and a well-developed erect configuration (*Cystoseira mediterranea, C. usneoides, Saccorhiza polyschides*) (stratum **3**). Correspondingly, the number of strata that can be categorized depends on the authors' preferences and on the diversity and morphotypes of the pre-existing algae. We have classified three levels for didactic purposes and for simplicity.

For the case of the latter, concerned with habitats where the light is very weak and the fauna predominate, we can distinguish up to **five biological strata** (**fig. 10, photos 21 and 22**), with morphotypes similar to those cited above, with epibiosis frequently observed in very compact and highly-structured environments where the competition for space becomes extreme. Stratum **1** comprises species that perforate the rocky substrate, such as the bivalve *Lithophaga lithophaga.* Stratum **2**, inert but of biogenic origin, is defined by calcareous concretions of once-living organisms. Stratum **3** comprises encrusting (*Mesophyllum alternans, M. expansum*) or perforating organisms (Clionaidae sponges) that are laminar or slightly globular in form (several sponge species) and not very tall. In stratum **4**, stand out essentially the larger and taller massive sponges (*Sarcotragus spinosulus, Crella elegans, Spongia officinalis*) or massive corals (*Astroides calycularis*) and colonial, small-sized, erect sponges (*Myriapora truncata, Omalosecosa ramulosa, Gymnangium montagui*). Stratum **5** includes species of large dimensions and with an erect morphology, generally speaking the gorgonians, upon which there are frequent manifestations of epibiosis. For various reasons (endobiosis, epibiosis, concealment, feeding), numerous species of small dimensions can live in levels 3, 4 and 5, thus they themselves intrinsically constitute a factor of diversity.

Phot. 20

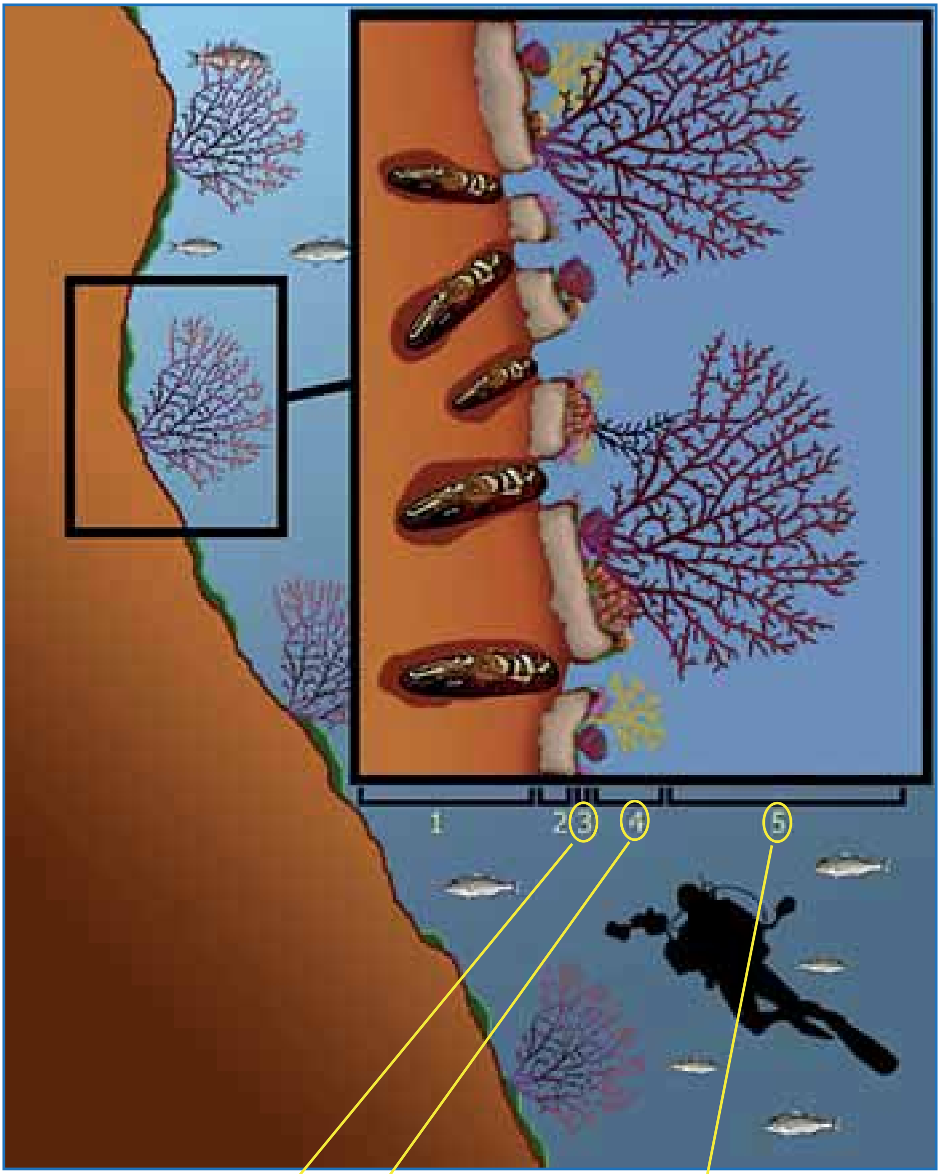
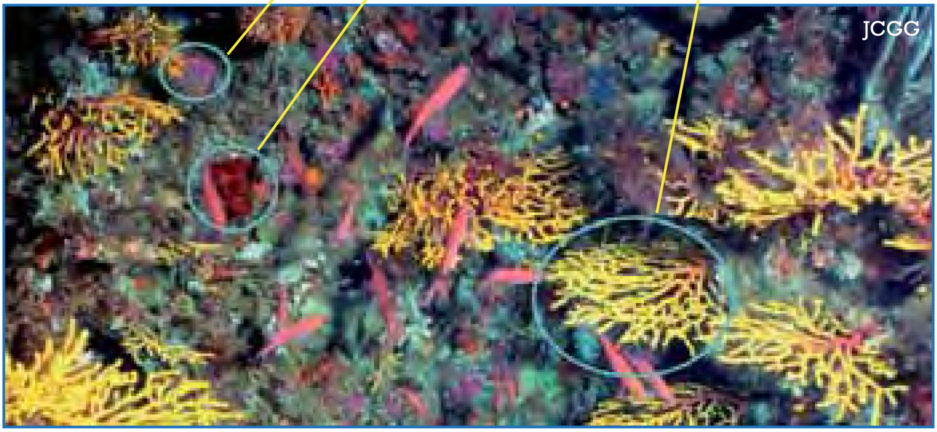


Fig. 10



Phot. 21

Phot. 22

8 IMPACTS ON SEABEDS AND INTERTIDAL BIOTA

Due to its current relevance, this section has been reproduced in its entirety from a related, preliminary work produced by the same author (García-Gómez, 2007).

8.1. Undisturbed vs. disturbed seabeds

The comparison between an undisturbed, biodiverse and highly structured system (**photo 23**) with a strongly disturbed one (**photo 24**) presents both extremes of the "continuum" that exists in a progressive process of transformation from the former to the latter. It is akin to assuming the two systems to be representations of black and white, with a range of greys existing between the two extremes. This imaginary "color gradient" exemplifies the difficulty of applying the correct environmental diagnoses to the intermediary situations, which gives an idea of the extreme complexity of the matter we are addressing. It is worth remembering that independent biological units, with different capacities to respond to anthropogenic disturbances, are not only formed from entire species but also from each of the individuals in a population (as is the case with humans, who show different tolerances and responses to the same type of disruptive event). Therefore, the overall response to a given disturbance event of a system comprised of several biological species (about which there is a large void in our knowledge) is very difficult to predict in conditions of low or moderate pollution. As numerous disruptive elements can exist within the system and be present in multiple combinations of concentration, total load and prevalence, anyone attempting to interpret the health of our coastal ecosystems is at an absolute and total disadvantage. Although the prevention, as it is in medicine, is always better than the cure, in the present case we should conform (but without detriment to the highest of expectations) with obtaining and knowing how to apply a simple method to enable the detection of negative changes in littoral seabeds which can be reported to the competent

Phot. 23

Phot. 24

authorities so they may attempt to mitigate or revert their effects.

Photos 23 and **25** both reveal a high level of organization and balance in benthic communities, with substrate-attached sessile species (calcareous algae, corals, bryozoans, sponges, ascidians) of different sizes and morphologies constituting the bioarchitectonical framework for the system and offering many other species numerous possibilities for life, including fish sensitive to water quality (*Anthias anthias*). Alternatively, **photo 24** shows an underwater scene that is practically a barren wasteland, in which the benthic diversity has collapsed and there is a sensation of total desolation.

Figure 11 helps to explain how the progressive degradation of the benthic ecosystem could occur in four stages, starting from the scenario of highly-diverse and structurally complex communities (**A**), and ending in the other extreme, a collapsed ecosystem with a generalized invasion of opportunistic algae (greenish stain in the figure) that are associated with pollution processes entailing a significant influx of nutrients (**D**). Stage **B** does not yet include any losses in numbers, but it does present morphological signs of stress (dead zones, changes in color tones, abnormal whitening, modifications in body shapes, etc.); similarly, it may be possible to observe slight or significant coverage of generalist algae (greenish stains in the figure). Stage **C** represents a warning about the worsening situation, detected in the measurable loss of numbers and notable increase in the presence of opportunistic algae (greenish stains in the figure).

8.2. Undisturbed seabeds and their identification

If there is nothing in nature to imply that life should be strictly stable over time, then we should conclude that nature is always subject to the natural fluctuations of multiple parameters and their varying degrees of impact. The red lines warning of the

Phot. 25

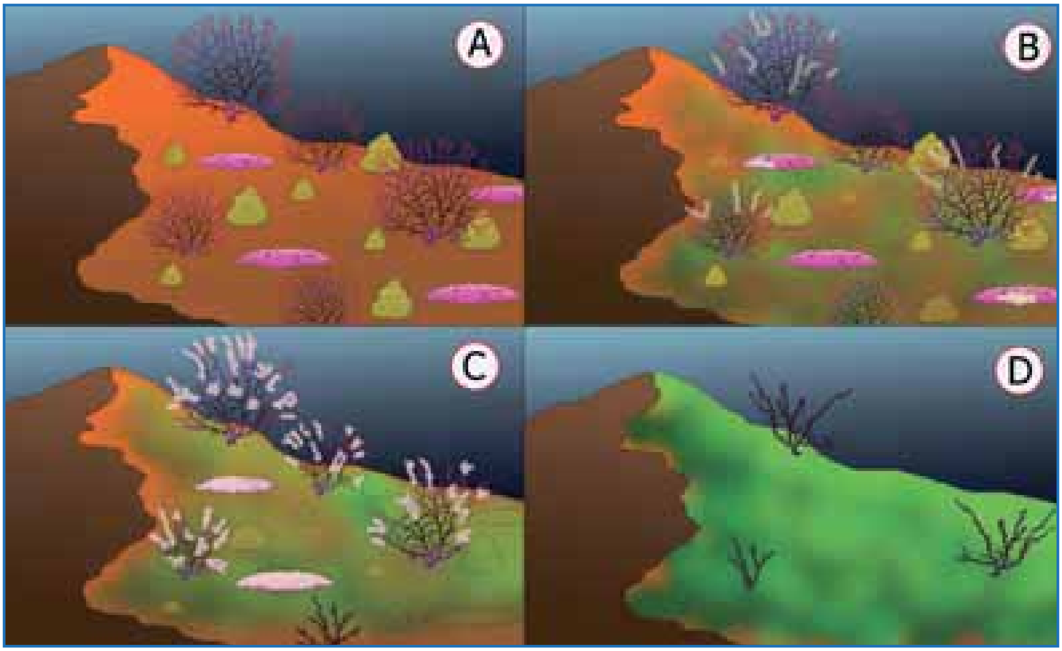


Fig. 11

passage from changes that can be tolerated by the system's structure and constituent biota, to those that cause environmental stress and functional difficulties in the biota (for individuals, populations and communities), possibly triggering mass deaths and culminating in a measurable environmental impact, are in fact only imaginary and largely depend on expert opinion. Therefore, when referring to situations of environmental stress that are specifically caused by man, which ultimately constitute just one type of change of the many that could be recognized, we prefer to use the terms **disturbed** and **undisturbed**, because in practice they are the closest and most descriptive terms for explaining situations at the level of conservation, environmental health, balance or imbalance of our coastal seabeds.

Expressions regarding littoral zones such as, "high environmental quality of the seabeds", should not be confused with ones like, "high ecological value", since the environmental quality can be high (rejuvenated and uncontaminated waters) and yet the ecological value can be low (low diversity, presence of generalist species, absence of protected species, etc.). For example, an area of reefs in open coast where the pounding of the waves is almost constant could be of high environmental quality (as the waters are very clean and uncontaminated) but of low ecological interest because there are few species and a very low degree of ecosystem organization, due to the constant mechanical impact of the waves and the intense subsurface motion this causes. The opposite, however, does tend to be true; in other words, an area of "high ecological value" in a good state of conservation is, by extension, of "high environmental quality" (unless an undetected pollutant has been introduced to the community's structure and composition). Furthermore, it is not necessarily true that the "high" environmental quality of certain waters is associated to their purity and transparency since they may be chronically turbid and deserve to be classified as such (e.g., the unpolluted and continually refreshed waters of large-volume estuaries). Thus phrasing should be chosen carefully and set out in a context for each specific area, since the use of certain unwisely selected words or expressions taken out of context could lead to misinterpretations.

Do note, however, that the concept of "ecological value" is in practice intrinsically subjective and can also only be considered in qualitative terms and not necessarily in quantitative ones. For example, an area of low diversity and little scenic interest could be identified as a zone of "high ecological value" due to its singularity or because it may include stable populations of species classified as "at risk of extinction". This case applies, in the Western Mediterranean, to the ribbed Mediterranean limpet (*Patella ferruginea*), which is an indicator of clean and rejuvenated waters (see its description later in the guide), yet it can live in the intertidal zone of coastal stretches where there is hardly any structure in the system and a low number of accompanying species. Therefore, for this reason alone, its habitat is of indisputable ecological value as it is ecologically essential for the survival of the species.

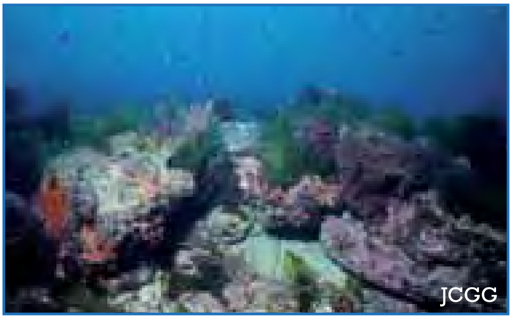
If the typical level of transparency in our littoral waters is noted to diminish with time, observed as a slow but progressive increase in turbidity, it could be a sign that foreign elements which negatively affect water quality are entering the system (for example, due to the start-up of a new wastewater discharge point in the vicinity). The opposite (decreasing turbidity) could represent an improvement in the system.

Photos 26 to 35 show some examples of different types of undisturbed seabeds, each with a high environmental quality but of varying ecological value. Simply from the appearance of the biota, one can distinguish between the seabeds which are obviously highly-biodiverse and well-structured (**photos 30-35**) from those which are less so (**photos 26-29**). In the typical diving zone, assuming a range of 0 to 40 meters, communities progressively become more organized, structured and species-rich as we increase in depth. Consequently, even though the water may be of consistently high

Phot. 26

Phot. 27

Phot. 28



Phot. 29

Phot. 30

Phot. 31

Phot. 32

quality across the rocks throughout the linear range of 0 to 40 meters, the diversity and ecological value of the specimens observed increases (in terms of structural complexity and species richness).

Phot. 34

Phot. 33

As such, undisturbed seabeds may present a low degree of spatial structure with few species, and vice versa. To identify them it helps to remember that the closer to the surface we are then the system becomes more dynamic and unstable, thus it has less structured communities and fewer species. The opposite situation is encountered at greater depths (as discussed later on), where it is easier, at least relatively, to identify undisturbed seabeds and differentiate them from disturbed ones. The reason behind this lies in the fact that seabeds containing many species and a high degree of spatial heterogeneity in the substrate-attached biota do not tend to endure

Phot. 35

any significant disturbances, while, conversely, disturbed seabeds never exhibit such diversity and organization. Diagnostic refinement, however, should be carried out at shallow depths because typically there are few species and barely any structural organization; thus, evaluations in shallow waters could be attributed to disturbances of an anthropogenic origin (e.g., organic pollution) instead of the system's natural instability (which, to a certain degree, is also a type of impact that causes stress, e.g., winter storms). In such cases, if the general lack of species and forms observed is not accompanied by a disproportionate abundance of certain substrate-attached species, then one can infer with reasonable certainty that the water is of good quality and there is no apparent motive to consider them as disturbed seabeds.

Some shallow subtidal sections can be used as examples to illustrate this last point. The water quality in these areas can be environmentally excellent, but we could be unsettled by the sensation of a prevailing lack of flora and fauna, primarily derived from the presence of calcareous algae belonging to the genus *Lithothamnium*, certain sponge species (associated with shaded enclaves) and sea urchins, among other organisms (**photos 26, 27 and 29**). Our doubts should dissipate if we confirm the absence of generalist algae (often associated with either occasional or chronic bouts of pollution), tube worms, solitary ascidians and other organisms that, in periods of affluence of nutrients or suspended organic material, numerically explode, becoming overly abundant and displacing other species from the system that cannot compete or simply cannot adapt to the new, reduced quality of the water in which they live (see **chapter 8.3**). Forests of *Cystoseira usneoides* (**photo 28**) provide another example, this time from the shallows of the Alboran Sea, where the apparently low diversity of species and monotonous seascape could be interpreted as signs of eutrophication by an inexperienced observer, confusing the cited taxon with a generalist algae. Nevertheless, the natural abundance of this species, very competitive in its own habitat, is a sign of the exact opposite, i.e., it is representative of clean, rejuvenated and uncontaminated water because it is one of the flora species that is most sensitive to deterioration in its habitat.

From the above, one can deduce that an essential factor facilitating collaboration in the monitoring of our littoral zones is knowing how to select scenarios that yield the greatest amount of information which can be easily interpreted and is eligible for observation over time. To prevent monotonous seascapes with few observable species from erroneously being classified as disturbed, it is a good idea to concentrate on the interval between 20-35 meters (the favorite zone of most divers), a zone which often forms the habitat of complex, species-rich communities, at least on the shaded vertical enclaves. Observations in this range would confirm whether there are **laminar** forms (those tending to planar growth) among the tapestry of species seen anchored to the wall, but above all whether there are **massive** and **erect** forms (which exploit three-dimensional space in order to get the most out of the spatial opportunities afforded by the system). These three morphotypes and their attachment to the substrate generate a microcosmos of biological concretions, weakly or strongly cemented to the substrate, with numerous interstices, cavities and recesses in which live many small species unseen by the diver. The beautiful seascape created by these communities is not only explained by the complex architecture of the gardens which they form, but also by the variety and intensity of the colors they frequently display (only noticeable with the aid of a flashlight in the cited depth interval). Furthermore, with the exception of calcareous algae (in the genus *Lithothamnium*) and other sciaphilic algae, the majority of substrate-attached species that are visible to divers *in situ* are generally colonial invertebrates with very diverse colorations. As these types of systems are highly-structured and species-rich, they are very sensitive and vulnerable to human disturbances. Therefore, in attempts to monitor our littoral seabeds, they make excellent subjects for divers to study in their usual diving zones where they consider, for various reasons, that there may be a threat.

8.3. Disturbed seabeds and their identification

It seems obvious that indirect laboratory methods could be used to diagnose disturbances in the marine environment by assessing the biota which is present but submerged and "unseen" (as it is small or stays hidden), or through physico-chemical and microbiological analyses which could be performed on samples of water, sediment or organisms. However, this would extend beyond the scope of the present guide which is designed to detect disturbances in the fauna and flora that, thanks to their size, can be observed *in situ* with the naked eye and without needing to collect samples or cause any damage to the ecosystem. Having said that, it must be stressed that the detection of disturbances described in these recommendations does not guarantee the nonexistence of other types of disturbances with "**invisible effects**" that may only be diagnosed by means of indirect methods similar to those outlined above. The guide is directed towards the monitoring of a well-preserved, pollutant-free littoral environment, such that a **zero or**

initial state is recorded and used as a reference for the future identification of disturbances with "**visible effects**". Reliable determinations of whether or not communities being monitored continue to be well-balanced over time can be attained by comparing the "before" (zero state) and the "after", with imbalances bringing warnings of changes whose classification would help to elucidate an environmental analysis of the situation. If one concludes that a significant change is occurring or has occurred in the ecosystem, another point is to address the cause and effect relationship. It would be the competent authorities' duty to verify the situation, to identify the cause of the disturbance and to implement appropriate corrective measures.

In view of the above and since it is advisable to select "gardened", multicolored and species-rich sites (see **chapter 8.2**) when establishing a starting point, significant disturbances can be recognized when a net loss in numbers or coverage of sensitive species, substitution of habitual species with others or, less typically, the intrusion of a new, unexpected species (invasive species) is confirmed during environmental monitoring activities.

It follows on that the identification of previously unmonitored, disturbed seabeds suffers from a lack of information concerning "the before" which prevents comparison with "the after", hence the observer starts with a clear disadvantage. Regardless of whether the observer tries to imagine "the before" (which would be an admirable but ill-advised attempt as it would fall strictly within the area of guesswork), he or she should at least try to decide whether or not there is a disturbance based on the evidence available at that time, which is a challenge in itself. The near nonexistence of life is an obvious clue (**photo 36**), whereas a scarce abundance of life is a less apparent one. And so on, until we find intermediate situations which can paint a very confusing picture. Nevertheless, though the problem may be extraordinarily complex and multifactorial, it does not stop us from attempting to estimate what is actually going on. Some of the examples presented below can help to clarify the points introduced above and simultaneously guide us through the correct diagnosis of a series of disturbances which could provide warnings about unwanted changes.

Phot. 36

Phot. 37

Phot. 38

We have already indicated that low degrees of diversity and spatial organization in benthic communities do not necessarily signify that the water they inhabit are of a low environmental quality. Furthermore, if these circumstances are observed to coincide with a low abundance of suspension-feeding organisms, usually related to the presence of organic material in the water column, it is likely that we will not be far from the truth if we assume, despite the shortage of species, that the environmental water quality is good or excellent. As already mentioned in **chapter 8.2**, this could occur in shallow depths where there are rocky patches that are hardly covered by any organisms except for the clearly dominant *Lithothamnium* genus of calcareous algae (which lend a pink or violet tone to the rocks they encrust or carpet), an abundance of urchins (which feed on this type of algae) and a few other species. The monotonous seascape can also cause confusion, but this is relieved if there are no observations, on the well-lit enclaves and vertical walls, of suspension

Phot. 39

Phot. 40

feeders which are habitually associated with high organic loads and sedimentation rates (some species of polychaete worms, solitary ascidians, dendrochirotida holothurians) or at least their abundance is minimal.

However, when there is a large abundance of suspension feeders (which are generally whitish, yellowish, or of dark or dull and very rarely bright colors) and the number of species observed is low, we should conclude that the environmental quality could be substandard (**photos 37-41**). In such cases, the water is usually turbid, has a high sedimentation rate and measurements of organic material and sediment levels in the water might be slightly elevated. **Photo 38** illustrates this assumption, indicating an abundant presence of solitary ascidians, covered by generalist algae. **Photo 37** captures a similar situation of moderate or low environmental quality, due to the massive presence of filtering tube worms (seen in the image as irregular, whitish tubes). **Photo 40** shows excessive sedimentation due to the overflow from containers used when dragging in aggregate extraction operations.

To summarise, if a low diversity of organims has been observed it is important to check whether there is an abundance of generalist macroalgae (both green and red varieties), solitary ascidians, filtering polychaetes, or a combination thereof. If one or more of these organisms is abundant, then it is very likely that the substrate is suffering some disturbance whose real extent goes beyond our diagnostic capacity. In this type of scenario, the color tones of the biological carpets are muted (including whites, greens, browns and other dark colors), in contrast to the brightly multicolored biota which typify well-preserved substrates with a high biological richness.

8.4. Vertical and horizontal enclaves

Rocky seabeds form the habitats with the greatest diversity of organisms identifiable during a dive, thanks to the stability of the substrate and spatial heterogeneity between the rocks. This biodiversity particularly applies to substrate-attached species with the capacity to act as bioindicators, which are exactly the species upon which we should concentrate when collaborating in the environmental monitoring of littoral seabeds.

Although the morphology of the submerged rock formations is intrinsically irregular, we can basically distinguish between vertical and horizontal enclaves, or those which are similar due to their layout and slope. Vertical enclaves tend to be shaded, more so as we near the seabed and particularly in caves. Horizontal or minimally sloping enclaves generally receive a lot of light, again the amount obviously declines at greater depths, while the roofs of caves, under rocks (infralapidicolar) and horizontal surfaces between large walls are essentially shaded.

Horizontal enclaves, as they receive more light, usually have a greater coverage of macroalgae and lesser presence of invertebrates than vertical surfaces, which we should bear in mind if there is little room to maneuver and we have to choose between one organism or another

Phot. 41

for the development of our own environmental monitoring program. At certain depths, where the incident light has been significantly filtered, both disturbance-sensitive macroalgae and invertebrates may coexist in such enclaves and so both types of organisms can be used as subjects for monitoring the same horizontal (or minimally sloping) rocky surface. (A preset depth cannot be established for all monitoring points since local factors such as turbidity strongly affect the bathymetric zoning applicable to benthic organisms, although in the south of the Iberian Peninsula we can consider a depth of 15 - 20 meters.) Horizontal enclaves are more vulnerable to sedimentation caused by both natural (storms and littoral dynamics) and anthropogenic events (fine sediments from various sources, e.g., the overflow of ships using suction dredgers for aggregate extraction processes, see **photo 42**; this **overflow** of powdery elements is basically a discharge of fine sediment that, in terms of turbidity, moves through the water column and slowly deposits on the seabed where it directly affects any communities established on the submerged rocks). Therefore, biota covering horizontal surfaces is more susceptible to these types of impacts than the biota attached to vertical enclaves (**photos 43 and 44**). The paired images shown in **photos 45-46** and **47-48** illustrate the "before" and "after" for two zones subjected to an influx of sediment from the overflow of a dredger.

Phot. 42

Vertical enclaves are generally richer in species and more biologically structured than horizontal ones, so they are more fragile and sensitive than the latter with respect to general disturbance processes involving the progressive loss of biodiversity. For example, even in the case of abnormal sedimentation arising from short- or mid-term dredging the horizontal enclaves may be seriously affected (less diverse and organized) while vertical ones are affected to a much lesser degree (with zones of greater structural complexity and biological richness capable of prevailing in the light of such impacts). However, during a slow but inexorable contamination process caused by wastewater discharges (for example), the mid-to-long term consequences could be worse for vertical enclaves, with massive, irreversible losses of structure and numbers of species, in addition to considerable potential losses in the horizontal

Phot. 43

Phot. 44

enclaves. **Photo 49** illustrates an episode of direct impact (excessive sedimentation) affecting colonies of the Anthozoa *Astroides calycularis* and the Ascidiacea *Stolonica socialis* on vertical enclaves. This type of impact is also evidenced on the same kind of enclaves shown in **photos 46 and 48.**

Phot. 45

Phot. 46

Phot. 47

Phot. 48

Phot. 49

8.5. Infralapidicolar enclaves and their inversion consequences

Loose rocks found in the littoral zone with subsurfaces that are not in direct contact with the underlying substrate and are thus susceptible to colonization by marine biota are known as infralapidicolar enclaves (*lapidicola* is Latin for rock-dwelling). If we overturn a stone and inspect its underside we can observe an **infralapidicolar enclave**.

This type of enclave can provide important environmental information that should not be ignored. Nevertheless, it is important to include some recommendations to avoid committing errors which could have an undesired environmental cost. As shown in the accompanying illustrations (**figs. 12 and 13**), a loose rock in the mid-littoral zone (whether intertidal or subtidal) includes a well lit surface (the top) and a shaded one (the underside), the latter basically coinciding with the infralapidicolar enclave. Fundamentally, microalgae inhabit the former and fauna the latter. As such they comprise two completely different systems which if inverted would cause an overall loss of their constituent species. There is no relevant environmental information to be found about rocks lying on and

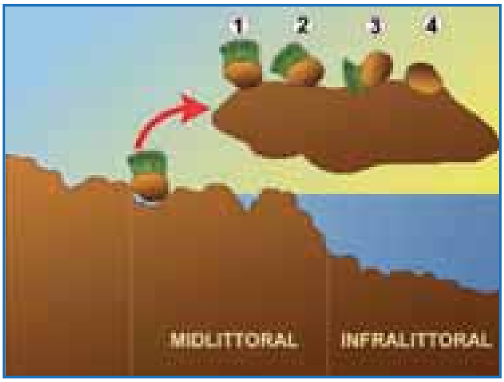


Fig.12

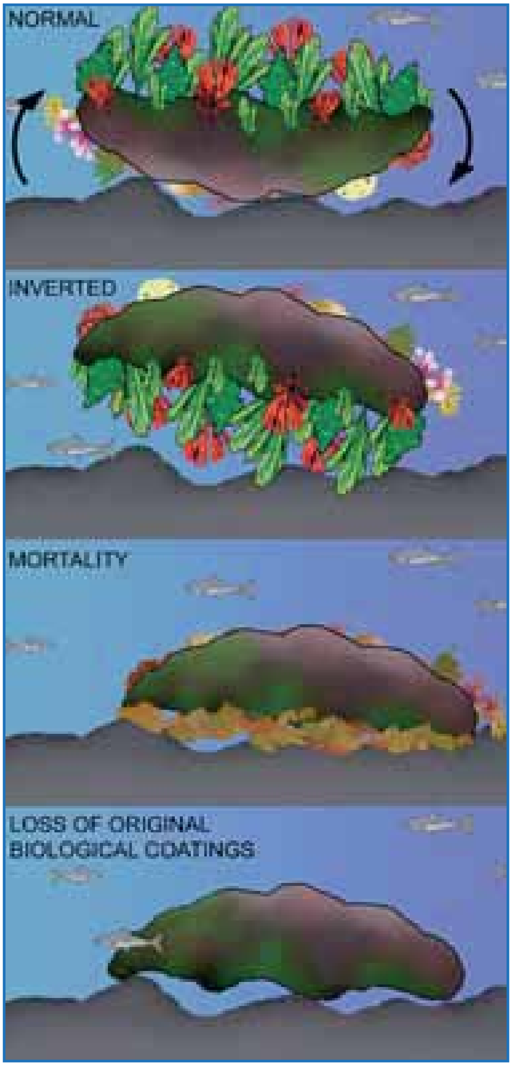


Fig. 13

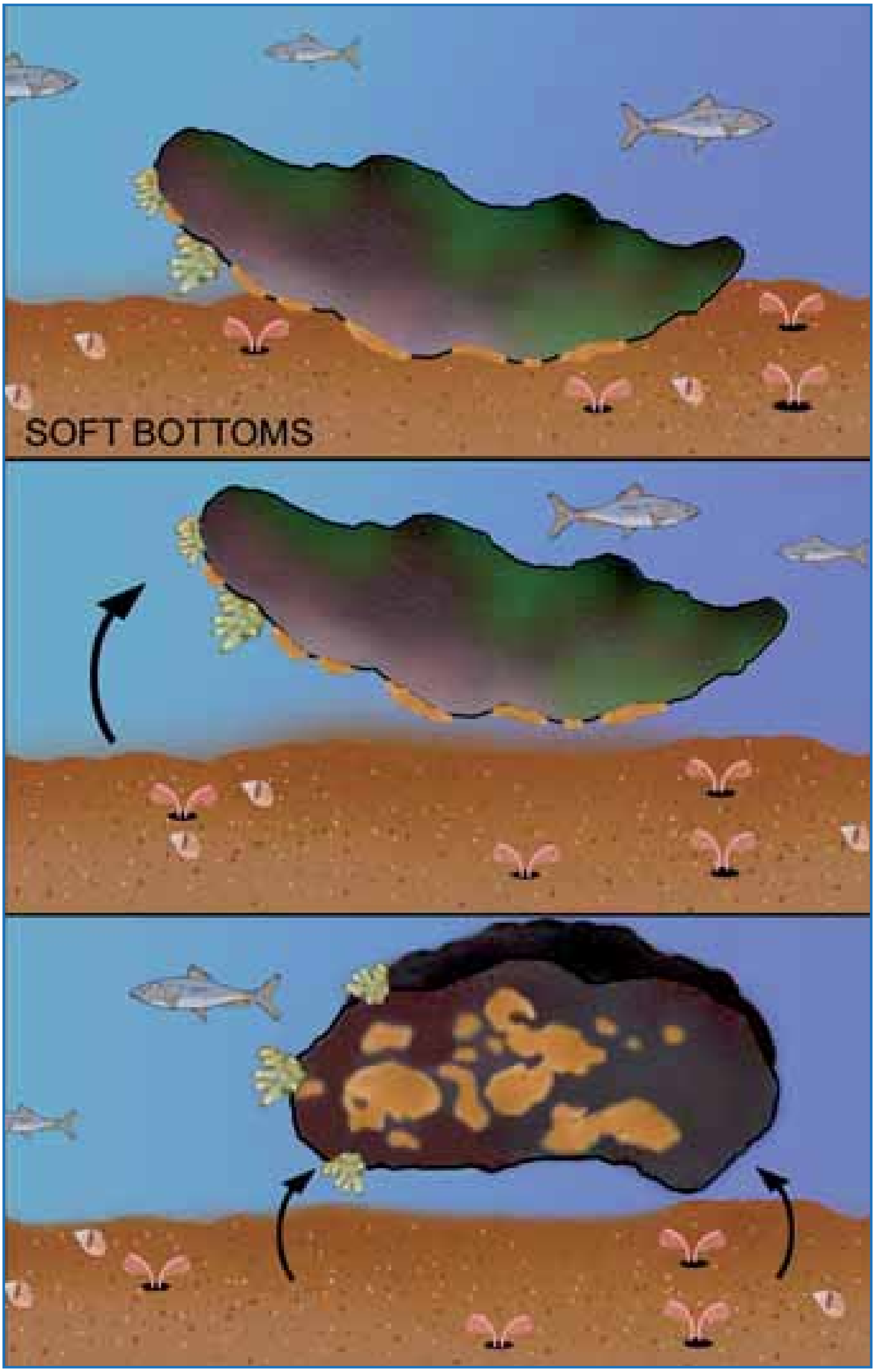


Fig. 14

practically buried within soft seabeds (**fig. 14**). Therefore, they should not be overturned because the action would not only be fruitless, but would also cause massive resuspension of sediment and introduce the possibility of affecting immediately adjacent biota.

Hence, overturing stones should be avoided in the intertidal zone due to curiosity or to capture specimens (e.g., worms for fishing bait) but, if so, the stones should always be replaced in their original position while taking great care to minimize any possible damage. These considerations should be extended, for obvious reasons, to loose rocks in the infralittoral zone which are permanently covered by water. In the case of subtidal seabeds and during the dive, if, for justifiable reasons (e.g., to obtain additional information about the state of our littoral waters), blocks, which are relatively easy to overturn, are selected, then they should be inclined to a maximum angle of 90° (stone being subjected by the diver or a partner) and not at 180° (which would cause total inversion of the surfaces and crush the macrobiota inhabiting the well-lit surface, as depicted graphically in the aforementioned **figures 12 and 13**). After recording observations and taking photographs, rocky blocks must be replaced in their original position as carefully as possible.

8.6. Undisturbed and disturbed infralapidicolar enclaves

Mechanically turning over blocks (explained in **chapter 8.5**), especially those submerged at a certain depth (from 15 m downwards) where the movement of aggregates caused by storms is practically negligible and where the physical environment is more stable, reveal the communities inhabiting infralapidicolar enclaves, which can provide important information for the evaluation and future monitoring of our coast's level of environmental health.

Infralapidicolar enclaves, representing a kind of colonized roof in close proximity to the underlying substrate, do not offer many opportunities for vertical growth (in this case, downwards) because of the lack of space and so their biota can only develop spatial organisation when loose rocks rest on top of two or more other rocks in such a way that the sessile fauna has space to develop and provide vertical growth opportunities. These enclaves host numerous organisms that can provide valuable environmental information, especially because they don't tend to suffer the detrimental effects of sedimentation (unless the rocky blocks become severely buried), and so the species living there give a reliable reflection of the physico-chemical properties of the column of water and its contents (e.g., the different amounts of plankton, suspended organic material or pollutants).

When such enclaves, in stabilized depths at around 20 - 30 meters, receive a clean and renewed flow of water (undisturbed) then their colonizing biota typically present a variety of multicolored forms and species with bright and contrasting tones (**fig. 15 and photo 51**), including organisms sensitive to any decreases in water quality, such as the comatulida (e.g., the crinoid species *Antedon mediterranea*) (**photo 50**). And so, upon overturning stones to an angle of 90°, patches and varieties of colors and, therefore, the species which exhibit them can be observed. Seabeds affected by an excess of sedimentation or organic load in the water column (which generally becomes turbid) favor the invasion of generalist or ubiquitous species, these essentially feed on suspended organic material and displace other species from the system as they become more abundant. As a result, such enclaves present a meager or minimal variety of different species (which themselves are highly-abundant in terms of numbers) plus an absence of those species which are indicative of clean waters (**fig. 16 and photo 52**).

Phot. 50

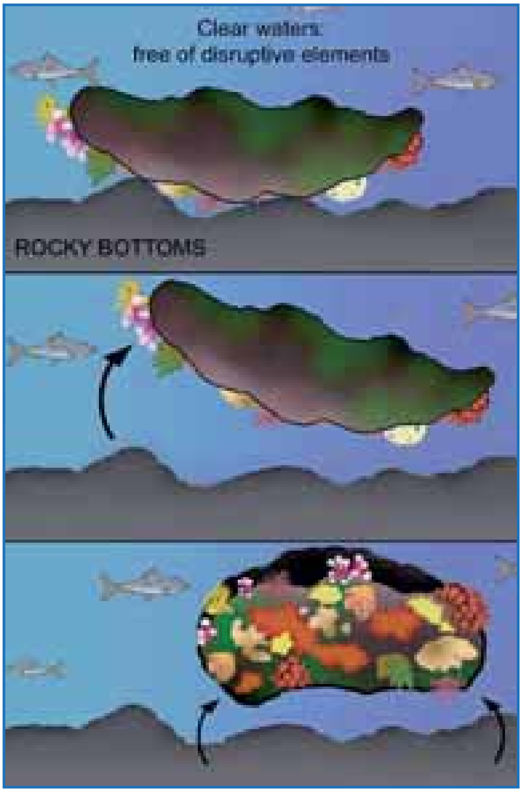


Fig. 15

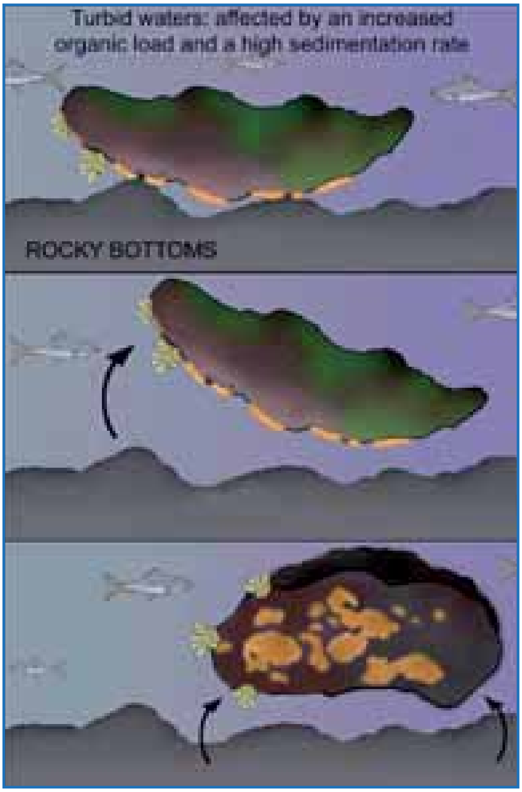


Fig. 16

Phot. 51

Phot. 52

8.7. Submerged or partially submerged marine caves

In Annex I ("Natural habitat types of community interest whose conservation requires the designation of special areas of conservation") of EU Council Directive 92/43/EEC, "submerged or partially submerged sea caves" are classified as habitats that require protection, so they are particularly relevant to this guide.

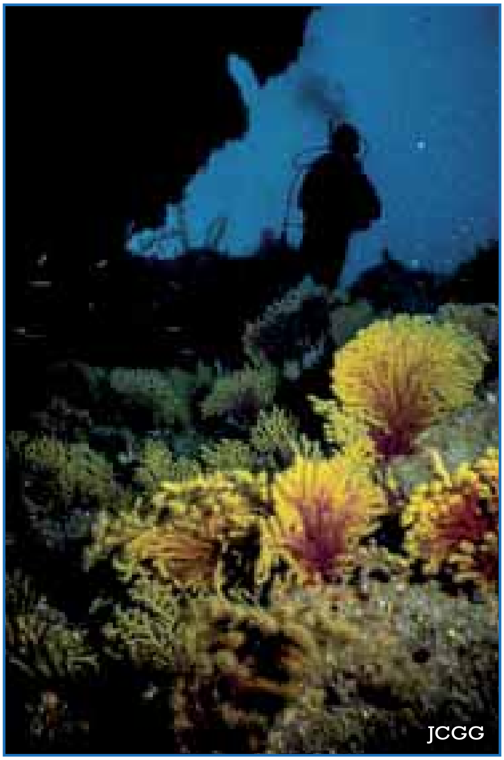
The light in cave environments progressively diminishes towards the interior, giving rise to flora and fauna distribution gradients. Beyond the point at which light becomes insufficient for photosynthesis, sciaphilic flora (which prefer shaded zones) disappear and the walls are coated with invertebrates (sponges, anthozoans, bryozoans, etc.) which eventually disappear further inside the cave where the conditions for life can be extreme. This forms the final region of the gradient were only highly-specialized organisms may survive.

Partially submerged caves are of notable ecological value, but significantly less than those which are totally submerged, particularly because the latter, at least near their entrances, host communities with more complex structures and a greater number of species. Protected subtidal species, such as *Astroides calycularis* and *Dendropoma petraeum*, can establish themselves in the intertidal zone of partially submerged caves thanks to the permanently dim light, which serves to highlight the environmental fragility of this type of habitat, particularly when faced with emerging threats (e.g., oil slicks). Deep sessile fauna (which in lives fixed to the substrate throughout adulthood) can occasionally be found in submerged caves since the severe limits of obscurity characteristic of some parts inside these caves correspond to the darkness existing at much greater depths. If the larvae of species from this zone drift with surface water currents and are deposited in this type of enclave, the dark environment of the caves could facilitate attachment and metamorphosis on the cave walls, in some cases reaching adulthood. This has recently been observed in the case of certain deep sea sponges, spectacular specimens that are carnivores rather than suspension feeders.

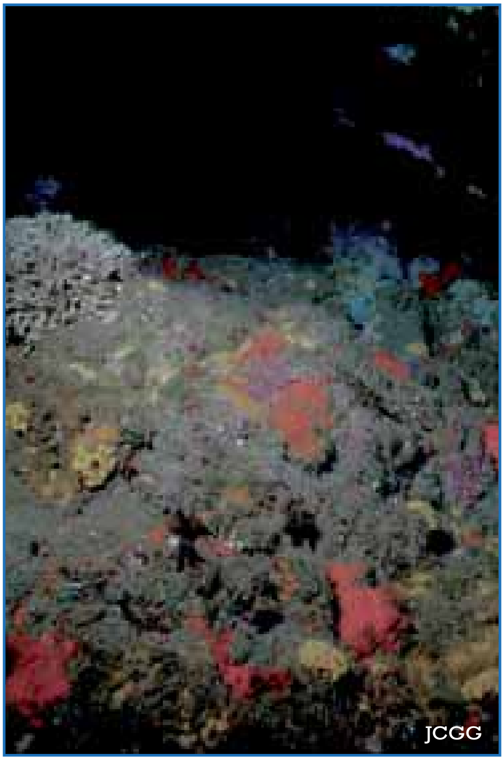
Submerged caves have a unique reputation among the itineraries of underwater ecotourists and are particularly threatened around their entrances where divers cause notable destruction to the fragile calcareous structures of numerous sessile organisms (**photo 53**), even those with corneal skeletons such as the gorgonians shown in **photo**

Phot. 53

Phot. 55



Phot. 54



Phot. 56

54 (*Paramuricea clavata*, cave entrance), which are sensitive to the abrasive actions of groups of divers who frequently visit these types of enclaves. Furthermore, the roofs of caves are particularly vulnerable to the actions of divers because if there are no escape routes for the air bubbles they produce then the air collects in pockets at the top of the roof, thus creating a surreal scenario by killing all species that coat the given area as they are no longer submerged in the life-giving water. **Photos 55** and **56** illustrate examples of cave roofs and floors, respectively, in internal areas close to the entrances.

Environmental monitoring of these types of enclaves should be carried out by focusing on whether or not air pockets exist at the top of the cave or if there is evidence of damage to the sessile fauna at or inside the entrance. If clear signs of these situations are observed, then they should be reported to the competent authorities so they may correct the tendency, give instructions to diving club guides and, in cases of submerged caves with no means of evacuating the air, consider the possibility of prohibiting diving inside them with scuba equipment. An excess of sedimentation, which can be noted over the surface of suspension feeders in the area just inside the entrance, may also provide an indication of the misuse of this habitat type as it could correspond to sediment raised up by the flippers of inexperienced divers who have poor control over their buoyancy compensators or quite simply need to improve their skills in the water.

8.8. Algal blooms

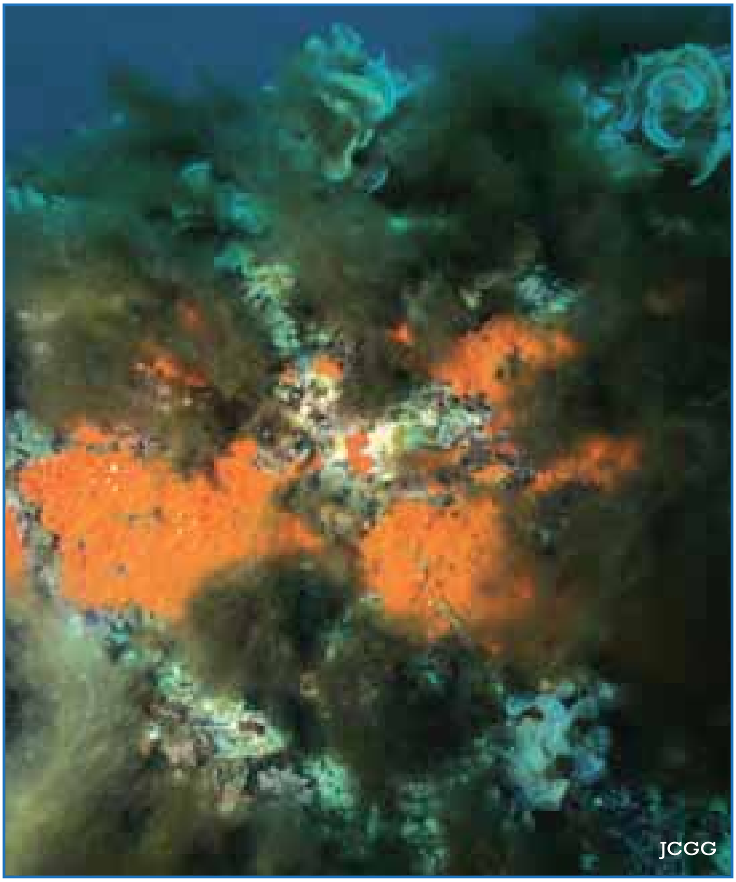
The philosophy held by this guide appropriately classifies blooms of coastal macroalgae as elements of disturbance because they are perfectly "tangible" and identifiable by observers who can physically recognize them with little effort thanks to their size. As a result of their extreme abundance they can even stain the seascape, sometimes forming genuine carpets that cover a large part of the organisms living on the substrate. However, blooms of microalgae go beyond the scope of this guide because, although the blooms can easily be observed by divers or even by traffic passing over the water (red tides), we do not recommend attempts to deal with the microscopic scale of their individuals.

Various species of macroscopic algae are responsible for these reproductive explosions that are accompanied by an exponential increase in biomass and can only be explained by an excess of nutrients that are temporarily introduced into the system, thereby over-fertilizing it to the benefit of certain algae which reproduce and grow with extreme vigor.

We have selected the brown algae *Ectocarpus sp*. (see descriptions of tolerant species), which is actually yellowish green, has a filamentous appearance and a gelatinous consistency, as an example. It is formed from long, fine strands (of up to 50 cm). It is cosmopolitan and can be seen branching out over rocky substrates or growing as an epiphyte on other large algae. The alga inhabits ranges from surface zones down to depths of several meters below the tide. It usually appears in abundance in springtime.

Ectocarpus sp. is capable of accumulating heavy metals and can appear in blooms, particularly in spring when the synergy between nutrient load, water clarity and temperature are optimal. Such reproductive explosions cause no more than a little stress to the biota that they cover (**photo 57**) unless they last a long time or if they occur in calm waters where oxygen levels can decrease near the seabed, whether due to the additional night-time respiration of the algal bloom or due to their mass death and decomposition. If this type of "carpeting plague" persists for too long then the macroalgae below could be affected, as could other types of organism. The massive presence of this algae could be associated with abnormal waves of eutrophication and, when detected, their duration, their evolution and that of the biota partially or totally carpeted by the algae must be monitored.

As we have already mentioned, there are also other species of algae which cause these visible blooms that massively coat the sessile benthic organisms. While their taxonomical identification could be very complicated or virtually impossible to the naked eye, this is secondary the aim of this guide, as the relevant



Phot. 57

point is for the observer to be able to warn about the appearance of this phenomenon (i.e., the abundant or massive presence of these types of algae) in the zones where they habitually dive and to suspect their association with a disturbance factor (e.g., an excess of nutrients produced by uncontrolled human activity is introduced into the system). Divers should try to monitor the persistence of these blooms before reporting them to the competent authorities since their presence could be short-lived, natural and practically harmless to the system.

8.9. Epibiosis (organisms living attached to others)

Epibiosis, or the ability to live on top of another organism, as with endobiosis (to live within another organism), is a naturally occurring phenomenon that, in the majority of cases, has no relation to anthropogenic disturbances. Regardless of whether there is a mutual or parasitic relationship, the fact is that epibiosis can be disconcerting from an environmental point of view. It could be a sign of a disturbance caused by an excess of nutrients and the subsequent eutrophication (e.g., the case of algal blooms presented in **chapter 8.8**) or it may confirm the highly structured and fragile nature of an ecosystem free from any type of significant disturbance. The latter case would apply to coralline beds with a high spatial heterogeneity in their communities and where the effects of extreme competition in search of space on the substrate prompts many species to attach themselves to other pre-existing specimens and use them as support. Therefore, the environmental evaluation of a given ecological scenario can prove to be very complicated, but this is no reason to immediately abandon offering suggestions about how to refine and perfect our monitoring techniques.

Photos 58 to 60 present some normal situations of epibiosis of the bryozoan species *Membranipora membranacea* growing on *Laminaria* algae. They often provide information about the age of the algae, which can be estimated from the amount of coverage, as shown in the **photo 60** image presenting a large example of an alga that is basically carpeted with the said bryozoan and has an unhealthy appearance. This type of epibiosis also occurs on marine phanerogams, such as the case of the bryozoan *Electra posidoniae* growing on the leaves of *Posidonia oceanica.* **Photos 61 to 64** illustrate the phenomenon occurring on benthic invertebrates in biodiverse, spatially-competitive seabeds, so it should be not considered as being associated with abnormal disturbances. **Photos 65 to 68**, however, are associated to moderate disturbances derived from excessive sedimentation. Green algae, such as *Codium bursa*, often have sedimentary encrustations, but if they become excessive they will enable other algae to settle (**photo 65**). This is also the case for the gorgonian *Eunicella singularis*, which is almost always free of epibionts, but when it suffers an abnormal sedimentation event, the encrustations of aggregates or fine sediments enable the attachment of generalist hydrozoans (**photo 66**). The European spider crab (*Maja squinado*) can live in zones with high levels of sedimentation, which is not only evidenced by the surface of its carapace but also by the organisms capable of settling on it (**photo 67**, the circle highlights the animals left eye). The ascidian *Halocynthia papillosa*, of narrow ecological valence and an excellent indicator of clean and rejuvenated waters, only very rarely presents epibionts and when it does, it is usually associated with occasional or persistent disturbances of a moderate nature (**photo 68**).

Phot. 58

Phot. 59

Phot. 60

Phot. 61

Phot. 62

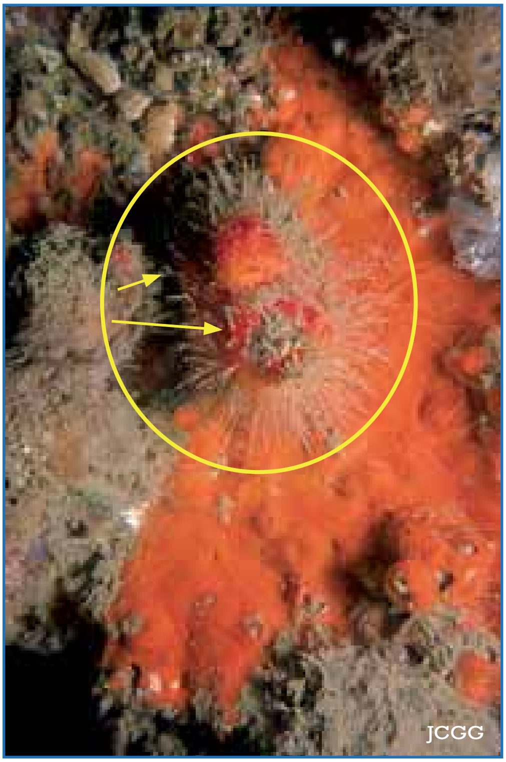
Phot. 63

Phot. 64

Phot. 65

Phot. 66

Phot. 67



Phot. 68

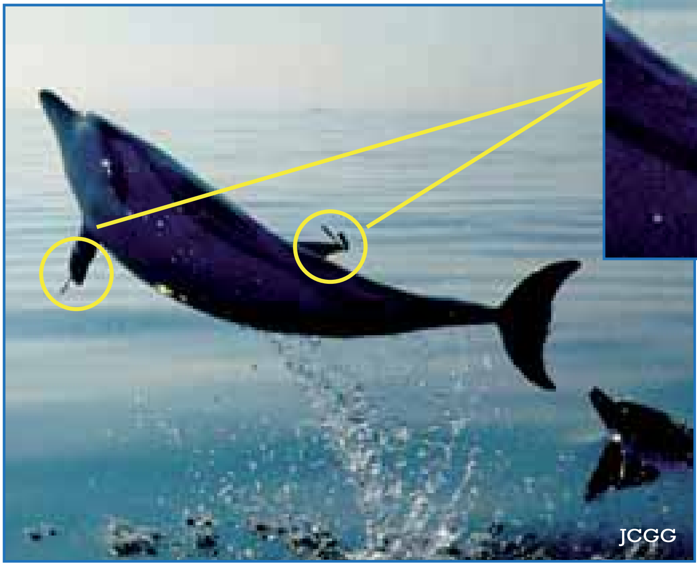
Epibiosis with a "negative environmental message" can also manifest in non-benthic marine organisms, such as cetaceans and turtles. In dolphins, which do not usually have any ectoparasites, the presence of epibionts (**photos 69 and 70**) can be a sign that the affected specimens are old or slightly ill, which could be due to a natural or anthropogenic cause (pollution). As dolphins, unlike other cetaceans, do not tend to facilitate the adhesion of ectoparasites, if by chance you observe a situation such as the one mentioned above on a specific specimen then you should try to confirm whether or not they are present on more members of the pod. If a high percentage of dolphins exhibit a similar type of parasitism then this should be reported to the competent authorities so they may deal with the case, as they could be the result of causes directly related with the contamination of their habitat. Something similar is observed in the case of marine turtles, as when they are ill they tend to have ectoparasites on their heads (supraorbital area) and can even present generalist algae. Nevertheless, situations of natural epibiosis on these types of animals, particularly in the case of older specimens, is relatively common. This last point, combined with the fact that turtles are very rarely seen and usually in isolation (i.e., not in a group), greatly hinders any attempts to draw general conclusions beyond what can be deduced from the individual sighting itself.

8.10. Nets, anchors, divers and uninstructed passers-by

The frequent incursions of trawlers at illegal depths are well known in littoral zones that do not fall within protected areas. This type of intrusion acquires special relevance in coastal areas that, due to their ecological and environmental importance, benefit from a certain degree of protection. Therefore, environmental monitoring of this type of activity in protected areas assumes particular importance, whether achieved by detecting the marks trawling gear leaves on the seabed (clearly observed in marine phanerogam meadows) or by directly observing their physical presence in areas where they are prohibited (e.g., trammels or pots) (**photos 71 and 72**). Divers should be aware of when these types of activities are illegal. They can also represent a danger to their physical integrity and should be reported to the competent authorities when detected. In this respect, poaching in protected areas is worthy of special mention.

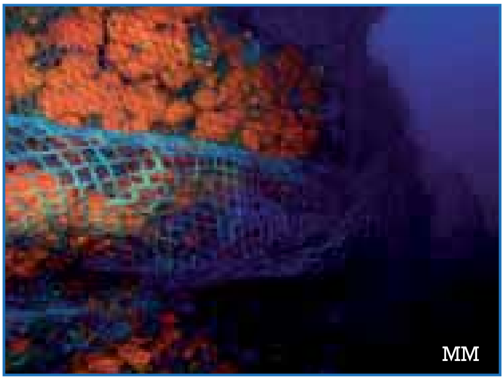
Dragged anchors cause significant damage to marine phanerogam meadows (**photo 73**) and also to the biota settled on pre-coralline and coralline seabeds (**photo 74**) which, around the south of the Iberian Peninsula, are found from depths of 15 - 20 meters. This is a trickier point

Phot. 70



Phot. 69

Phot. 71



Fot. 72

Phot. 73

to address because in the majority of seabeds the use of this kind of anchoring is not expressly prohibited. It is therefore necessary to reinforce environmental awareness among, in this case, the users of sports and leisure boats who could get involved by becoming familiar with the type of seabed where they usually like to anchor. If recreational divers, without causing negative effects with their own vessels, frequent seabeds with a high ecological value and often observe other leisure boats setting down their anchors, they should report it to the authorities who will try to correct the harmful effects and manage a method for minimizing this type of impact.

With respect to the leisure, scientific or professional divers to whom this guide is primarily directed (and who also form key elements of the environmental monitoring that we wish to encourage), we request that they exercise continual self-analysis. As such, even if they do not wish to contribute to the monitoring, at least they know the correct norms of underwater conduct, procuring to swim at a certain distance from the bottom, to avoid brushing against the seabed biota as much as possible, to avoid catching specimens for consumption or collections and, where possible, to fall in love with underwater photography, which is not only innocuous for sea life but reinforces, develops and enhances it.

Phot. 74

In the intertidal zone, especially in the platforms susceptible to abrasion, it is important that uninstructed visitors should acquire some basic knowledge about the biota so that their movements do not cause any environmental disturbances. In this regard, the abrasive effect of footsteps can be very harmful to virgin coatings of microalgae (particularly if it is a group of visitors, tourists or students who are observing a specific area of high ecological value in a protected zone). Species notably sensitive to this situation are the calcareous formations of the mollusc *Dendropoma petraeum* or of the alga *Lithophyllum byssoides*, both of which are included in this guide.

8.11. Unacceptable waste

The habitual use of the sea as a garbage tip, particularly for the owners of vessels who, for reasons of comfort, have no qualms whatsoever about discharging trash or waste from their ships, converts certain underwater areas into genuine pigsties (**photos 75 and 76**). Thus, the tidal zones in the abrasion platforms and rocky littoral strips constitute a dumping ground of waste material, frequently left by the area's unscrupulous users, and of floating garbage thrown into the sea, largely from boats.

Divers who visit species-rich seascapes of outstanding beauty should attempt to monitor any deterioration that may be caused by these types of discharge, which are typically more prevalent on the seabed and can incorporate strong pollutants (e.g., cells or electrical storage batteries for boats, which are observed on seabeds with much more frequency than is desirable). Apart from the seabed cleaning initiatives (**photos 77-80**), fortunately currently

Phot. 75

Phot. 76

being performed by numerous diving clubs around the world, divers who sympathise with the philosophy of environmental monitoring promoted by this guide can contribute by detecting and reporting previously unknown situations. For example, those derived from diving itineraries that (once again) suffer from leisure boat moorings which have no reservations about throwing all types of trash overboard, blatantly contravening the principles of environmental respect which we wish to stimulate, cultivate and transmit in this publication. In other words, if the aforementioned divers notice that their customary diving areas, supposedly of clean waters, tend to become progressively dirtier, then they should strive to discover the causes and help to stop or invert this trend.

Photograph 79 illustrates the 130 kg of lead collected by divers from the Algeciras CIES Club. Contamination by this metal can follow unsuspected routes. One of them, as we have already suggested in an earlier publication, could be through octopi which tend to introduce pieces of lead into their caves (**photo 81**) and scratch them with their beaks. The "frontal X" displayed by some examples (**photo 82**) could be related to contamination derived from lead.

One must not forget that, in addition to the esthetic impact of dumping highly persistent waste materials (and in many cases of considerable polluting power, as already explained), a part of this waste can have a direct impact on marine species, even though

Phot. 77

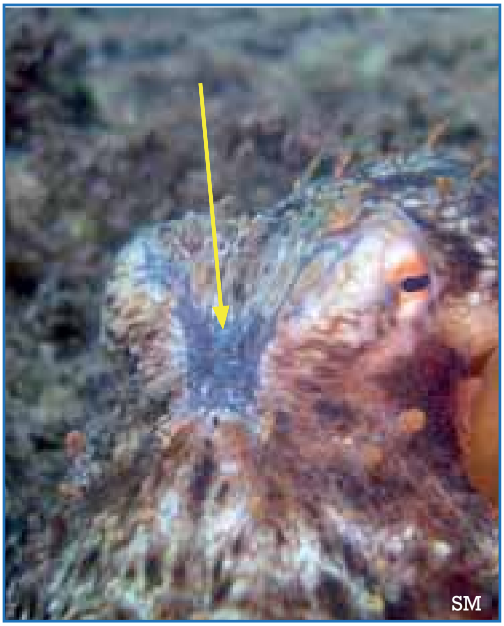
Phot. 78

we may be totally unaware that it is happening. This occurs, for example, with transparent plastics which marine turtles sometimes confuse with jellyfish resulting in severe injuries or even death (**photo 83**). Or even plastic rings, with which dolphins play but can actually lead to death if they become entangled among their jaws (**photos 84 and 85**).

Phot. 79

Phot. 80

Phot. 81



Phot. 82

Phot. 83

Phot. 84

Phot. 85

9 SBPQ METHOD OF UNDERWATER ENVIRONMENTAL MONITORING: TEMPORAL MONITORING OF SESSILE BIOINDICATOR SPECIES IN PERMANENT QUADRATS

Based on the results obtained from a pre-established 10-year temporal data series analyzed in a previous study (García-Gómez *et al.*, publication under way) and from the experience acquired in realizing the said study, we propose the following methodological protocol, the **SBPQ method (Sessile Bioindicators in Permanent Quadrats)**, as an **underwater environmental early-warning** system for the detection of ecological changes caused by local or global impacts (Climate Change). This protocol has been tested in 2013-14 within the framework of the MedPAN-North European project for sensitive zones of Mediterranean Marine Protected Areas (MPAs) and their neighboring vicinities. It strives to generate a synergistic collaboration between different social sectors regarding monitoring plans, ecological monitoring and environmental warnings for the littoral zone, with the aim of creating geographic networks that are likely to become interconnected.

Ideally, the **SBPQ** method should be used to establish **networks of underwater sentinel stations** (preferably to be assigned to pristine depths of high environmental quality, which are inhabited by structured, mature and highly biodiverse communities) where **permanent quadrats** will be installed to monitor **sessile bioindicators (target species)** previously identified as being **sensitive** to environmental changes in the system (**photos 86 and 87).** The programs to be applied will start with an initial series of images of the quadrats (**zero or initial state**), these will hold the key for future detection of whether or not any significant changes have occurred in the system and help reveal their possible causes. In the short term, the method will contribute to the detection of impacts of a more local nature, whereas in the long term it applies to those of a more general nature (e.g., derived from the slow but progressive effects of Global Warming).

Phot. 86

Phot. 87

If the target species being compared are found in geographically distant sentinel stations (e.g., *Astroides calycularis* and *Paramuricea clavata* in zones far from the Western Mediterranean where they are normally distributed), then the environmental information may have a wider geographical relevance. In such cases, **international networks of sentinel stations** could be established with participation from the different countries capable of getting involved in the environmental monitoring program of the target species selected for monitoring.

Nevertheless, if the target species are different, then wide-scale environmental information can also be relevant. For example, if the given species are sensitive to temperature changes, then such information could be used to draw an extensive map of progressive ecological changes upon combining the data from geographically very distant sentinel stations. This approach would be particularly useful for monitoring Global Warming.

The aim of our method is, therefore, to accurately observe, using a non-invasive and reliable method, and help prevent that the coverage of target species subjected to monitoring neither wanes nor disappears with time which, independent of global warming monitoring, will be particularly useful for the environmental monitoring of Mediterranean Marine Protected Areas and adjoining buffer zones of other coastal areas subjected to strong anthropogenic pressures.

9.1. Geographical area

The main geographic area, in which this guide and it methodology could be applied is the Mediterranean Sea. However, since the methodology described hereafter was firstly experimented in the Strait of Gibraltar, this guide could be thus used in the same area and in nearby Atlantic waters.

9.2. Selection of target species

According to the proposals of preliminary publications (García-Gómez, 2007, 2008) the target species should be: 1) **sensitive** to environmental changes (stenoic, of narrow ecological valence); 2) **sessile** (so they cannot relocate if environmental conditions deteriorate); 3) of **moderate to large size** (visible while diving and identifiable in photographs: in each quadrat, the total coverage of the target species in the zero or initial state must be as great as possible, **avoiding those with less than 20% coverage**, which should also be included if only one target species is being monitored); 4) **common or**

abundant in the zone; 5) preferably **perennials or with a long life-cycle**; and 6) preferably **macrophytes** from shaded zones or benthic fauna belonging to the taxa of **Sponges**, **Anthozoa**, **Hydrozoa**, **Bryozoa** and **Ascidiacea**; of which sponges, anthozoans and ascidians have the best characteristics for selection as target species.

9.3. Selection of ideal littoral zones (sentinel stations)

The littoral zone selected for the location of sentinel stations must be pristine (undisturbed), with rocky or mixed substrates, located either near to anthropized areas (important for detecting impacts on a local scale) or relatively far from them (important for detecting impacts on a larger scale, such as global warming) and easy to find (by remaining close to the coastline). Stations should preferentially be located at a depth of between 20 and 35 meters, any vertical walls must be at least 4 meters high, with structured and mature benthic communities (potential hot spots for stenoic or sensitive bioindicators, where the coverage of sessile species tends to experience very little variation with time) that contain at least one target species (colonial or individual). It is important to select sentinel station installation points that are located within the typical diving zones of recreational diving clubs and centers, thus their participation in this type of initiative requires very little additional effort.

In fact, this guide could be used not only in the Mediterranean Marine Protected Areas, but also outside of them, including the Strait of Gibraltar and the nearby atlantic waters.

9.4. Installation of permanent monitoring quadrats

- Before submerging the quadrats, it is necessary to drill holes in them and to paint them according to the requirements set out below (**fig. 17**).

Fig. 17

- A vertical wall should be carefully chosen according to the criteria presented in **section 9.3.**

- The exact location is selected for at least three PVC quadrats of 1 m x 1 m, horizontally positioned with a maximum separation of 1 m and placed at least 1 m from the seabed to avoid disturbances caused by the inevitable raising of sediments (including those due to divers' flippers). **Each quadrat must include at least one target species, which must be present in all of the quadrats (each quadrat must be represented with at least a 10% overestimate of the total coverage).** If the target species have not yet been characterized (which would open a new, future line of investigation), it is recommended to opt for species that could be "potential environmental indicators" (belonging to the taxonomical groups mentioned in **section 9.2**), but which are established in well-structured and mature rocky substrate communities (intrinsically affected by anthropization, due to the potential presence of stenoic bioindicator species) as per the specifications and taxa given in **section 9.2.** If, in order to begin the photographic series (zero state), the taxonomy needs to be ratified in a laboratory, a small sample should be extracted from an exterior area bordering the quadrats but never from within their perimeter.

- For each quadrat (with a hole previously perforated in the center of each side), manually drill 2 to 4

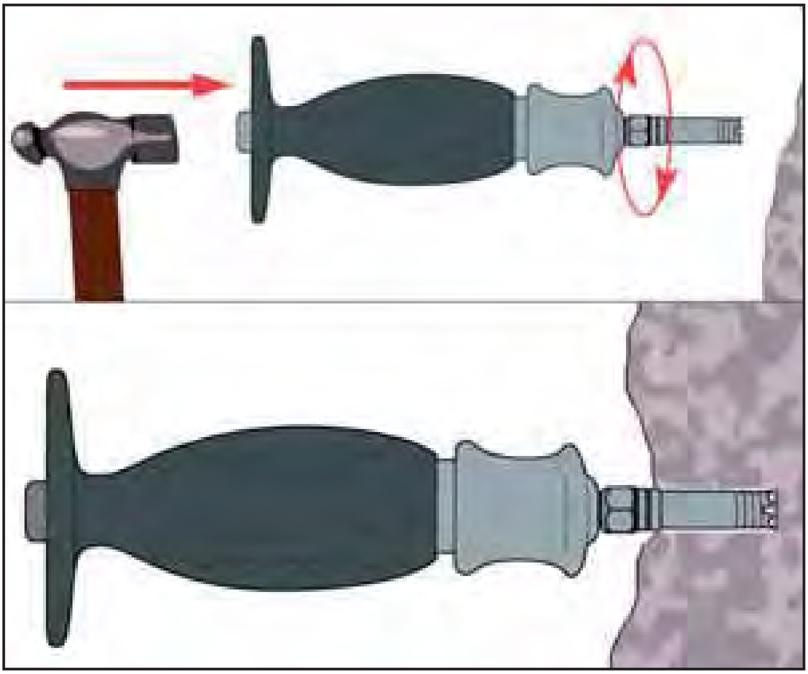


Fig.18

holes in the rock with the help of a hand drill and a traditional hammer (**fig. 18**), making sure they coincide with those in each quadrat. Fix the quadrats to the substrate by inserting adjustable metal stakes (**fig. 19**), then reinforce them with underwater epoxy cement (Ivegor, Speed Blue, among others) so they last longer. Anchor the quadrats to the wall by passing the stakes through the pre-drilled holes (**fig. 20, photo 88**). Given that the substrate's surface is usually irregular, two attachment points placed opposite each other are usually sufficient. Avoid fixing quadrats too close to the substrate, leave at least 10 cm between the quadrat and the vertical substrate so that vagile fauna can pass through.

- Each quadrat should be labelled close to each corner with one, two or three, clearly visible, painted lines (that are protected with transparent plastic) to help identify their position on the substrate with respect to the series of three quadrats. For a series of three; quadrat 1 will appear on the left of the photograph, quadrat 2 in the middle and quadrat 3 on the right (**fig. 21**). For three series of three (nine quadrats of 1 m x 1 m forming a macro-grid); the procedure is similar for each series, with series 1 being the closest to the seabed and series 3 the furthest (**fig. 22**).

- Each installation point for a **horizontal series of three quadrats** will be marked with a small submerged

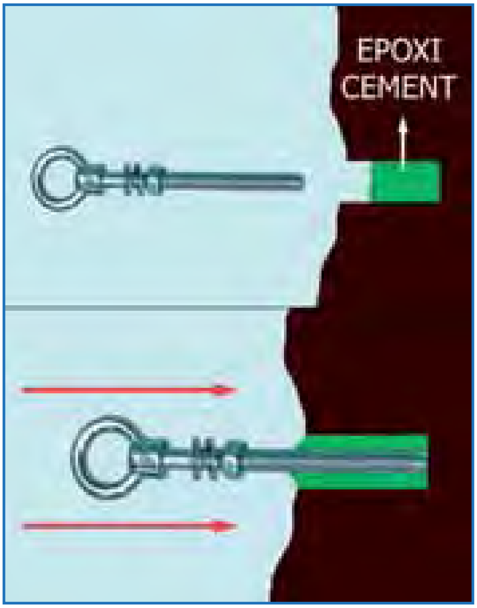


Fig. 19

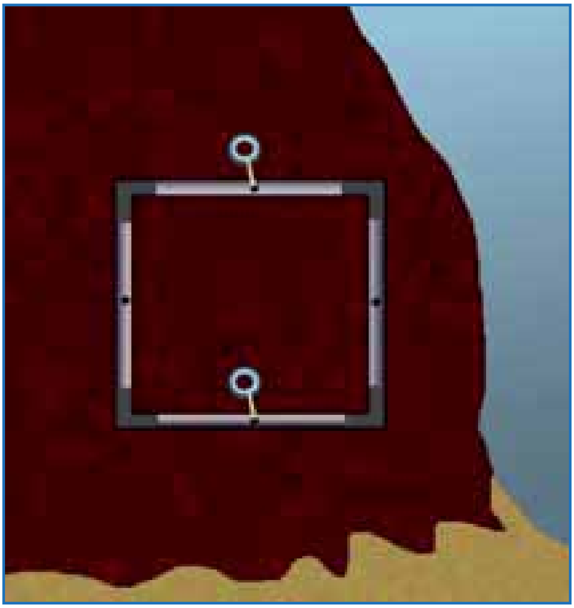


Fig. 20

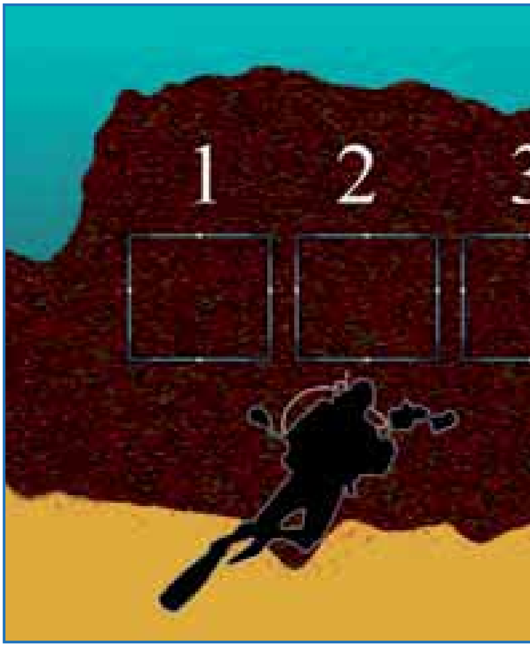
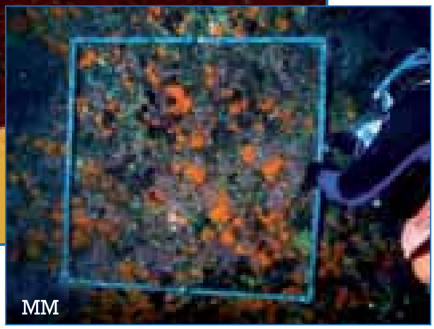


Fig. 21



Phot. 88

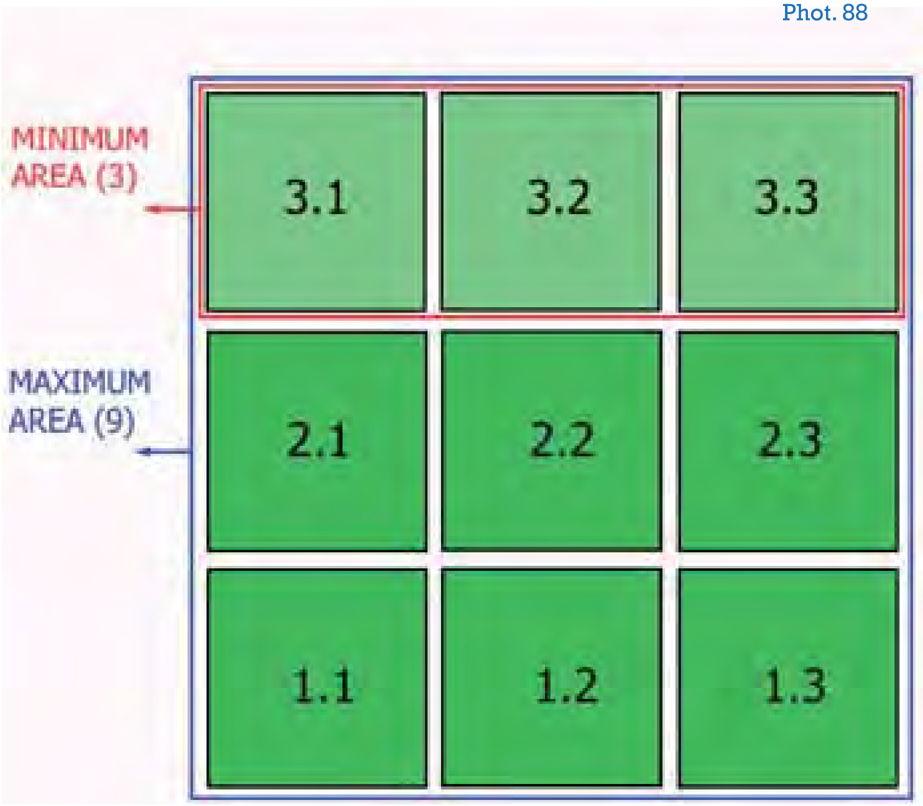


Fig. 22

buoy (with a maximum cable length of 1 m) to help localize the station when diving; similarly, in the long term, the buoys will also help if any grids accidentally loosen due to the mechanical motions of the waves and need to be repaired, since they immediately indicate the location of the holes in the substrate where the damaged quadrats should be reinstalled. Buoys should be labelled with clearly visible information about the substation, the program and contact details. They should also try to persuade divers who are not involved in the program to respect the quadrats and request that they report any incidences to the contact person who features on the label (e.g., the need to repair one of the structures).

- The only maintenance the grids require is regular revision of the marks indicating the quadrat's number and occasional repairs of any accidental damage or deterioration. With time, the quadrats will be integrated within the ecosystem by a biological coating, but they still serve their purpose for photographs and analysis of their contents, as can be seen when comparing **photographs 89 and 90.**

Phot. 89

Phot. 90

9.5. Labelling and GPS coordinates of sentinel stations

Once the quadrats have been installed, if it is inconvenient or impossible to mark it with an authorized buoy, the geographic coordinates of the point must be recorded using GPS (preferentially a differential GPS system with sub-metric positioning). In the absence of a marker buoy, two divers (one at the surface and one on the seabed) should employ the vertical rope technique explained in **figure 23** to locate the quadrats (this way they will correct any possible errors in the accuracy of the GPS coordinates). A backup copy of this information should be saved and sent to the environmental monitoring network's coordination center that geographically corresponds to the diving club or center responsible for the substation.

9.6. Obtaining underwater images starting from a zero or initial state

- *Photographic equipment.* High-quality photographic equipment is always the most recommendable option, for example, professional or semi-professional cameras by Nikon or Canon incorporating external flashes and internal synchronization (particularly complete format units). Nevertheless, the use of simple compact digital cameras (which is important for achieving the largest possible response to our proposal from diving clubs and centers) with their corresponding waterproof cases can suffice for our monitoring needs, but we do

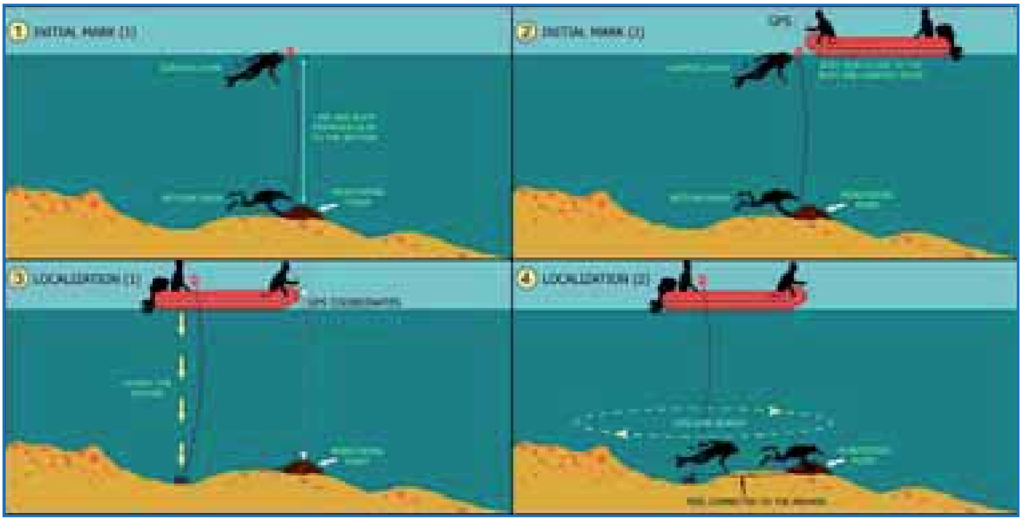


Fig. 23

recommend attaching a lateral external flash to avoid the typical front-on illumination from these types of cameras and, therefore, the unwanted reflection of suspended particles. Among the second line of cameras with a good quality-to-price ratio, the most useful are those in kits (camera plus waterproof case): Olympus (TG-1, TG-2 or TG-3 and the corresponding cases; TG-820 and case PT-052; XZ-1 and case PT-050; TG-310 and specific Ikelite case), Canon (G1X and case WP-DC44 or specific Ikelite case; S100 and case WP-DC43 or Ikelite, FIX or Patima cases for S100) or Sony (DSC RX100 and specific Patima case) and among the connectable external flashes, different Inon models (Epoque 230, Z-240, D-2000, S-2000). Images must have the greatest possible resolution, ideally a minimum of 3 MB, so they can be adequately processed. Images can also be taken from digital video, as long as the fixed images they produce have sufficient resolution.

- *Procedure*. Take one photograph of each 1 x 1 m quadrat that captures the whole of the grid (plus a second photograph as backup, in case unfocused images go unnoticed when diving). For each of the four smaller squares in each of the three 1 x 1 m quadrats, take one "macro" photograph (plus a backup) ensuring that the border of the grid is always captured in the image (to identify the corner that each of the four "macro" images corresponds to within the parent quadrat and to identify the quadrat itself), see **figure 24**. This totals 5 photos per quadrat (plus 5 backup photos) or a total of 15 (plus 15 backups) for the smallest series of three 1 x 1 m quadrats. Zero or initial states should be recorded at the most stable time of year in terms of the weather, thus we recommend summer as the most appropriate season for making these observations in the Western Mediterranean.

- *Precautions*. Divers must exercise extreme care when approaching quadrats to avoid unnecessarily brushing against the sessile biota or re-suspending harmful sediment.

9.7. Periodicity of underwater image collection. Aiming towards long temporal series

For the implementation of the underwater environmental monitoring method proposed for the Mediterranean Marine Protected Areas and their surrounding zones, it is important to commit to the collection of at least one photographic series for each season (i.e., four series per year), although the periodicity of image collection can be left very open and with time become narrower or wider depending on how much the scientific and sporting centers wish to get involved. The formal creation of an underwater

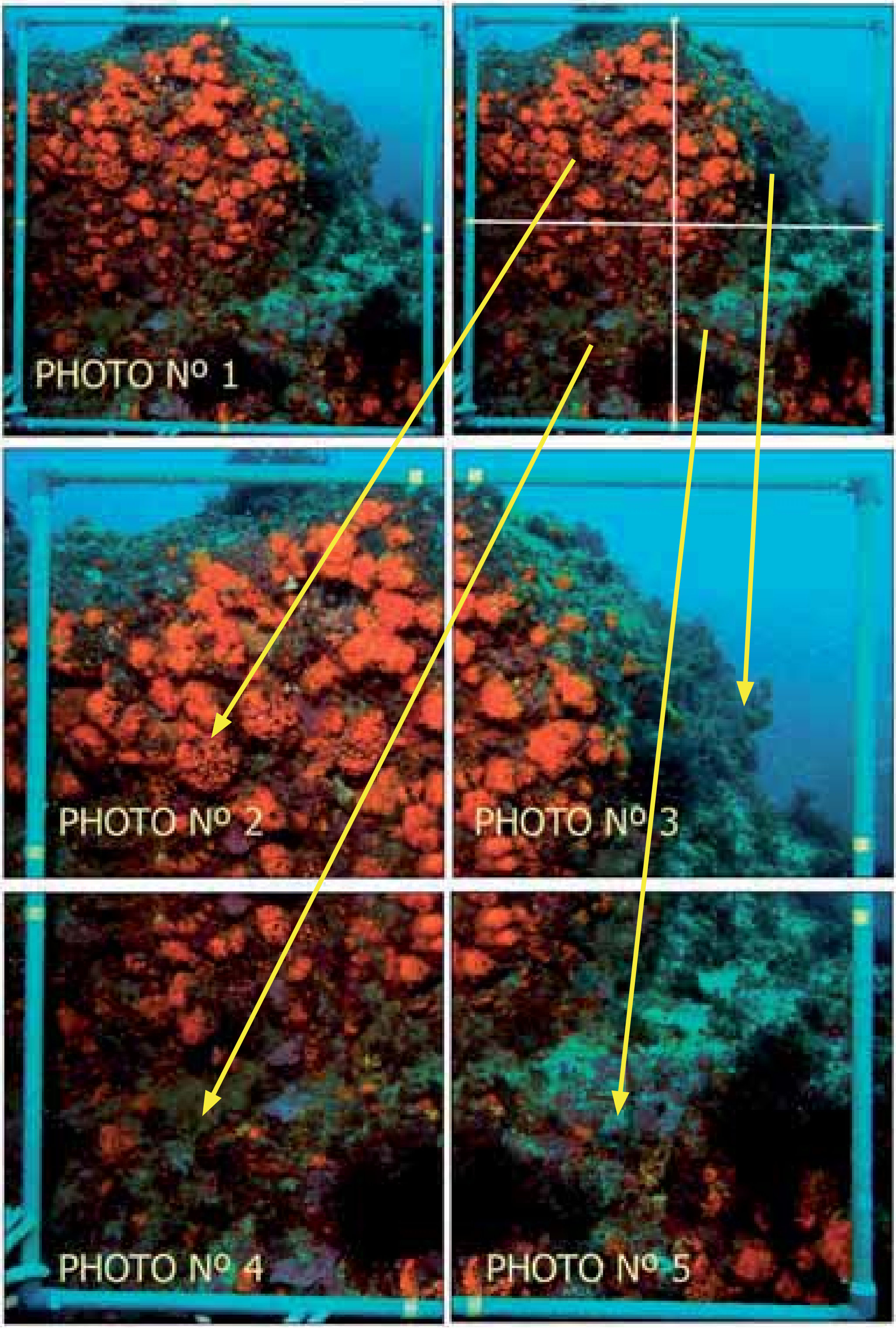


Fig. 24

monitoring surveillance network could itself propose a minimum common periodicity in order to facilitate comparisons between distant stations, thus affording an opportunity to detect changes in the system on a wider geographical scale.

For scientific, environmental or recreational diving organizations that enter into the SBPQ underwater environmental monitoring plan, short or long temporal data series will always provide valuable information since the zero state acts as a reference point for the observation of any significant changes in the benthic system, if they occur.

9.8. Depositing photographic series in the environmental monitoring network's coordination centers that correspond to the sentinel stations. Aiming towards the creation of libraries of underwater environmental monitoring images.

Diving clubs and centers who participate in their local monitoring network should upload their periodically collected photographic series to the coordination center's image compilation library so the experts can perform a thorough analysis, although we also encourage amateur divers to get involved in the initial assessment, thus converting themselves into highly participative tools.

The environmental monitoring networks will not only combine all of the information and create backup copies for future consultation in direct or cross analysis techniques, but they also count on specialized researchers who can process and evaluate the images.

9.9. Analyzing underwater images to identify changes occurring in the system

While a simple comparison of the photographs (by looking at the "before", "during" and "after") can help to detect important changes in the coverages of preselected target species, establishing thresholds for different degrees of impact can facilitate rapid assessment of whether or not any notable changes have occurred in the benthos.

The following scale has been set out and should be applied to at least one target species: 1) **Loss of less than**

25% coverage, the system continues its normal development, with no apparent impact in terms of lethal effects (sublethal effects are not detected by the method, unless they present phenotypic signs of stress or illness, such as the stains that appear on certain species of sponges when attacked by cyanobacterias); 2) **Loss of between 25 and 50% coverage**, an orange warning sign (hopefully this will stimulate divers to confirm the regressive trend); and 3) **Loss of over 50% coverage**, a red warning sign (this should be reported to the environmental monitoring network's coordination center that geographically corresponds to the sentinel station or, if a coordination center has not yet been established, to the Competent Environmental Authority or their delegated research center for diagnosis and, where appropriate, intervention).

At a strictly scientific level, the correct procedure involves completing repeated measures statistical analysis (Mauchly, 1940; Geisser and Greenhouse, 1958; Greenhouse and Geisser, 1959; Lanyon y Marsh, 1995), which can reveal, as a function of time, whether or not there are any significant differences between the coverages observed within the same permanent quadrats.

Statistical analysis of temporal series of images taken from the same quadrats is based on the overestimation of coverage changes in those target species which comply with the criteria given in **section 9.2.** This can be done with simple software programs, e.g., Adobe Photoshop Elements, according to the method explained in this guide. Although the matrix that is superimposed over each image accurately measures whether or not the target species is present or absent from each particular subsquare (pixel), an overestimation always arises because the software assumes 100% occupation of even partially filled pixels. The system, though it always overestimates the real coverage of each target species, is very simple to apply and constitutes an effective environmental warning system that circumnavigates the difficulties associated with precise parameter measurements (bearing in mind the species' surfaces and volumes, plus whether or not they are arborescent, i.e., grow upright).

9.10. A summary of the procedure and future prospects: image analysis on the website, environmental diagnosis and coordination

Figure 25 summarizes the method to follow after taking the first underwater

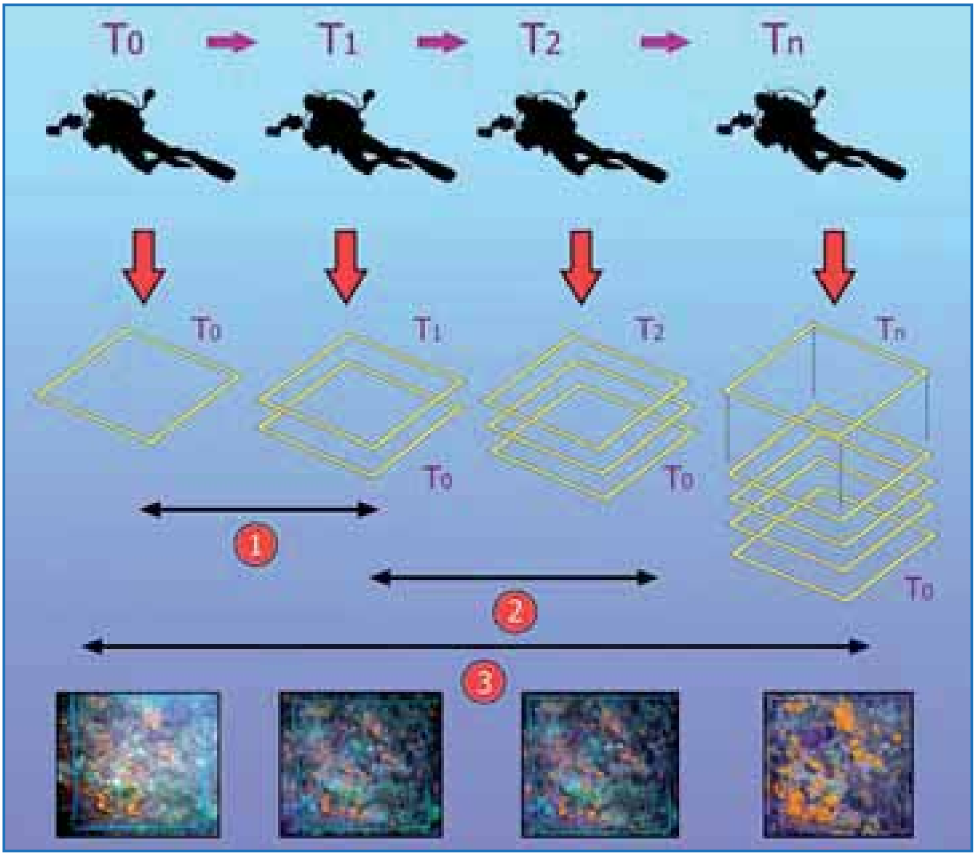


Fig. 25

images of **at least three quadrats** (see **section 9.4**) of each sentinel station during the **zero or initial phase** (T_0). This will allow two things: A) the comparison of target species coverage over short time intervals (T_1 with T_0, T_2 with T_1 … T_n with T_{n-1}; with just a few months between them), a useful method to evaluate impacts or disturbances which may occur at a local scale and also for a potential **BACI** (**B**efore **A**fter **C**ontrol **I**mpact) environmental control; and B) long-term comparisons (T_n with T_0; several years of difference), which will provide information about other possible disturbances that are imperceptible in the medium term, such as those related to a progressive temperature increase (Global Warming), while they may also provide warnings about low-intensity but continuous anthropogenic disturbances on a local scale.

Figure 26 lays out a proposal for the elaboration of a website which should have specific routers that divers involved in the control sentinel station could access once they have registered. A specific application should allow rapid and

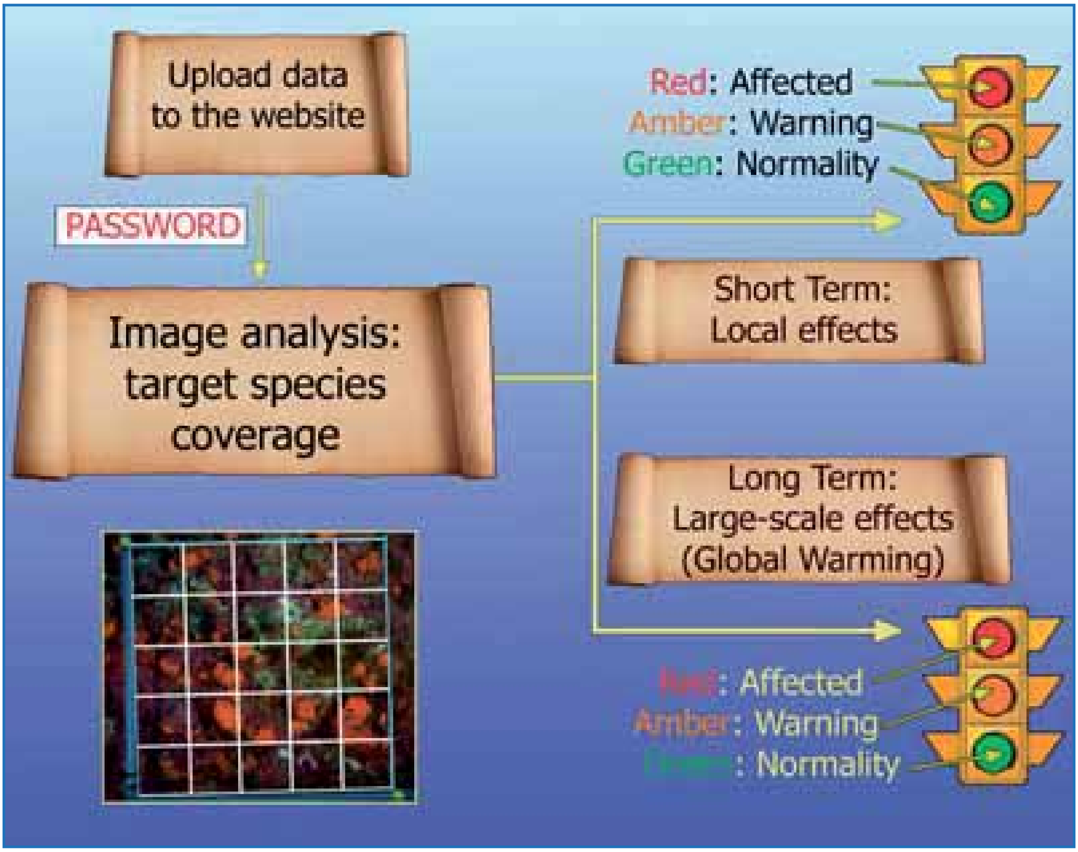


Fig. 26

simple comparison of target species coverages in the permanent quadrats. Traffic light colours will illustrate the environmental status: **green**, represents a normal environment; **amber**, depicts an unexpected decrease in coverage of at least one target species (loss of between 25 and 50% of its average coverage); and **red**, blatant regression of at least one of the target species being monitored (loss of more than 50% of its average coverage). As such, the data management company IT3 Cloud, in close collaboration with the Laboratory of Marine Biology at the University of Seville, have designed a software program, currently undergoing testing, for the target species *Astroides calycularis* and *Paramuricea clavata* which will allow their coverages to be compared within the permanent quadrats. The program will also express the results immediately and graphically, while incorporating the traffic light classification system mentioned above. This software could be adapted to other target species that comply with the necessary shape and colour requirements, or adapted to the normality (or lack thereof) of the species' coverage values, as new ecological and environmental information about the target species is obtained from different geographical zones (**sentinel station networks**). Thus the program's diagnostic capacity could be perfected with time.

The Laboratory of Marine Biology at the University of Seville, in close collaboration with the Andalusian Regional Council's Department of Environment and Land Planning (CMAYOT), RAC/SPA and MedPAN, **intends to coordinate the underwater monitoring activities** carried out by the program's participants by means of the aforementioned website and the corresponding links. The overall goal is to facilitate the implementation of the tool presented in this guide within the framework of a Mediterranean (and neighbouring Atlantic areas) monitoring and environmental surveillance macro-network for observing target species in underwater sentinel stations located within MPAs and their surroundings.

9.11. Analyzing the accompanying biota (optional, only recommended for experts)

The foundation of organized underwater environmental monitoring networks should aspire to the creation of a large database that can be permanently updated with new information and freely accessed by the scientific community. This would facilitate cross analysis of all the available data by any accredited scientist, while also allowing them to work on images with a level of zoom that provides powerful information about the biota accompanying the "target species". With time the monitored information would become more robust, broader and more useful, even helping to identify new sensitive species that were not initially classified as target species (possibly due to their small size) but which may reveal even greater information.

9.12. SBPQ method pilot experiment with diving centers in the Strait of Gibraltar and nearby Atlantic areas

The method described above was experimentally initiated in January 2013, with the backing of the European MedPAN-North Project and the voluntary participation of diving clubs and centers located in and around the Strait of Gibraltar (**photo 91, figs. 27 and 28**), in order to explore its strengths and weaknesses with the passage of time. The intention of the pilot experiment is to extend the initiative to the whole of Andalucia's Atlantic-Mediterranean coast (the south of the Iberian Peninsula), not only to detect abnormal changes of a local character (particularly in sensitive zones located in and close to Mediterranean MPAs) but also to monitor for future abnormal changes that may occur at an Atlantic-Mediterranean level (long temporal series), especially those related to Global Warming. The two target species selected from among several sensitive species were the anthozoans *Astroides calycularis* and *Paramuricea clavata*, both of which are abundant in the coastal waters around the Strait of Gibraltar. However, we now recommend to extend the environmental monitoring to the entire Mediterranean basin, in and outside the marine protected areas and their surrounding areas.

The following diving clubs and centers are participating in the January 2013 experiment: The University of Seville's Underwater Activities Club (CUASS), Campo de Gibraltar Diving Club (located at La Línea), La Línea Nautical Club (Diving Section), "The Strait" Diving Club (Algeciras), Caetaria (Algeciras), Algeciras Center for Underwater Research and Exploration (*CIES*), Tarifa *CIES*, Scorpora (Tarifa), Nature Explorer (Barbate), Urta Nautical Club in Rota (Diving Section), Ocean Addicts (Conil de la Frontera). The divers involved are explicitly mentioned in the annex and, with their collaboration, we shall study the creation of "environmental diving sections" in their respective clubs.

Furthermore, we plan to install various sentinel stations in Atlantic zones close to the Guadalquivir estuary. They will be used to study the evolution of benthic indicator species in function of their tolerance to disturbances involving extreme levels of turbidity and sedimentation produced by large discharges of suspended solids from the Guadalquivir during periods of heavy rainfall. They are the only sentinel stations that will be installed in intrinsically fluctuating benthic systems, so that we may gather contrasting information.

Phot. 91


BUCEO AMBIENTAL Y ESTACIONES-CENTINELA
PARA EL SEGUIMIENTO DEL CAMBIO CLIMÁTICO Y
LA DETECCIÓN DE IMPACTOS EN LA ZONA LITORAL
Laboratorio Biología Marina
LABORATORIO DE BIOLOGIA MARINA
UNIVERSIDAD DE SEVILLA
Club Universitario de Actividades Subacuáticas de Sevilla (CUASS)
CIES-SUB Algeciras
CIES-SUB Tarifa
Club de Buceo Caetaria
Club de Buceo Campo Gibraltar
Club de Buceo El Estrecho
Club de Buceo Nature Explorer
Club de Buceo Scorpora
Club Nautico Urta. Seccion de Buceo
Real Club Nautico de La Linea

Fig. 27


LABORATORIO DE BIOLOGIA MARINA
MedPAN
UNIVERSIDAD DE SEVILLA
PROYECTO: BUCEO AMBIENTAL Y ESTACIONES-CENTINELA PARA EL SEGUIMIENTO DEL CAMBIO CLIMÁTICO Y LA DETECCIÓN DE IMPACTOS EN LA ZONA LITORAL

Fig. 28

10 TOLERANT OR EURIOIC (SESSILE) BENTHIC SPECIES


JCGG

MACROALGUES

JCGG

10.1. *Codium bursa* (Olivi) C. Agardh, 1817

Phot. 94

Phylum: Chlorophyta
Class: Ulvophyceae
Order: Bryopsidales
Family: Codiaceae
Genus: *Codium*
Common name: Green sponge ball

Description

Balloon-like alga with a diameter that varies between 5 - 40 cm. Dark green in color, it has the consistency of an elastic sponge. It is hollow inside, so the central part of the developed specimens can sometimes sink.

Habitat

It tends to grow on gently sloping, well-lit, rocky bottoms, both as individuals or in groups. It is typically found from 1 m down to 45 m, but has even been cited at depths of 90 m.

Distribution

In the eastern Atlantic, from Ireland to the Canary Islands. Found throughout the Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

The species has a broad ecological valence and, therefore, it is tolerant to environmental changes (García-Gómez, 2007).

Thanks to its growth strategy and morphological characteristics, *Codium bursa* exemplifies tolerance to stressful conditions (Vidondo and Duarte, 1995), and, despite its apparent disadvantages, enjoys a high level of ecological and competitive success (Geertz-Hansen *et al.*, 1994). The species has been ecologically classified as an opportunist and is linked to environments with some degree of degradation (Orlando-Bonaca and Lipej, 2009; Bermejo *et al*., 2012) as it is often found in zones that are only inhabited by pollution-tolerant species (Parlakay *et al*., 2005).

Nevertheless, in systems of high environmental quality (**photos 94 and 95**), they can help to detect negative changes caused by excessive sedimentation (e.g., derived from the overflow of a nearby dredging operation), because the abnormal deposition of sediment presents an opportunity for the atypical epibiosis of other macroalgae, as shown in **photo 65 (chapter 8.9).** Although this species can tolerate a certain degree of sediment coverage (**photo 96**), if an excessive amount of sediment is not subsequently washed off by the motion of the waves or currents it can lead to the death of affected specimens (**photo 97**).

Phot. 95

Phot. 96

Phot. 97

10.2. *Codium vermilara* (Olivi) Delle Chiaje, 1829

Phot. 98

Phylum: Chlorophyta
Class: Ulvophyceae
Order: Bryopsidales
Family: Codiaceae
Genus: *Codium*
Common name: None

Description

A dark green alga with a cylindrical thallus and dichotomous branching that is abundant and irregular. Lateral branches are short. It attaches to the substrate via an enlarged planar basal disk (called a holdfast) that forms a type of crust. It has a spongy/elastic consistency and the surface is covered with delicate hairs giving it a woolly appearance. (**Photos 98 and 99**).

Habitat

The species is present throughout the year and settles on rocky seabeds at depths of 3 to 50 m.

Distribution

In the eastern Atlantic, from Scandinavia to Morocco. Found throughout the Mediterranean, including the Strait of Gibraltar. Also present in the Black Sea.

Environmental sensitivity

This species has been observed in port settings of low environmental quality (author's personal observations) and so it is not recommended for use as a bioindicator of good ecological conditions.

Phot. 99

10.3. *Ulva compressa* Linnaeus, 1753

Phot. 100

Phylum: Chlorophyta
Class: Ulvophyceae
Order: Ulvales
Family: Ulvaceae
Genus: *Ulva*
Common name: None

Description

The species is characterized by its dark green color. It is formed from planar tubes which can branch further; the smaller branches are also planar. It grows to lengths of between 5 and 40 cm, with branches up to 2 cm wide. Also reported to grow wider from the base towards the ends. An annual species, but with more abundance in spring and winter. (**Photos 100 and 101**).

Habitat

An annual species, but with more abundance in spring and winter. Found growing on rocky and sandy bottoms with gentle gradients and above all in zones with turbulent waters. It is common in brackish waters and also present in the zone influenced by the tides, thus from the surface down to depths of 10 - 15 m. (**Photo 102**).

Distribution

It is a cosmopolitan species.

Environmental sensitivity

This species has a high degree of tolerance to situations of organic contamination and eutrophication (Yüsek *et al.*, 2006; Scanlan *et al.*, 2007). It can be found as both an opportunist (Orlando-Bonaca *et al.*, 2008) and dominant species (López-Gappa *et al.*, 1990; Pinedo *et al.*, 2007).

Notes

The species was formerly known as *Enteromorpha compressa.*


Phot. 101
doris.ffessm.fr – Vincent Maran


David Fenwick – www.aphotomarine.com

Phot. 102

10.4. *Ulva lactuca* Linnaeus, 1753

Phot. 103

Phylum: Chloropyta
Class: Ulvophyceae
Order: Ulvales
Family: Ulvaceae
Genus: *Ulva*
Common name: Sea lettuce

Description

The species consists of thin, planar leaves that can grow up to 1 m long and 20 cm wide, and range from light to dark green in color. Some leaves are narrow and have curly edges, while others are wider; they are often perforated. It attaches to the substrate via a small clamping disk (holdfast). (**Photo 103**).

Habitat

Tends to be found on rocks and other algae. Inhabits the upper levels of the littoral down to 10 m. (**Photo 104**).

Distribution

It is a cosmopolitan species, but rarely seen in the Mediterranean.

Environmental sensitivity

Ulva lactuca, as with other species from the *Ulva* genus, is resistant to pollution conditions and disturbances associated with eutrophication events and organic contamination (Golubic, 1970; Pinedo *et al.*, 2007; Scanlan *et al.*, 2007). Different studies and methodologies associated with the European Water Framework Directive consider *U. lactuca* to be an opportunist species with a low level of environmental sensitivity (Ballesteros *et al.*, 2007; Wells *et al.*, 2007).

Notes

It is used as a food, an agricultural fertilizer and also in cosmetics.

Due to the high degree of similarity with *Ulva australis*, examples of which have been cited in the Iberian peninsula (Altamirano, personal correspondence), it is a good idea to perform a detailed examination of any specimens encountered to determine a species-level identification.

Phot. 104

10.5. *Ulva rigida* C. Agardh, 1823

Phot. 105

Phylum: Chlorophyta
Class: Ulvophyceae
Order: Ulvales
Family: Ulvaceae
Genus: *Ulva*
Common name: Sea lettuce

Description

A dark and light green colored alga that grows up to a height of 5 to 30 cm, although it can reach over 1 m in diameter in some zones. It is formed from a fairly rigid, almost contoured and cartilaginous lamina; there tend to be microscopic teeth on its lower edges. It attaches to the substrate via a very short or almost nonexistent peduncle (stem). A perennial species, but more abundant in spring and winter. (**Photo 105**).

Habitat

Usually settles on rocky bottoms in turbulent waters. Common in ports and coastal lagoons where it is free-living. Ranges from the upper levels of the littoral zone down to 15 - 20 m. (**Photos 106 and 107**).

Distribution

In the eastern Atlantic, from Scandinavia and Iceland to the Canary Islands, also in the western Atlantic, the Mediterranean Sea, the Black Sea and the Pacific Ocean.

Environmental sensitivity

Ulva rigida is typically cited as an opportunist species (Orlando-Bonaca *et al*., 2008; Sfriso and Facca, 2011; García-Sánchez *et al*., 2012) which tends to dominate in areas presenting organic contamination (Sfriso *et al*., 2001), eutrophication (Scanlan *et al*., 2007) or anoxia, even when these disturbance parameters reach elevated levels (Munda, 1993).

Notes

This species can tolerate pollution and environmental stress. When present among communities of *Cystoseira mediterranea* or *Lithophyllum lichenoides* it is a sign of a certain level of environmental tension and the first stages of regression.

Phot. 106

Phot. 107

10.6. *Asparagopsis armata* Harvey, 1855

Phot. 108

Phylum: Rhodophyta
Class: Florideophyceae
Order: Bonnemaisoniales
Family: Bonnemaisoniaceae
Genus: *Asparagopsis*
Common name: Harpoon weed

Description

This alga's shape often resembles an asparagus and it can grow to 30 cm tall. The main axes are cylindrical with irregular branching. Emerging from the surface of these axes are several fine lateral branchlets which form pyramidal tufts. There is also a second group of lateral branches, these are harpoon-shaped and measure approximately 3 cm long. Its colors range from light red to pale purple, while the alga's overall shape is pyramidal. It is an annual species. (**Photos 108 and 109**).

Habitat

Located in well-lit zones of shallow, rocky seabeds. Frequently settles on other algae species. Found below the low-tide line, generally at depths of 3 - 5 m.

Distribution

Originally from Australia and New Zealand, it is an invasive species that colonized the Mediterranean in 1925, including the Strait of Gibraltar. Also found across the eastern Atlantic, from the British Isles to Morocco.

Environmental sensitivity

In the Mediterranean, this species has successfully incorporated itself within a defined spatial range and, since the middle of the 1920s, has lived as an integrated part of the photophilic algae community (Horridge, 1951; Pacios *et al.*, 2011). Although it gives very little to the ecosystem (it is basically inedible since fish cannot digest it) neither is it harmful, unlike other invasive species such as *Caulerpa taxifolia*, so there is no compelling reason to exclude it from the present guide. A significant disadvantage arises from its particularly invasive character (Klein *et al.*, 2005) as it can even displace other, less competitive, indigenous species (Boudouresque and Verlaque, 2002; Klein and Verlaque, 2009).

Phot. 109

10.7. *Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon, 1845

Phot. 110

Phylum: Rhodophyta
Class: Florideophyceae
Order: Bonnemaisoniales
Family: Bonnemaisoniaceae
Genus: *Asparagopsis*
Common name: None

Description

It has a similar appearance to *Asparagopsis armata*, with a thallus measuring 10 to 30 cm formed by a main axis crowned with a pyramidal crest. Irregular radial branching starts from the first third of the base, these branches are also shaped like pyramidal crests. *A. taxiformis* differs from *A. armata* because it does not have any harpoon-shaped branchlets. Colors range from dark red to pale purple. It is an annual species. (**Photo 110**).

Habitat

This species prefers well-lit, rocky habitats (**photos 111 and 112**). Usually found below the low-tide line, down to a depth of 20 meters in the Strait of Gibraltar zone.

Distribution

Cosmopolitan invasive species, from tropical and subtropical zones. It reached the Mediterranean via the Suez Canal, though entry from the Atlantic has also been considered.

Phot. 111

Environmental sensitivity

Asparagopsis taxiformis is considered to be a highly invasive species (Altamirano *et al.*, 2008; Tsiamis *et al.*, 2013) that is capable of tolerating moderate levels of pollution and organic load (Titlyanov and Titlyanova, 2013).

Notes

The species exhibits a high level of antimicrobial (González del Val *et al.*, 2001; Manilal *et al.*, 2009) and "antifouling" activity (Manilal *et al.*, 2010), making it an excellent competitor.

Phot. 112

10.8. *Caulacanthus ustulatus* (Mertens ex Turner) Kützing, 1843

Phot. 113

Phylum: Rhodophyta
Class: Florideophyceae
Order: Gigartinales
Family: Caulacanthaceae
Genus: *Caulacanthus*
Common name: None

Description

Examples range from reddish-brown to olive brown. It grows between 1 and 2 cm tall and characteristically forms dense, intertwined, cartilaginous and filamentous lawns (**photos 113 and 114**). Comprised of a segmented axis running across the lawn, from which emerge several side branches of between 0.2 and 0.4 mm wide.

Habitat

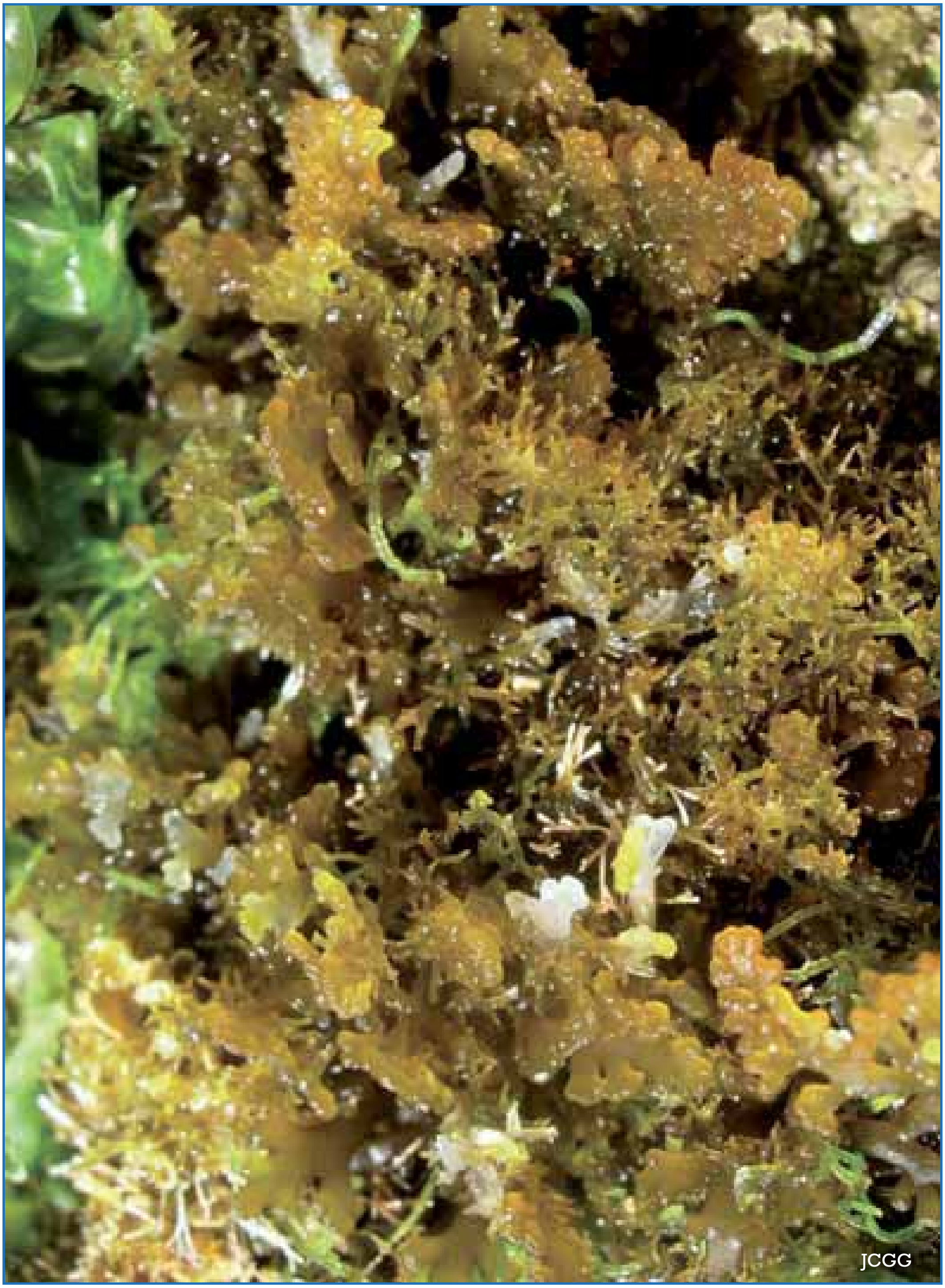
Found on rocks and large stones, as well as attached to the basal regions of the algal genus *Cystoseira*. Predominantly an intertidal species.

Distribution

Mediterranean including the Strait of Gibraltar.

Environmental sensitivity

Caulacanthus ustulatus is moderately tolerant of disturbances (Bard, 1998) and is often found as an opportunist in areas with relatively little pollution (Sfriso and Facca, 2011). However, it has also been observed in highly-polluted or degraded zones (Díez *et al.*, 2009, 2013).



Phot. 114

10.9. *Ellisolandia elongata* (J. Ellis and Solander) K. R. Hind and G. W. Saunders, 2013

Phot. 115

Phylum: Rhodophyta
Class: Florideophyceae
Order: Corallinales
Family: Corallinaceae
Genus: *Ellisolandia*
Common name: *Marine lichen*

Description

Erect alga with pinnate branching; axes are branched, articulated and calcified. Pinkish-violet or grayish-violet in color, it forms very thick coatings which resist the pounding of the waves **(photo 115)**. Very similar to *Corallina officinalis*, but differs in that it has flattened, winged articulations **(photo 116)**.

Habitat

The species lives over rocky substrates in the lower midlittoral and early infralittoral levels; it can survive periods of exposure to the air. Often found in midlittoral pools or basins.

Phot. 116

Distribution

Throughout the Mediterranean, including the Alboran Sea and the Strait of Gibraltar and in the Black Sea. In the north-east Atlantic, from the British Isles to Mauritania.

Environmental sensitivity

Despite the species' vigorous appearance, and while it prefers clean and turbulent waters (**photo 115**), it also resists precarious environmental conditions (Gorostiaga *et al.*, 2004; García-Gómez, 2007), even when subjected to organic pollution and in areas with a high sedimentation rate (Diez *et al*., 1999; Soltan *et al.*, 2001; Arévalo *et al.*, 2007). In rocky enclaves, *Ellisolandia elongata* (a.k.a. *Corallina elongata*) forms an important part of the conglomerates that replace the communities of *Cystoseira*, once the latter begins to be affected by rising pollution levels (Benedetti-Cecchi *et al.*, 2001). The species is capable of forming successful colonies (with over 90% coverage) on artificial breakwater blocks located in ports and harbors **(photos 117 and 118**).

Notes

The species was previously cited as *Corallina elongata* and *Corallina mediterranea.*

Phot. 118

Phot. 117

10.10. *Gelidium pusillum* (Stackhouse) Le Jolis, 1863

Phot. 119

Phylum: Rhodophyta
Class: Florideophyceae
Order: Gelidiales
Family: Gelidiaceae
Genus: *Gelidium*
Common name: None

Description

This darkish brown-red to blackish-red alga is characterized by the formation of dense lawns. It reaches a height of just 1 to 3 cm, is rigid, leathery and highly branched. It has an irregular appearance and cylindrical fronds which are flattened at the ends, the apices of the leaves broaden to resemble oars. (**Photos 119 and 120**).

Habitat

Lives in rocky, shaded, wave-exposed bottoms. Grows in relatively polluted and dirty zones. Found from the surface down to 15 - 20 m.

Distribution

A cosmopolitan species.

Environmental sensitivity

This alga tolerates environmental stress caused by pollution; in fact it is one of the species that characteristically starts to dominate as the level of pollution increases (Littler and Murray, 1975; Díez *et al.*, 1999). *G. pusillum* is classified as an opportunist because it displaces other species which are less tolerant of eutrophication and organic pollution (Littler and Littler, 1981; May, 1985; Sfriso and Facca, 2011; García-Sánchez *et al.*, 2012).

Phot. 120

10.11. *Chondracanthus acicularis* (Roth) Fredericq, 1993

Phot. 121

Phylum: Rhodophyta
Class: Florideophyceae
Order: Gigartinales
Family: Gigartinaceae
Genus: *Chondracanthus*
Common name: None

Description

This species of alga is dark red, except in summer when it fades to brownish-olive green (**photo 121**). It grows to heights of between 5 and 10 cm with branches of 1 - 3 mm in diameter. There is a main cylindrical frond that is slightly compressed and with irregular branching. The branches are pointed, curved and finish with acute, curved branchlets (**photos 122 and 123**), which attach themselves to any substrates they contact, thus the alga presents the characteristics of a creeper. It has a cartilaginous consistency. A perennial species, but it is most abundant in autumn and winter. It typically forms large, compact lawns over rocks.

Habitat

The species settles in well-lit zones and tolerates being covered by sand. Found from the surface down to 5 m.

Distribution

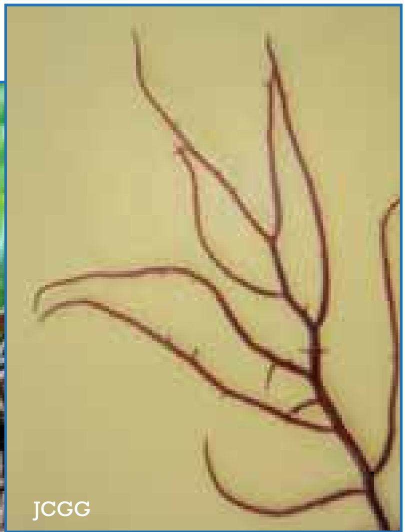
Located across the eastern Atlantic, from the British Isles to Cameroon. Also found throughout the Mediterranean, including the Strait of Gibraltar, and in the north-western Atlantic.

Environmental sensitivity

Gigartina acicularis (*Chondracanthus acicularis*) is tolerant of high sedimentation rates (Gorostiaga *et al.*, 1998) and low to moderate levels of pollution (Mallia and Schembri, 1995; Díez *et al.*, 2009; Scherner *et al.*, 2013). It can be found in highly eutrophized zones (Chryssovergis and Panayotidis, 1995) while it can simultaneously be considered a species indicative of the final stages of ecological succession (Borja *et al.*, 2012).

Notes

Formerly cited as *Gigartina acicularis.*



Phot. 122

Phot. 123

10.12. *Lithophyllum incrustans* R. A. Philippi, 1837

Phot. 124

Phylum: Rhodophyta
Class: Florideophyceae
Order: Corallinales
Family: Corallinaceae
Genus: *Lithophyllum*
Common name: None

Description

An encrusting calcareous alga with a thallus of up to 3 - 4 cm in diameter and generally thick crusts. The species has several morphologies and is violet-pink or slightly grayish in color. Older examples present thalluses with serrated edges; these form highly visible ridges when they come into contact with the edges of other individuals during their continual growth.

Habitat

It is generally found coating natural, wave-exposed rocky blocks and also in zones with a moderate level of hydrodynamism. Also covers calcareous remains of a biogenic origin. Inhabits the inferior mid-littoral (including intertidal pools) and subtidal zones, where it is very common in the first 20 m.

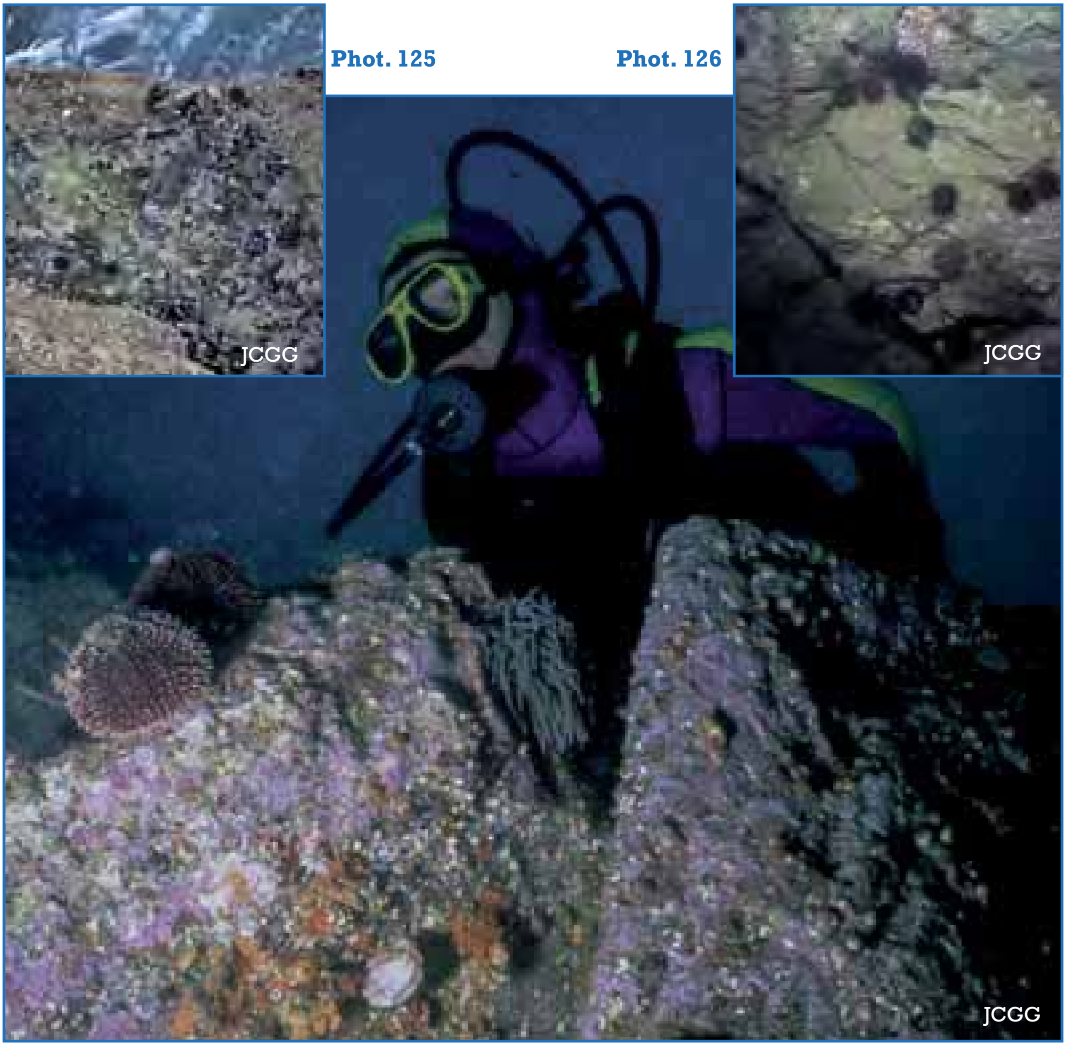
Distribution

Throughout the Mediterranean and Atlantic.

Environmental sensitivity

A species of broad ecological valence that is tolerant of diverse environmental conditions (García-Gómez, 2007). In several studies into indicators of ecological quality, this species was typically situated in a mid to low range (Pinedo *et al.*, 2003; Torras *et al.*, 2003; Bermejo *et al.*, 2013).

Photo 124 shows the species covering rocks (pink shades) in areas of clean, rejuvenated, unpolluted and semi-turbulent waters (alongside indicators of high environmental quality, such as the orange coral *Astroides calycularis*). A similar case is observed in **photo 125**, this time in intertidal pools of high environmental quality (isolated pinkish patches). *L. incrustans* can also be found in zones of average environmental quality very close to ports (**photo 126**) and even in areas of yet lower quality, tolerating moderate sedimentation and organic loads (Soltan *et al.*, 2001; Arévalo *et al.,* 2007) (**photo 127**).



Phot. 125

Phot. 126

Phot. 127

10.13. *Mesophyllum alternans* (Foslie) Cabioch and M. L. Mendoza, 1998

Phot. 128

Phylum: Rhodophyta
Class: Florideophyceae
Order: Corallinales
Family: Hapalidiaceae
Genus: *Mesophyllum*
Common name: None

Description

An encrusting species with a diameter of 2 - 25 cm. It is calcified and forms brittle, glossy foliar or lobular laminae which are undulated and concentrically striated (**photo 128**). The edge is lobular, curved, rounded, striated, bulging and somewhat swollen. Wart-like structures, which are related to reproduction, may be seen on the surface. The color varies from violet-pink to yellowish-brown, while the laminae have whitish edges. Perennial species.

Habitat

A species that appears in shaded (**photo 129**), rocky bottoms with moderately turbulent waters. Also found living over other organisms such as algae from the genus *Laminaria* and marine phanerogams. Located from surface waters down to 30 - 35 m.

Phot. 129

Distribution

Throughout the Mediterranean, including the Strait of Gibraltar, and eastern Atlantic (from the British Isles to Mauritania).

Environmental sensitivity

Mesophyllum alternans is a highly tolerant species in terms of light, temperature and hydrodynamism (Hergueta *et al.*, 2004; Ballesteros, 2006), thanks to which it is dominant in many environments, including both the shallows and deeper waters. References also report that it is moderately resistant to organic pollution (Terlizzi *et al.*, 2002). On the other hand, this algal species is the primary generator of coralline systems (Garrabou and Ballesteros, 2000; Piazzi *et al.*, 2010), one of the richest and most diverse ecosystems in the Mediterranean that are characteristic of deeper, more stable and, therefore, more sensitive environments.

As this alga consists of highly-structured, coating laminae that lack elasticity they are very vulnerable to blows from hard elements, even the hands of divers or curious sight-seers browsing the intertidal rocks (**photos 130 and 131**), a reason why examples of this species, which look like colored rocks, are prone to the inadvertent or unwitting damage caused by people ambling around in their vicinity.

Phot. 130

Phot. 131

10.14. *Padina pavonica* (Linnaeus) Thivy, 1960

Phot. 132

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Dictyotales
Family: Dictyotaceae
Genus: *Padina*
Common name: Peacock's tail

Description

An erect, laminar alga which stands from 4 to 15 cm tall and has a similar width. Examples are fan or funnel-shaped, the upper rim is slightly rolled over and covered in hairs. They present a brownish-green to whitish color that is more or less translucent. Specimens have a series of concentric radial clefts and very notable stripes on the surface; these tend to have calcium encrustations that further emphasize the stripes. The consistency is membranous and robust. Present throughout the year. (**Photo 132**).

Habitat

This species settles on rocks and stones in shallow, well-lit, horizontal or gently sloping seabeds with relatively calm waters. Juvenile examples appear in spring. Observed from the low-tide line down to depths of 30 m, also found in well-lit intertidal pools. (**Photos 133 and 134**).

Distribution

In the eastern Atlantic, from the British Isles to Mauritania. Also present in the north-east Atlantic and throughout the Mediterranean, including the Strait of Gibraltar. Also present in the Black Sea, Pacific Ocean and Indian Ocean to Australia and French Polynesia.

Environmental sensitivity

The species has been classified as sensitive to pollution (Boisset-López, 1989; Mallia and Schembri, 1995) or anthropogenic disturbances (García-Sánchez *et al.*, 2012). Different studies have also categorized it as a "*late successional*" (Orfanidis *et al.*, 2001, 2003).

However, it can be found in zones with a moderate or slight degree of pollution, although always replacing communities that demonstrate a much greater degree of sensitivity to pollution (Munda, 1993). The species' suitability as an environmental bioindicator is, therefore, questionable and it is considered to be a tolerant species.

Phot. 133

Phot. 134

10.15. *Pterocladiella capillacea* (S. G. Gmelin) Santelices and Hommersand, 1997

Phot. 135

Phylum: Rhodophyta
Class: Florideophyceae
Order: Gelidiales
Family: Pterocladiaceae
Genus: *Pterocladiella*
Common name: None

Description

This blackish red alga grows between 5 and 20 cm tall. Its main fronds are flattened, measure from 1 to 2 mm wide and are abundantly branched from the lowest third onwards. The branches are arranged in a single plane. It has a soft, flexible consistency. The species is present throughout the year. (**Photos 135 - 137**).

Habitat

It inhabits zones with low levels of light, in calm or slightly turbulent waters and tends to settle on the walls of narrow crevices. Observed over a range of 0 to 1 m.

Distribution

In the eastern Atlantic, from the British Isles to Morocco, as well as in the north-western Atlantic, the Black Sea, both the South and East China Seas and the Mediterranean.

Phot. 136

Environmental sensitivity

Pterocladiella capillacea can be found in areas strongly influenced by contaminating discharges or eutrophication (May, 1985; Chryssovergis and Panayotidis, 1995), replacing other species that are more sensitive to the disturbances (Littler and Murray, 1975). It has also been cited as moderately resistant to organic (Mallia and Schembri, 1995) and hydrocarbon pollution (Binark *et al.*, 2000).

Notes

Species formerly cited as *Pterocladia capillacea.*

Phot. 137

10.16. *Plocamium cartilagineum* (Linnaeus) P. S. Dixon, 1967

Phot. 138

Phylum: Rhodophyta
Class: Florideophyceae
Order: Plocamiales
Family: Plocamiaceae
Genus: *Plocamium*
Common name: None

Description

A bright red alga that forms in tufts of around 30 cm tall and generally over 30 cm wide. The species has several, flattened primary axes arranged in a zigzag and measuring between 2 and 4 mm wide. Emerging from the main axes are several lateral branches and alternating secondary branches. Branching is regular. Furthermore, the tips of the branches all bend over in the same direction, forming the teeth of a comb that curve in the shape of a sickle (**photos 138 and 139**). It has a cartilaginous texture. Its overall profile looks like a fan. It is an annual species.

Habitat

An alga that usually grows on rocky bottoms, overhangs and vertical surfaces. It also grows over other algae. Prefers shaded zones where there is moderate to strong hydrodynamism. Observed from 1 m down to great depths. (**Photos 140 and 141**).

Phot. 139

Distribution

In the eastern Atlantic, from Norway to Senegal. Throughout the Mediterranean, including the Strait of Gibraltar. Pacific Ocean.

Environmental sensitivity

There is a certain degree of controversy regarding *Plocamium cartilagineum* and its properties as a bioindicator species.

On one hand, there are data which favor its use as a sensitive bioindicator: it is a species that starts to appear, along with other macroalgae, in the intermediate and advanced stages of recolonization of polluted zones, once the said pollution has reduced or stopped (Gorostiaga *et al.*, 2004). It has also been used as a representative species in a study monitoring a port presenting only slightly disturbed conditions (Van Rein *et al.*, 2011).

At the same time, it has been discovered in areas subject to strong environmental impacts (urban, industrial and agricultural discharges), where it demonstrated high levels of accumulated lead (Benkdad *et al.*, 2011). On the other hand, when faced with impacts derived from hydrocarbons, despite suffering evident damage, it has displayed a capacity for rapid recovery (Cullinane, 1975).

Given this ambiguity the species' utility as an environmental indicator is questionable; nevertheless, in this guide it is provisionally included as a tolerant species despite the fact that, according to our own observations, it has always been found in clean waters of moderate to high hydrodynamism and never in disturbed waters along the lines of those indicated by Benkdad *et al.* (2011).

Phot. 140

Phot. 141

10.17. *Ectocarpus spp.* Lyngbye, 1819

Phot. 142

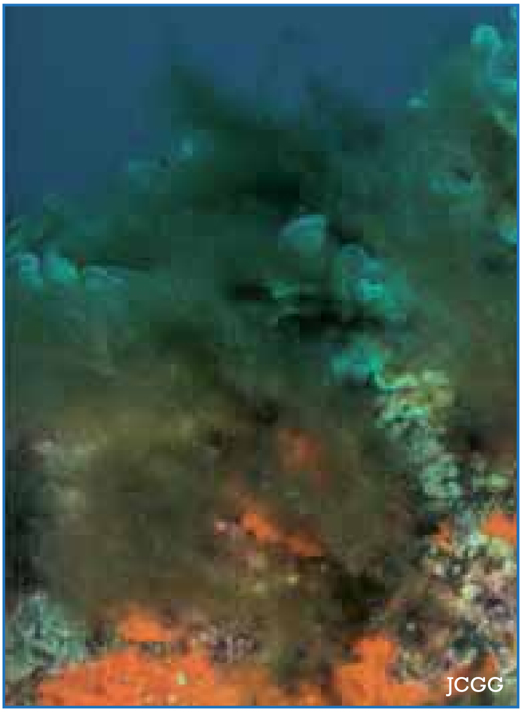
Phylum: Ochrophyta
Class: Phaeophyceae
Order: Ectocarpales
Family: Ectocarpaceae
Genus: *Ectocarpus*
Common name: None

Description

Species in this genus are yellowish-green, filamentous algae with a gelatinous texture. They are formed from long, fine strands (up to 50 cm long). They may present branching. (**Photo 142**). Usually appear abundantly in springtime.

Habitat

These species can be found on rocky bottoms or growing as an epibiont on other large algae. Often observed in zones close to the surface down to depths of several meters below the tide line. (**Photos 143 and 144**).



Phot. 143

Distribution

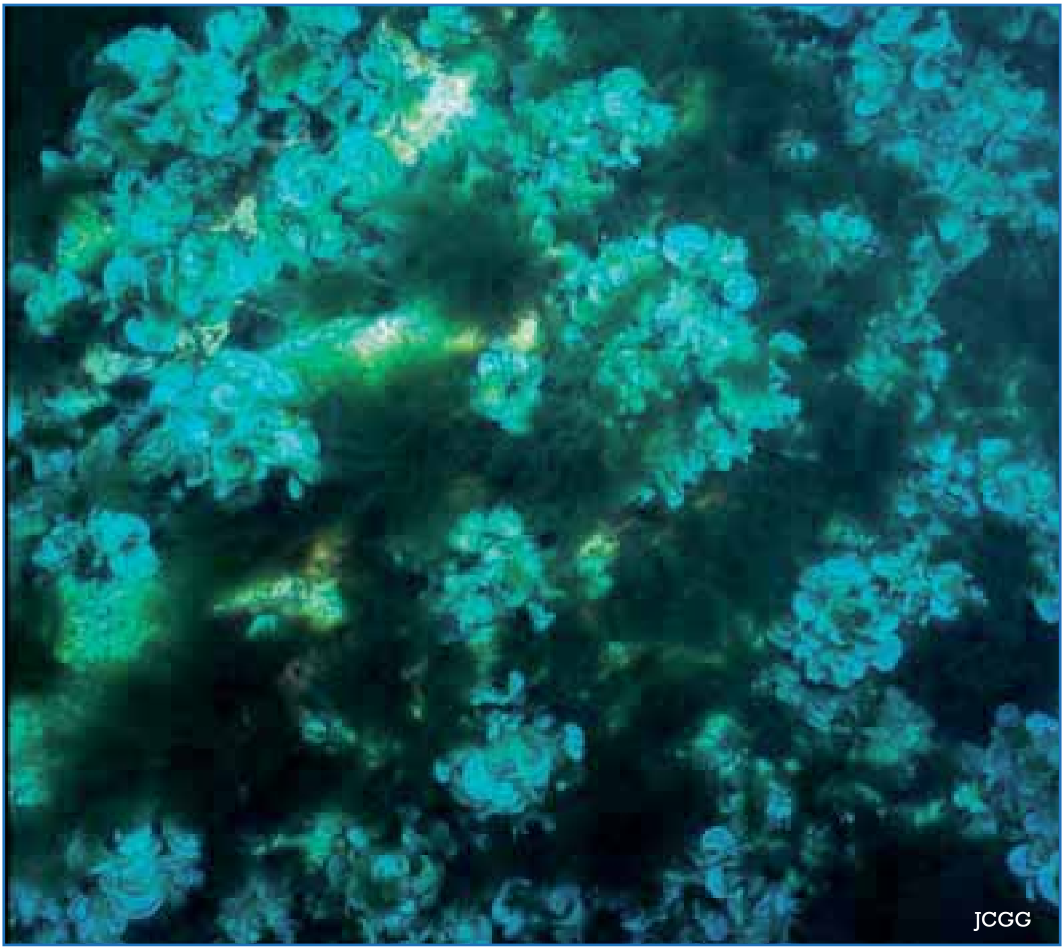
Cosmopolitan species.

Environmental sensitivity

The genus *Ectocarpus* constitutes many species which tend to be quite tolerant of elevated levels of eutrophication (Yüsek *et al.*, 2006) whether due to anthropogenic causes, such as organic pollution derived from wastewater discharges (Jeffrey *et al.*, 1993), or natural causes, for example "upwellings" (Kiirikki and Blomster, 1996).

Several studies have classified the genus as an opportunist (Orfanidis *et al.*, 2001, 2003; Sfriso and Facca, 2011).

Chapter **8.8** ("Algal blooms") specifically discusses this genus.



Phot. 144

10.18. *Halopteris scoparia* (Linnaeus) Sauvageau, 1904

Phot. 145

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Sphacelariales
Family: Stypocaulaceae
Genus: *Halopteris*
Common name: None

Description

An erect alga standing between 10 and 15 cm tall. It has a wide axis branching abundantly in all directions. These branches have a single axis from which emerge smaller branches that have no further bifurcation. This lends the species a brush or broom-like appearance. The tips of the branches are very coarse. It is a dark brown alga. Perennial species. (**Photos 145 and 146**).

Habitat

A species that inhabits well-lit, rocky and sandy bottoms with relatively calm waters. Found from the low-tide line down to 30 m.

Distribution

In the eastern Atlantic, from Scandinavia to the Cape Verde Islands. Also distributed throughout the western Atlantic and the Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

Halopteris scoparia can be found in environments with moderate and even high levels of disturbance (Munda, 1993; Sánchez-Moyano *et al.*, 2000a; Parlakay *et al.*, 2005), as it is well tolerant of situations involving organic pollution and anoxia derived from excessive eutrophication.

However, there are also studies that report the species' sensitivity to other types of pollution (Díez *et al.*, 2007) and it has been noted to disappear when contamination levels increase (Boisset López, 1989; Díez *et al.*, 2009) for it to only reappear in the final stages of ecosystem recolonization, along with other macroalgae (Gorostiaga *et al.*, 2004).

Considering this plasticity, we have provisionally classified this species as tolerant.

Phot. 146

10.19. *Sargassum vulgare* C. Agardh, 1820

Phot. 147

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Fucales
Family: Sargassaceae
Genus: *Sargassum*
Common name: None

Description

Grows to lengths of between 20 and 80 cm, and has a robust, leathery texture. It attaches to the substrate via a basal disk from which emerges the main axis; at a height of 2 - 4 cm this divides into well developed, smooth, cylindrical branches of approximately 2 mm in diameter. There is secondary branching, although not very abundant, with branchlets of a similar appearance to the primary branches. This gives rise to numerous leaf-like branches, measuring between 1.5 - 4 cm long and 2 - 4 mm wide, with serrated or slightly undulated edges and a central rib. The side branches have some spherical bladders which are full of air and form on the ends of peduncles (stems). Examples are colored light to dark brown. (**Photo 147**).

Habitat

Found in groups or in isolation, over moderately turbulent rocky seabeds or in coastal pools with frequently renewed water (**photos 148 and 149**). Inhabits depths from a few meters down to 20 m.

Distribution

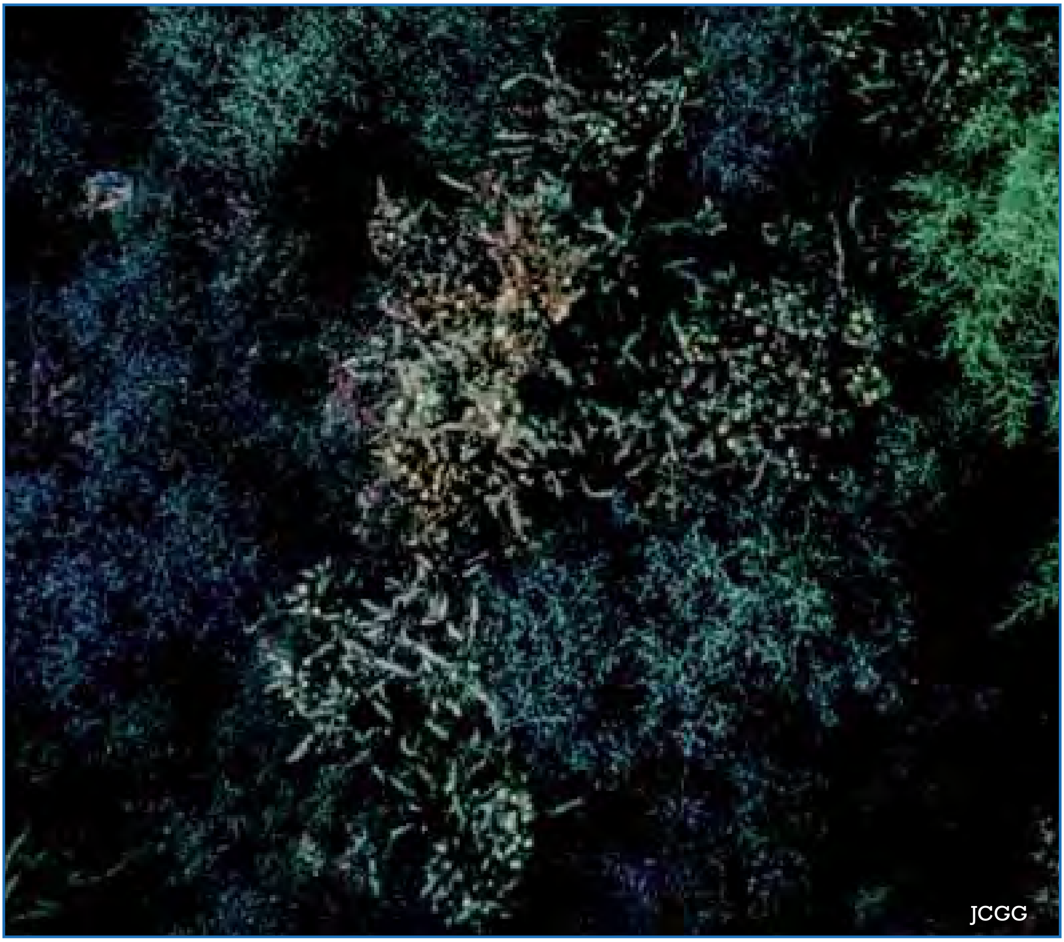
Common to the warm-temperate and tropical zones of the Atlantic, throughout the Mediterranean and in the Black Sea. It is indigenous to the Pacific.

Environmental sensitivity

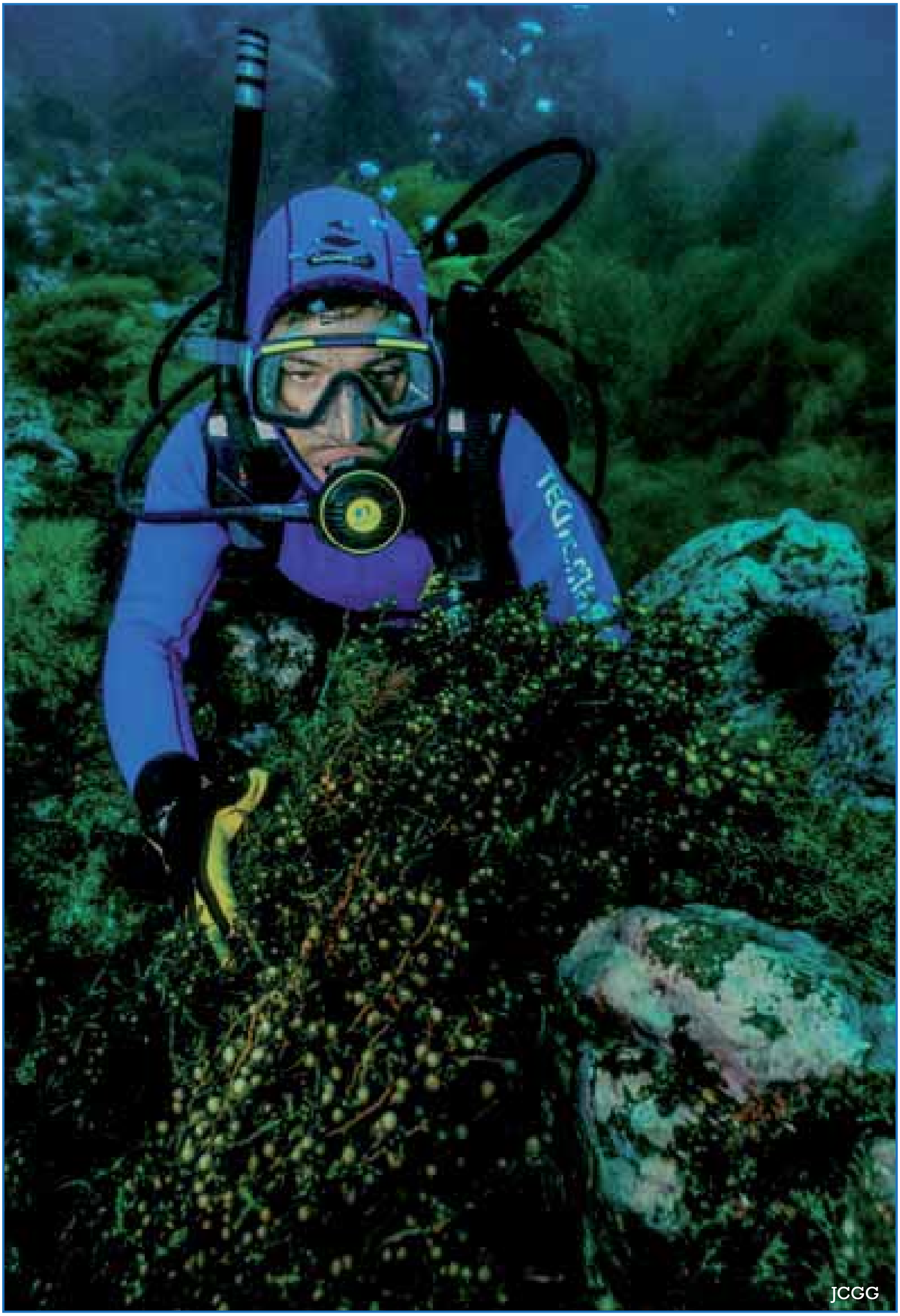
This species is normally found in association with other indicators of a good state of environmental conservation (Orfanidis *et al.*, 2001, 2003; Astruch *et al.*, 2012) and is no longer dominant when faced with disturbances (Falcao and Menezes de Széchy, 2005).

However, it has been cited as capable of accumulating high levels of different elements associated with pollution (Serfor-Armah *et al.,* 2006), while other studies observed its average accumulation of contaminating elements to be very similar to that of sensitive species (Hardisson *et al.,* 1998; Lozano *et al.,* 2003).

Considering this information, its suitability as an environmental bioindicator species is questionable.



Phot. 148



Phot. 149

SPONGES

JCGG

10.20. *Cliona celata* Grant, 1826

Phot. 151

Phylum: Porifera
Class: Demospongiae
Order: Hadromerida
Family: Clionaidae
Genus: *Cliona*
Common name: Red boring sponge or yellow boring sponge

Description

This sponge species includes examples varying in color from pale yellow to golden-yellow, while it has a fine, rigid consistency. It is also characterized by its ability to bore into stones, shells and all different types of calcareous substrate. It can form a network of galleries within this substrate and is connected to the exterior by means of circular papillae (or nipples) of between 1 and 5 mm in diameter. This boring sponge can grow outwards and cover the substrate, even developing so much that it completely encrusts and hides the substrate. When this occurs the sponge presents the massive form, which is lobed or plate-like and grows up to 1 m wide, 25 cm thick and 50 cm high. The boring, encrusting and massive morphological stages are known as alpha, beta and gamma (**photos 151 and 152,** gamma stage).

Habitat

Colonizes all types of calcareous substrate. This species, particularly the alpha form, can appear in a large variety of environments, for example, intertidal estuary substrates that experience large changes in environmental conditions, semi-stagnant waters, ports and exposed habitats. The gamma form tends to appear in deep-water detritic or sandy bottoms. Its distribution ranges from the surface down to 200 m.

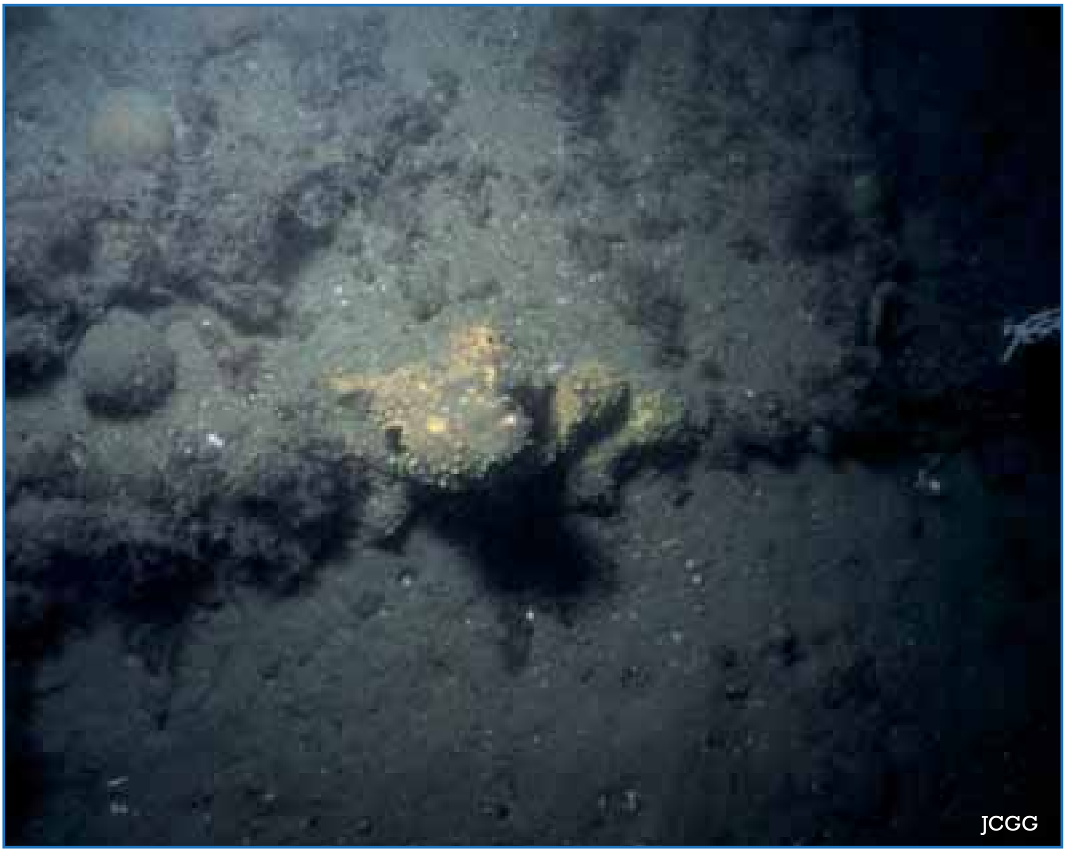
Distribution

Considered a cosmopolitan species.

Environmental sensitivity

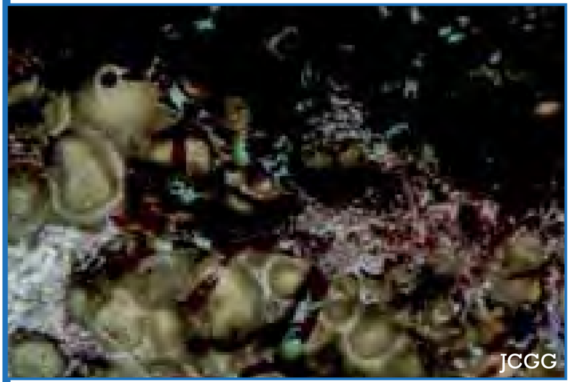
Cliona celata tolerates high levels of solids in suspension and sedimentation (Carballo *et al.*, 1994). Consequently it is found in areas affected by environmental disturbances such as ports and bays (Carballo *et al.*, 1996; Saiz-Salinas and Urkiaga-Alberdi, 1999).

The species is also characterized by a high tolerance threshold with respect to temperature and salinity levels (Miller and Strychar, 2010), as well as an elevated capacity to accumulate elements such as zinc (Araújo *et al.*, 1999).



Phot. 152

10.21. *Cliona viridis* (Schmidt, 1862)



Phot. 153

Phylum: Porifera
Class: Demospongiae
Order: Hadromerida
Family: Clionaidae
Genus: *Cliona*
Common name: Green boring sponge

Description

This sponge has a hard but fragile consistency and its color varies from dark green/almost black to yellowish-green or olive green depending on the solar radiation it receives, hence in poorly-lit zones it presents a whitish color. Its surface is rough and irregular. The species likes to bore into calcareous substrates with a just a few round or oval papillae measuring up to 1.2 mm in diameter visible to observers (**photo 153**). Examples can also grow outwards, appearing in the encrusting form, or if its development continues it may present in the massive form. These three forms are known as alpha (**photo 154**), beta (**photo 155**) and gamma (**photo 156**), respectively. In the second and third forms, the papillae are elevated considerably above the substrate with diameters of more than 2 cm.

Habitat

The species is present in a large variety of environments. The alpha form is common in shallow zones, whether they be sites with a strong hydrodynamism or semi-stagnant waters, but always growing on calcareous substrates. They are also found in ports. At deeper depths we find examples of the beta form on calcareous rocks, this form can reach large sizes and cover all of the substrate available. It is also found growing on detritic sea floors. Inhabits a range from the surface down to 140 m deep.

Distribution

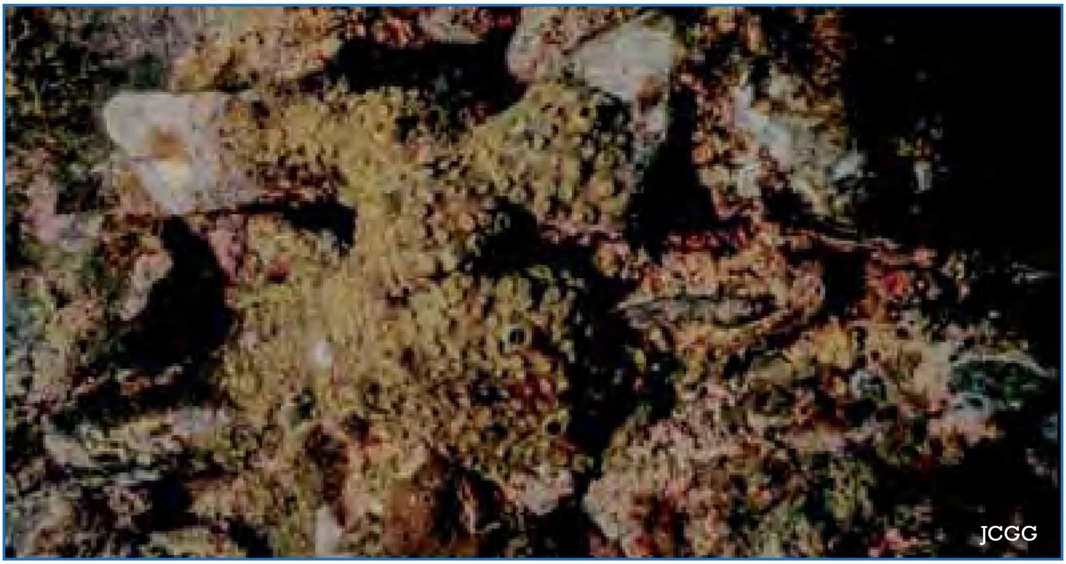
Distributed throughout the eastern and western Atlantic, as well as the Mediterranean including the Strait of Gibraltar.

Environmental sensitivity

C. viridis can tolerate extreme pollution conditions, such as high levels of solids in suspension and sedimentation (Carballo *et al.*, 1996), as well as the presence of different heavy metals (Pérez *et al.*, 2004). It is indicative of polluted or environmentally disturbed waters (Carballo *et al.*, 1994; El-Wahidi *et al.*, 2011).

Phot. 154

Phot. 155



Phot. 156

10.22. *Crambe crambe* (Schmidt, 1862)

Phot. 157

Phylum: Porifera
Class: Demospongiae
Order: Poecilosclerida
Family: Crambeidae
Genus: *Crambe*
Common name: Orange-red encrusting sponge

Description

An orangey-red laminar sponge with 1 to 3 mm thick. It has a compact, fleshy and yet soft, consistency. The surface is crossed by large channels that open into slight ridges and form water exhaust orifices (oscules) which are easily recognized when diving (**photo 157**).

Habitat

They tend to be very abundant in shallow zones growing over vertical or slightly inclined rocky substrates. As the depth increases and the light's intensity decreases, they often appear on horizontal substrates. It is an epibiont species that lives on organisms such as bivalves, tunicates, bryozoans and algae. It is also found in detritic bottoms, *Posidonia* meadows, coralline habitats and ports. Its range of habitat spans from the intertidal zone down to depths of more than 100 m.

Distribution

Common throughout the Mediterranean, being very abundant in the Alboran Sea and the Strait of Gibraltar.

Environmental sensitivity

Tolerant species that is a highly successful competitor with a broad ecological valence (Becerro *et al.*, 1994; García-Gómez, 2007). Although it is found in clean waters and biodiverse bottoms in an excellent state of conservation, it can bear high levels of environmental stress (Carballo and Naranjo, 2002), such as elevated degrees of turbidity and sedimentation, as well as moderate concentrations of organic material in suspension (**photo 158**).

The species also exhibits a high tolerance to the presence of heavy metals (Cebrián *et al.*, 2003, 2007) and above average temperatures (Pérez *et al.*, 2000).

Therefore, due to its high adaptive plasticity, this species is not a good indicator of clean and unpolluted waters because it provides very limited information about these parameters. As such, it constitutes a perfect example of a species that should not be selected for monitoring well-conserved seabeds, which, in an effort to protect the future of such zones, are intended to be used in environmental surveillance programs based on sensitive bioindicator species.

Phot. 158

10.23. *Crella (Crella) elegans* (Schmidt, 1862)

Phot. 159

Phylum: Porifera
Class: Demospongiae
Order: Poecilosclerida
Family: Crellidae
Genus: *Crella*
Common name: None

Description

A coating sponge that can cover areas of several cm^2, it is characterized by some erect projections of between 3 to 11 cm long and its lobular appearance. The surface of this species is smooth, shiny and presents a network of lines. It has a soft consistency and the color varies from pale orange to pinkish-orange. (**Photos 159 and 160**).

Habitat

Tends to be found in open locations growing over rocky substrates (**photo 161**), in caves and in deep (70-80 m) detritic habitats growing on algae from the genus *Laminaria*. It is occasionally observed covering barnacles, gorgonians and the bryozoan *Myriapora truncata*. Found in depths ranging from 0 to 120 m.

Phot. 160

Distribution

Distributed throughout the North Atlantic and the Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

This species has great adaptive capacity and is found in areas of high environmental stress (Carballo *et al.*, 1996), although this tolerance is less than that of other tolerant species, such as *Crambe crambe*. For example, it appears to have a certain degree of sensitivity to the presence of metal ions in the environment (Sabya *et al.*, 2009).

Its tolerance to abnormal increases in water temperatures, which caused mass deaths in many other organisms, has also been documented (Verdura *et al.*, 2013).

Phot. 161

10.24. *Hymeniacidon perlevis* (Montagu, 1814)

Phot. 162

Phylum: Porifera
Class: Demospongiae
Order: Halichondrida
Family: Halichondriidae
Genus: *Hymeniacidon*
Common name: Crumb-of-bread sponge

Description

This laminar coating sponge has a soft texture and is pale orange in color. Papillae, almost 1 cm high and 0.5 cm in diameter, project from its surface. A pore opens at the end of each papillae from which radiates a series of channels, visible due to the sponge's transparent nature. It can grow up to 20 cm long and is also characterized by the ability to adapt to the substrate on which it finds itself; generally it prefers rocks and calcareous algae. (**Photos 162 and 163**).

Habitat

Found in numerous and varied environments due to its high degree of ecological plasticity. It appears in exposed and well-lit areas covering rocky horizontal surfaces, underneath stones, in detritic seabeds associated to the alga *Caulerpa prolifera* and in highly-polluted stagnant sites, such as ports. It can grow over other organisms such as some gastropods and algae, or form part of fouling in ports and harbors. Observed in depths from 3-4 m down to 70 m.

Distribution

Cosmopolitan species.

Environmental sensitivity

H. perlevis is often found coating artificial port structures (Carballo *et al.* 1996; Saiz-Salinas and Urkiaga-Alberdi, 1999; Corriero *et al.*, 2007; Bandelj *et al.*, 2009) and its presence has demonstrated a positive correlation with respect to turbidity and material in suspension (Urkiaga-Alberdi *et al.*, 1999). The species also shows strong resilience to physical impacts, such as those derived from recreational diving (Lloret *et al.*, 2006). These characteristics define the species as tolerant of the more typical anthropogenic disturbances. Furthermore, the species revealed a high capacity for *in situ* accumulation of pollutants (Mahaut *et al.*, 2013).

Notes

Species formerly cited as *Hymeniacidon sanguinea.*

Phot. 163

10.25. *Oscarella lobularis* (Schmidt, 1862)

Phot. 164

Phylum: Porifera
Class: Homoscleromorpha
Order: Homosclerophorida
Family: Oscarellidae
Genus: *Oscarella*
Common name: Flesh sponge

Description

This species has a lobed morphology; these lobes are round or elongated, and individual or interconnected. It is a laminar coating sponge and can carpet areas of several cm^2, while the thickness varies from 2 to 4 cm. The external surface is smooth and has a soft and slightly gelatinous texture. The color varies greatly depending on its exposure to light; thus, in exposed areas it has a blue and violet tone, reddish in more shaded sites and it is cream-colored in dark environments. (**Photos 164 and 165**).

Habitat

Very abundant in shaded zones, usually found growing over vertical walls and overhangs. Sometimes found under stones and growing over algae from the genus *Codium*. Also grows over other organisms such as bivalves and very often found in ports and harbors. It inhabits a range from the intertidal zone down to 350 m.

Distribution

Cosmopolitan species.

Environmental sensitivity

It is very tolerant of different environments and degrees of contamination, thanks to its major adaptive capacity (Carballo *et al.*, 1996; Hiscock *et al.*, 2010). However, it does appear to be sensitive to the negative effects derived from excessive sedimentation (Cocito *et al.*, 2002).

Phot. 165

10.26. *Spongia (Spongia) agaricina* Pallas, 1766

Phot. 166

Phylum: Porifera
Class: Demospongiae
Order: Dictyoceratida
Family: Spongiidae
Genus: *Spongia*
Common name: Elephant ear sponge

Description

This species of brown or dark gray sponge forms in erect laminae that frequently join together at the ends and form shallow-cup or plate-like structures (resembling an elephant's ear) (**photo 166**), it also has a stemmed base with which it anchors to the substrate. The height varies between 3 and 40 cm, while the laminae are 0.9 - 1.3 cm thick. Examples have a soft, flexible and elastic consistency.

Habitat

Found on all types of substrate but above all in settings which receive little light, settling on overhangs or the floor of small cornices, and as the depth increases (20 - 25 m) it is observed on horizontal substrates or vertical walls (**photo 168**). In yet deeper waters the species grows on detritic bottoms. The habitat ranges from 6 to 300 m.

Distribution

A primarily Mediterranean species that is found throughout the Mediterranean including the Strait of Gibraltar. Some examples are cited on the coasts of Portugal.

Environmental sensitivity

Spongia agaricina is semi-tolerant of environmental disturbances (Carballo *et al.*, 1996; Carballo and Naranjo, 2002) but it is a good indicator species because the shape makes it a perfect sediment trap. Thus, if it is observed that the 'cup' is full of particles then we can deduce that there is or has been some type of disturbance (**photo 167**). Furthermore, as with other sponge species described in this guide, it has demonstrated a high degree of sensitivity to abnormally elevated temperatures (Pérez *et al.*, 2000).

Other studies have reported that *S. agaricina* is a good indicator of the environmental presence of heavy metals (Pérez *et al.*, 2004) and organophosphate compounds (Coito *et al.*, 2007).

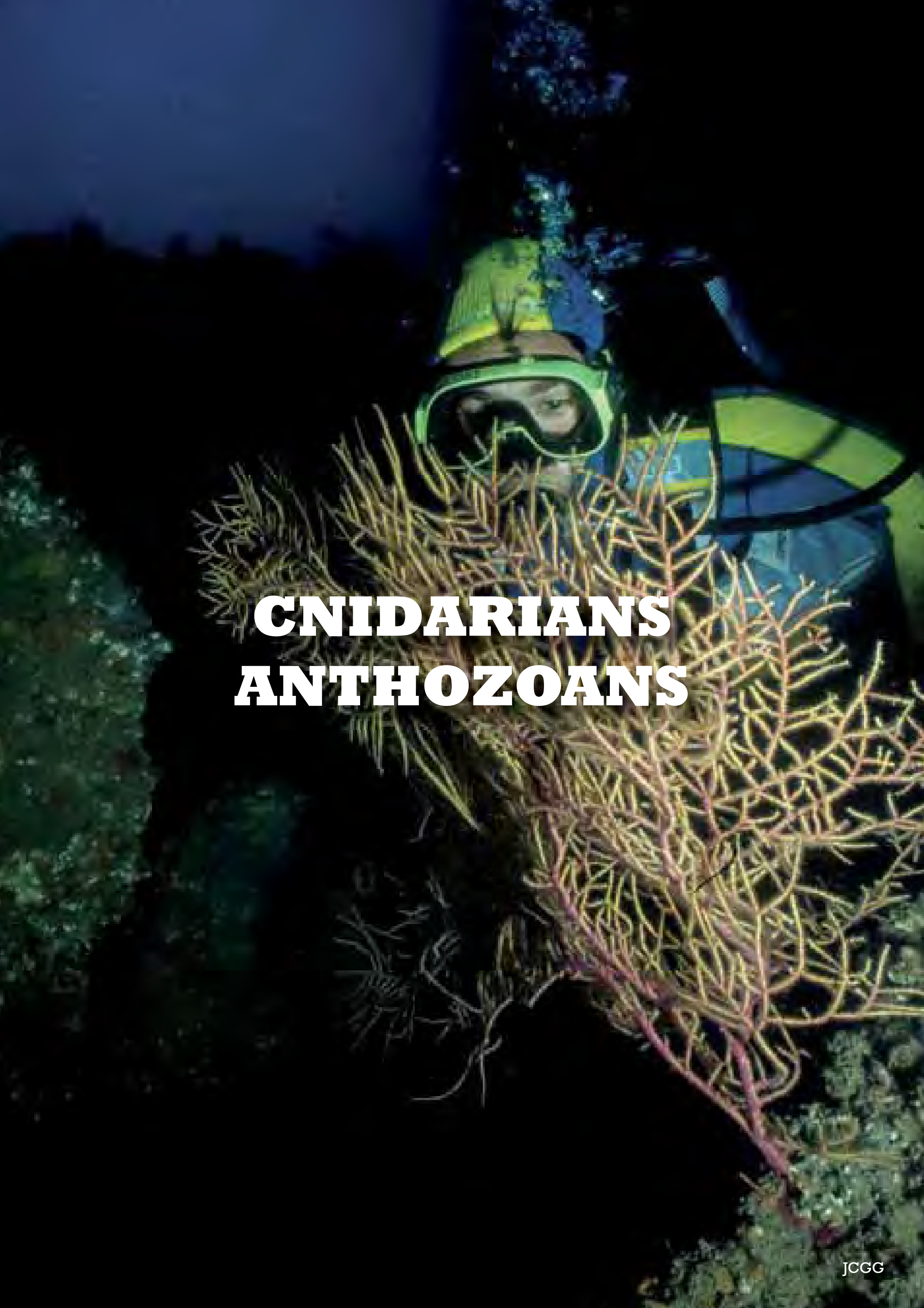
Environmental protection bodies

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".

Phot. 167

Phot. 168

CNIDARIANS ANTHOZOANS



JCGG

10.27. *Actinothoe sphyrodeta* (Gosse, 1858)

Phot. 170

Phylum: Cnidaria
Class: Anthozoa
Order: Actiniaria
Family: Sagartiidae
Genus: *Actinothoe*
Common name: Sandalled anemone or fried egg

Description

A solitary anthozoan anchored to the substrate via a well-developed circular disk (holdfast) from which emerges a cylindrical column with a slightly smaller diameter than that of the base. The surface is smooth and has a greenish-gray color with whitish longitudinal lines. The top of the column is usually reddish-chestnut or orange. Typically presents between 96 and 140 tentacles arranged in 5 rings, they are white with an orange or chestnut base. This anemone grows to diameters of up to 3 cm and heights of 5 cm. It has a fragile consistency. (**Photos 170 - 172**).

Habitat

Examples settle on rocky substrates, whether underneath stones or on vertical walls and overhangs. The species anchors directly to the rock or other animals, e.g., sponges and ascidians. It is often found living in groups and can cover large expansions. Commonly observed growing with other anthozoans such as *Corynactis viridis*. Generally inhabits a range from the surface down to depths of 40 m.

Distribution

In the eastern Atlantic, from the British Isles to Morocco and in the Strait of Gibraltar.

Environmental sensitivity

Actinothoe sphyrodeta has been observed in anthropized environments (author's personal observations). (**Photo 173**).

Phot. 171

Phot. 172

Phot. 173

10.28. *Anemonia sulcata* (Pennant, 1777)

Phot. 174

Phylum: Cnidaria

Class: Anthozoa

Order: Actiniaria

Family: Actiniidae

Genus: *Anemonia*

Common name: Spanish names are the "*common anemone*" or "*sea nettles*", whereas in English it is known as "snakelocks anemone"

Description

A solitary species that reaches 30 cm tall and 25 cm in diameter. Anchors to the substrate by means of a broad adhesive base. Its trunk is generally cylindrical with a fleshy texture and a smooth, somewhat slimy surface. Develops with numerous long, thin tentacles which expand at the points. The total of 180 - 260 tentacles are distributed among 5 or 6 circles. The color varies between yellowish-brown and green (due to the presence of symbiotic zooxanthellae algae) and the points of the tentacles are violet. The anemone cannot completely withdraw its tentacles which, when fully extended, cover the whole trunk. (**Photo 174**).

Habitat

Examples settle in well-lit or slightly shaded seabeds composed of sand, gravel or rocks, as long as there is a certain degree hydrodynamism. They are also typical in tidal rock pools. Its tentacles provide a refuge for various species of crustacean and fish. Observed from the surface down to depths of 25 to 30 m.

Distribution

Distributed throughout the Mediterranean and in the eastern Atlantic, from the north of Europe to the Strait of Gibraltar.

Environmental sensitivity

While *Anemonia sulcata* is found in shallow bottoms with clean and rejuvenated waters (**photo 174**), it is a species of broad ecological valence (García-Gómez, 2007), very adaptive, and which also tolerates environments with moderate degrees of organic material (Boyra *et al.,* 2004; Dolenec *et al.,* 2006) and sedimentation (Ruiz-Giráldez *et al.,* 2004; Dolenec *et al.,* 2005; Guerra-García *et al.,* 2006) (**photos 175 - 177**).

Therefore, it should not be used as an ecological indicator of waters that are unpolluted or of high environmental quality. It should also be remembered that it is edible (often eaten fried in Spanish restaurants under the name of *ortiguillas de mar*, or "sea nettles"), which should guarantee the provenance of the examples since, as shown in the photographs, it often grows abundantly in areas close to ports with moderate or high levels of disturbance.

Phot. 175

Phot. 176

Phot. 177

10.29. *Balanophyllia (Balanophyllia) regia* Gosse, 1853

Phot. 178

Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia
Family: Dendrophylliidae
Genus: *Balanophyllia*
Common name: Golden star coral

Description

A solitary coral whose individuals have a calcareous base but with a fragile and spongy texture. It can have a circular, oval-shaped or polygonal cross-section with a diameter of up to 1.5 cm. Polyps are yellow or orange and have approximately forty-eight 2.5 cm long tentacles presenting the same color as the rest of the organism (**photo 178**).

Habitat

This species is usually found in well-lit zones, growing over the surface of rocks of varying sizes. Also inhabits vertical walls and overhangs. Found in depths of between 3 and 25 m.

Distribution

Common to the Mediterranean including the Strait of Gibraltar. In the eastern Atlantic it extends from the south-west of Ireland to the Canary Islands.

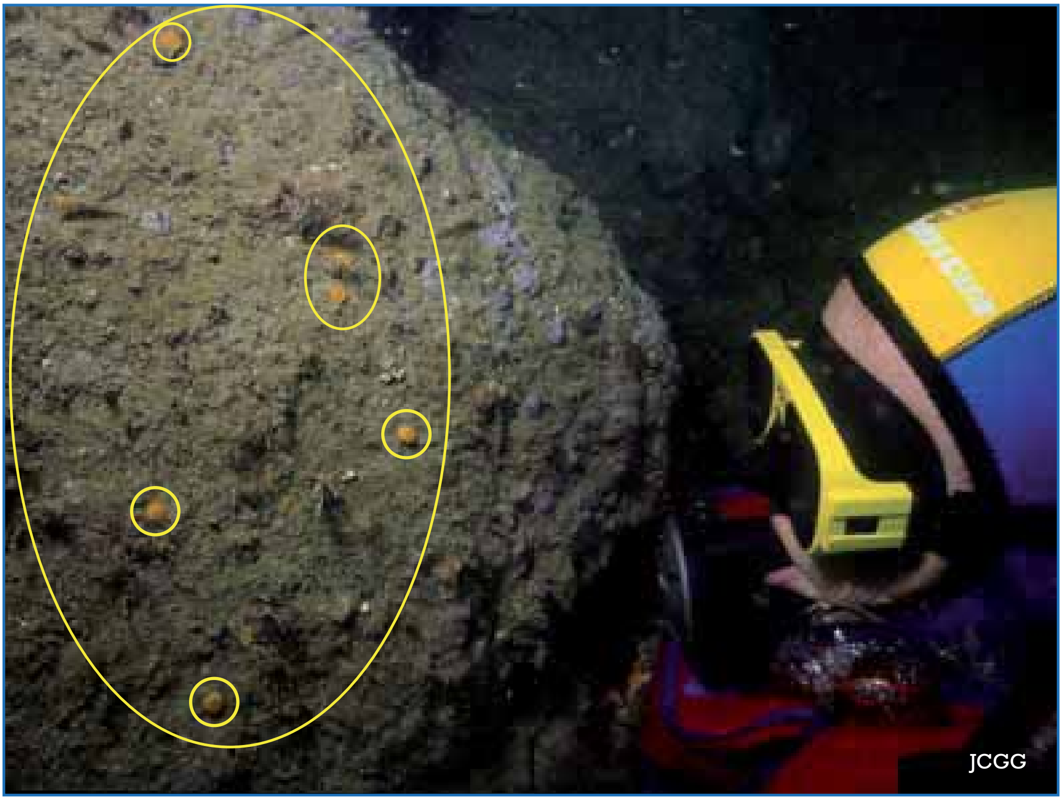
Phot. 179

Environmental sensitivity

Balanophyllia regia is a tolerant species that can be observed in both undisturbed seabeds (Bullimore, 1986; Davies, 1998) as well as those exposed to moderate organic loads, turbidity and segmentation (García-Gómez, 2007). It has recently been cited as a new species in the Adriatic (Kružić, 2002) and its introduction appears to be linked to climate change (Pećarević *et al.*, 2013). It does not, therefore, make a good choice of bioindicator for surveillance programs when considering the aims of this guide. **Photos 179 and 180** illustrate the different levels of impact in a sedimentation process caused by coastal dredging.

Notes

This species should not be confused with the similar but sensitive species *Leptosammia pruvoti*; the latter has more tentacles, and usually found in greater abundance in deeper coralline habitats and always tries to avoid horizontal surfaces - which is precisely where *Balanophyllia regia* frequently settles.



Phot. 180

10.30. *Eunicella singularis* (Esper, 1791)

Phot. 181

Phylum: Cnidaria
Class: Anthozoa
Order: Alcyonacea
Family: Gorgoniidae
Genus: *Eunicella*
Common name: White gorgonian

Description

This species forms erect, flexible and fixed colonies measuring up to 50 cm height and 9 cm width. It looks like a candelabra because it has very little branching and is open at the base, while the ends of the branches are quite long. The polyps extend slightly beyond the branches. As its common name suggests, it is typically white. (**Photos 181 - 184**).

Habitat

E. singularis usually appears in well-lit, horizontal or gently sloping, rocky enclaves, but also anchors itself to walls and small rocks in sandy seabeds (**photo 182).** Although it can grow at depths of 40 m, the "fields of white gorgonians" are habitually found between 10 and 20 m.

Distribution

Distributed from the western Mediterranean to the Atlantic coasts of Morocco and Mauritania. It is very abundant in the Alboran Sea and the Strait of Gibraltar.

Environmental sensitivity

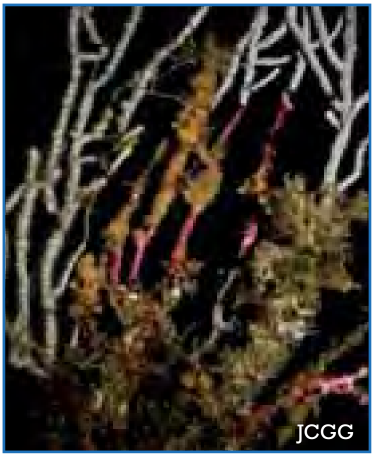
Although *E. singularis* prefers clean and renewed waters, it is a tolerant species with a broad ecological valence (Linares *et al.*, 2008), so it is also found on sea floors subjected to high degrees of sedimentation and in zones of moderate organic load. The species is also tolerant of very turbid waters. For these reasons, it is not a particularly good bioindicator for use in environmental surveillance programs designed to monitor coastal water quality. Nevertheless, it does appear to be sensitive to water temperature increases (Perez *et al.*, 2000; Garrabou *et al.*, 2009), although to a lesser degree than other gorgonian species (Previati *et al.*, 2010; Ezzat *et al.*, 2013).

Notes

The species is very similar to *Eunicella verrucosa*; they are differentiated by the rougher surface of *E. singularis* because its polyps protrude further.

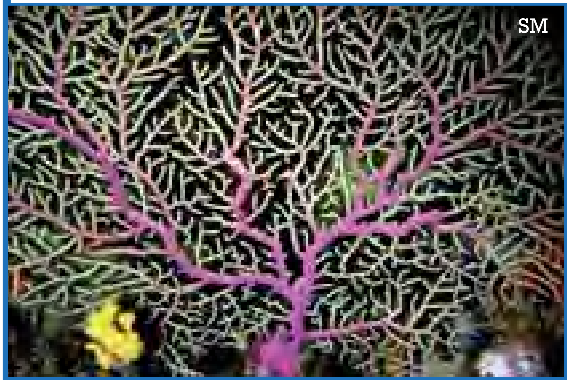
Phot. 182

Phot. 183



Phot. 184

10.31. *Leptogorgia lusitanica* Stiasny, 1937



Phot. 185

Phylum: Cnidaria
Class: Anthozoa
Order: Alcyonacea
Family: Gorgoniidae
Genus: *Leptogorgia*
Common name: None

Description

Colonies of this gorgonian are treelike and densely branched. Ramification tends to develop in just one plane. Branches are short, thick and slightly flattened. Examples grow to a height and width of 30 cm and have a coenenchyme skeleton. Coloring varies greatly as examples can be white, yellow or violet, while there are also violet colonies with yellow patches. (**Photos 185 - 189**).

Habitat

Inhabits rocky bottoms with adjoining areas of sand and mud, settling on vertical walls or horizontal blocks of rock. The species is also found on gravel or detritic seabeds. They usually appear in isolation from each other. Prefers less turbid waters than *L. sarmentosa.* Observed in depths of 6 to 100 m.

Phot. 186

Distribution

An Atlantic species that extends from the north coast of the Iberian Peninsula to Morocco, including the Strait of Gibraltar.

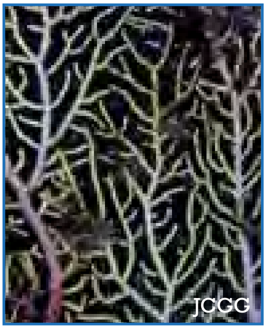
Environmental sensitivity

Unlike *Leptogorgia sarmentosa*, which is capable of tolerating high levels of turbidity, *L. lusitanica* is usually found in zones with less sedimentation (Cúrdia *et al.*, 2013) and turbidity (López-González, 1993). Having said that, and because it is a filter-feeder, *L. lusitanica* is also frequently observed in areas with a notable degree of sedimentation and/or turbidity (**photo 187**). These conflicting observations mean it is not a recommendable choice of bioindicator for environmental surveillance programs.

Notes

The species is very similar to *Leptogorgia sarmentosa*. The difference lies in that *L. lusitanica* tends to branch out in just a single plane, while *L. sarmentosa* has less dense, longer branches which open in all planes.

Phot. 187



Phot. 188

Phot. 189

10.32. *Leptogorgia sarmentosa* (Esper, 1789)

Phot. 190

Phylum: Cnidaria
Class: Anthozoa
Order: Alcyonacea
Family: Gorgoniidae
Genus: *Leptogorgia*
Common name: None

Description

Colonies form treelike structures (although with a low degree of branching) with a coenenchyme skeleton and measure up to 1 m tall. The color varies from terracotta to pale yellow. Branches are long, thin and planar; the main branches are between 4 and 5 mm thick, while side branches are around 0.5 mm. There are fine striations on the surface. (**Photos 190 and 191**).

Habitat

It grows in shaded environments over rocky, sandy/muddy or biodetritic seabeds where it settles on shell remnants (**photos 192 - 194**). Also found in cave entrances or crevices. Colonies almost always grow isolated and separated from each other. Observed at depths of 5 to 300 m.

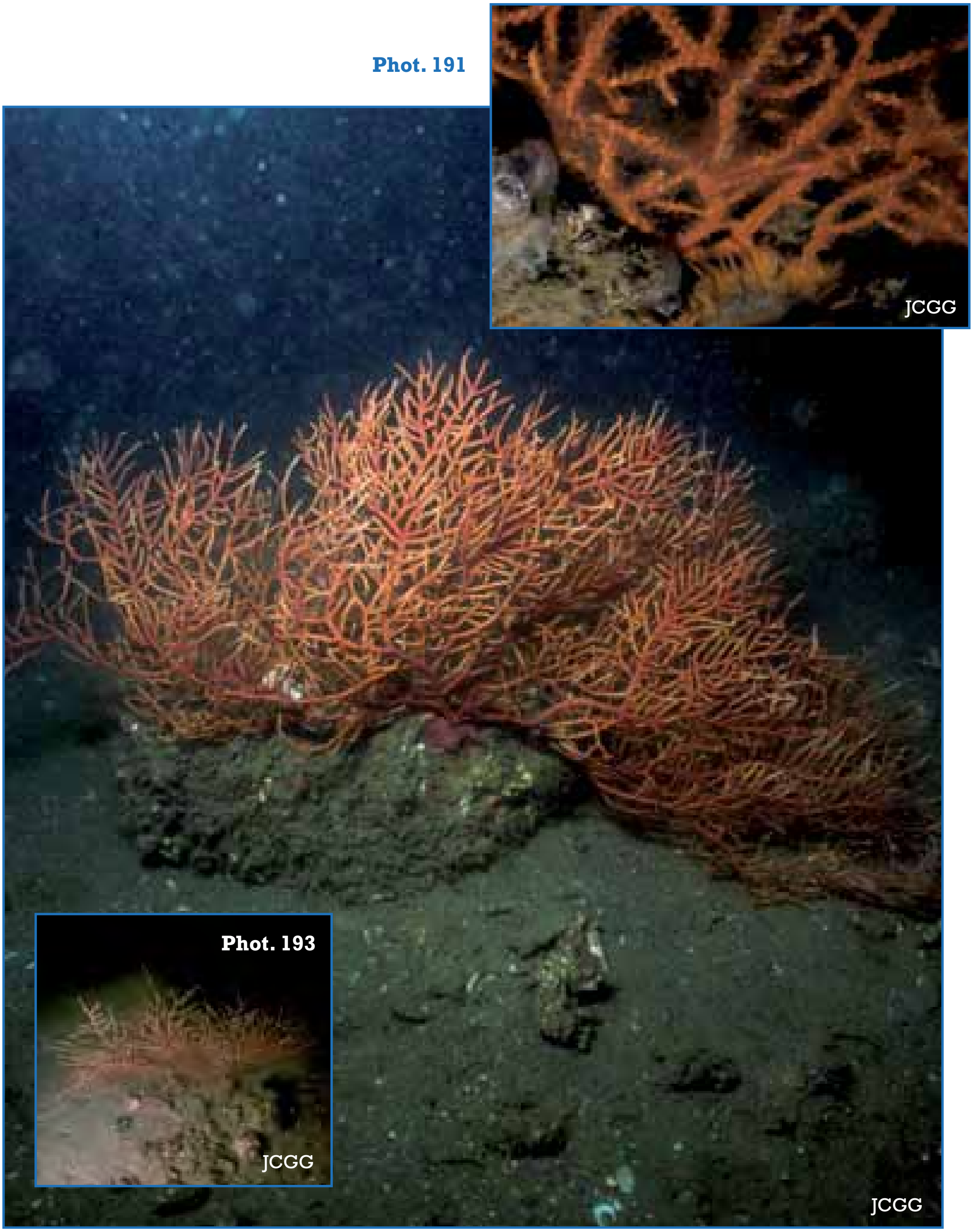
Distribution

Throughout the Mediterranean.

Environmental sensitivity

The species withstands high levels of turbidity (Bianchi *et al.*, 2012) and tends to be associated to benthic typologies with high degrees of sedimentation and turbidity, such as detritic bottoms composed of sand and muds (Cocito *et* *al.*, 2002; Gori *et al.*, 2011; Sardá *et al.*, 2012). Reports also indicate that it can tolerate water temperature increases (Roghi *et al.*, 2010).

Phot. 191



Phot. 193

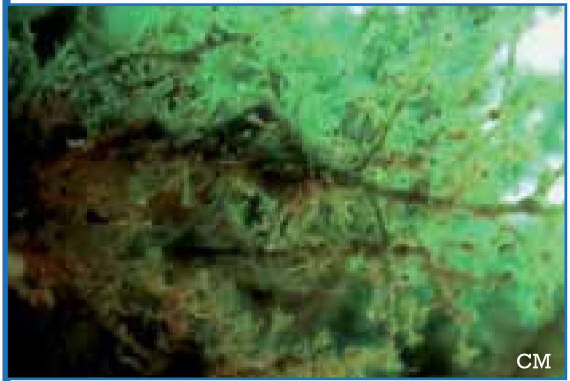
Phot. 192

Phot. 194

CNIDARIANS
HYDROZOANS

JCGG

10.33. *Eudendrium carneum* Clarke, 1882



Phot. 196

Phylum: Cnidaria
Class: Hydrozoa
Order: Anthoathecata
Family: Eudendriidae
Genus: *Eudendrium*
Common name: Red stickhydroid

Description

Eudendrium carneum forms colonies that reach up to 18 cm tall and its main axes are thick, nodular and densely branched. Branching is irregular and more or less alternate; the main branches are polysiphonic (several central tubes) while the lesser branches are monosiphonic. The branches and the pedicels have rings at their bases. The hydroids are large, with an elongated body, a broad hypostome and a crown of 28 to 32 tentacles. (**Photos 196 - 198**).

Habitat

Generally found in depths of 0 to 20 m, although it prefers shaded environments. The species colonizes both natural and artificial rocky substrates.

Distribution

Widely distributed in the Atlantic, Indian and western Pacific Oceans as well as the Red Sea. Examples have been cited in the Adriatic and western Mediterranean.

Environmental sensitivity

Eudendrium carneum is tolerant of anthropogenic disturbances (Cabral, 2013) and commonly found on port structures and in surrounding areas (Philp *et al.*, 2003; Megina *et al.*, 2013).

Notes

It is an invasive species that has been introduced into the Mediterranean by man, primarily by attaching itself to the hulls of ships.

Phot. 197

Phot. 198

10.34. *Eudendrium racemosum* (Cavolini, 1785)

Phot. 199

Phylum: Cnidaria
Class: Hydrozoa
Order: Anthoathecata
Family: Eudendriidae
Genus: *Eudendrium*
Common name: None

Description

Eudendrium racemosum forms bushy colonies of up to 15 cm tall. The polyps are athecate (without an external sheath) and have a club-shaped oral cone crowned by long tentacles. When mature, the colonies tend to be orange due to large-scale development of gonophores. (**Photos 199 - 202**).

Habitat

They are found growing over many types of substrate (rocks, mussels, algae), from depths of 0 to 30 meters. Preferably inhabits shaded environments.

Distribution

The species is considered cosmopolitan, broadly distributed throughout the Indo-Pacific and the eastern Atlantic. It has also been cited in the Mediterranean.

Environmental sensitivity

Eudendrium racemosum demonstrates a high tolerance to different pollution sources (Cattaneo-Vietti *et al.*, 2003; Marchini *et al.* 2004; Megina *et al.*, 2013).

Notes

It is a species very similar to *Eudendrium carneum*, both are basically indiscernible to the naked eye, requiring a microscope to study the fine details of morphological elements.

Phot. 200

Phot. 201

Phot. 202

10.35. *Obelia dichotoma* (Linnaeus, 1758)

Phot. 203

Phylum: Cnidaria
Class: Hydrozoa
Order: Leptothecata
Family: Campanulariidae
Genus: *Obelia*
Common name: Sea thread hydroid

Description

Forms hydroid colonies of various shapes and sizes. It has an erect, monosiphonic, branched thallus of up to 35 cm tall; this hardens in the maturest of colonies. There are several rings at the base of the internodes. The hydrothecas are arranged laterally and alternately, located on pedicels which display complete rings at the top of the internodes. (**Photo 203**).

Habitat

Generally found in shallow waters. It colonizes hard substrates, both natural and all types of artificial surface.

Distribution

A cosmopolitan species. Present across the Mediterranean, from east to west including the Adriatic.

Environmental sensitivity

Obelia dichotoma is a species with a high level of tolerance to different types of disturbance, such as eutrophication (Breves-Ramos *et al.*, 2005; Contardo-Jara *et al.*, 2006), elevated turbidity (Urkiaga-Alberdi *et al.,* 1999) or pollution (Albayrak and Balkis, 2000; Marchini *et al.* 2004). It is commonly observed growing over port structures and in surrounding areas (Megina *et al.*, 2013).

BRYOZOANS

JCGG

10.36. *Bugula neritina* (Linnaeus, 1758)

Phot. 205

Phylum: Bryozoa
Class:: Gymnolaemata
Order: Cheilostomatida
Family: Bugulidae
Genus: *Bugula*
Common name: None

Description

They form erect unilaminar colonies, shaped like wicks and measuring up to 10 cm long. Branching is dichotomous and each branch is comprised of two series of alternating zooids. The zooids have no spines, yet they do have a distal extension on the external side. Examples are a very dark reddish-chestnut color. (**Photo 205**).

Habitat

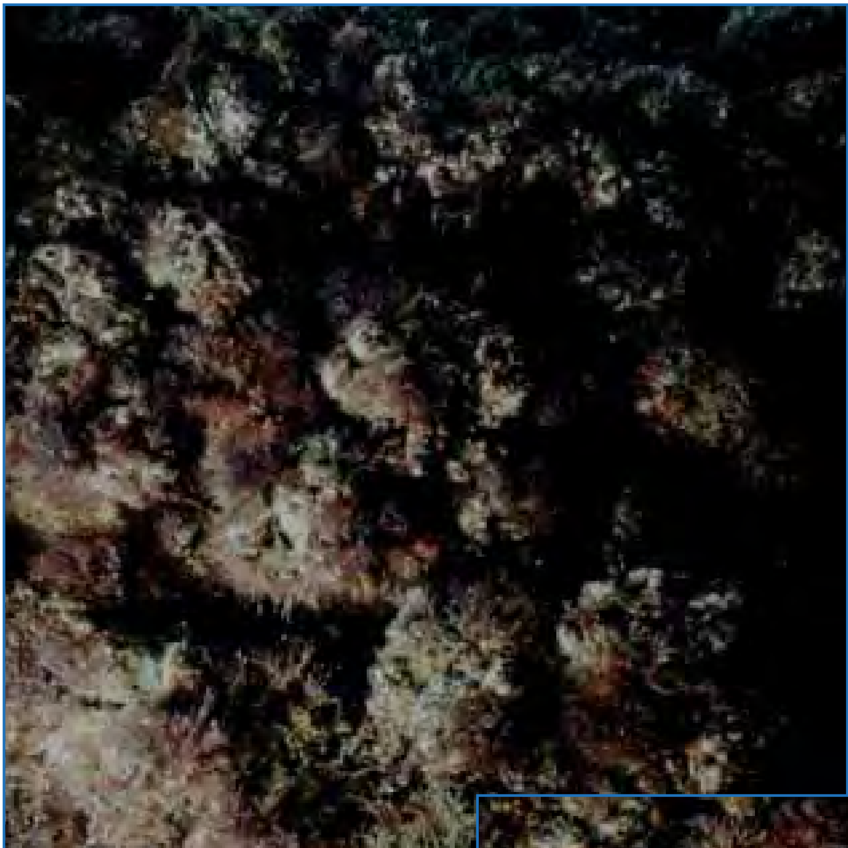
Often establishes profuse colonies on artificial substrates such as ship hulls, docks, quays, buoys and underwater ropes.

Distribution

Cosmopolitan species.

Environmental sensitivity

The species is commonly found among fouling communities and in areas of low environmental quality, such as port facilities (Ryland, 1965; Geraci and Relini, 1970; Arias and Morales, 1979; Arístegui, 1987). (**Photos 206 and 207**). It also presents substantial tolerance to certain heavy metals (Piola and Johnston, 2006).



Phot. 206

Phot. 207

10.37. *Myriapora truncata* (Pallas, 1766)

Phot. 208

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Myriaporidae
Genus: *Myriapora*
Common name: False coral

Description

Colonies of this orangey-red Bryozoa are erect and have dichotomously arranged strong, cylindrical branches which are truncated at the ends; its surface is covered with pores. Branches open out in all directions. The colonies reach diameters of up to 12 cm. They anchor to the substrate via an encrusting base. (**Photos 208 - 211**).

Habitat

Usually present in shaded, rocky bottoms, but also found in crevices and caves. Settles at depths of a few meters down to 100 m.

Distribution

Commonly observed in the Mediterranean and extends down to the coasts of the Strait of Gibraltar. Also cited around the Canary Islands and Morocco's Atlantic coast.

Phot. 209

Environmental sensitivity

It is a tolerant species, but less so than the related bryozoans *Pentapora fascialis* and *Omalosecosa ramulosa*. Although it prefers clean waters with a moderate to strong current, as it is more abundant in very structured seabeds represented by a high degree of biodiversity, it can occasionally be observed in turbid bottoms with sedimentation, even in areas with low levels of pollution derived from domestic wastewater discharges (Harmelin and Capo, 2002). It has also demonstrated a high degree of tolerance to factors such as water temperature increases (Pérez *et al.*, 2000; Garrabou *et al.*, 2009) or elevated levels of CO_2 (Wood *et al.*, 2012). So it does not represent a good indicator of clean waters and, therefore, nor does it have any practical use in a coastal seabed surveillance program.

However, as with the two species cited above and as is mentioned in their respective files, given the eye-catching and fragile nature of its colonies, monitoring this species could help to detect physical damage in benthic communities caused by nets, anchors and under-trained or inexperienced divers, who can cause significant damage to colony structures through accidental contact.

Notes

Easily confused with red coral, differentiated by red coral's lack of dichotomous branching and its white polyps.

Phot. 210

Phot. 211

10.38. *Omalosecosa ramulosa* (Linnaeus, 1767)

Phot. 212

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Celleporidae
Genus: *Omalosecosa*
Common name: None

Description

Grows in erect colonies with dichotomous branching. Branches are cylindrical and rigid. Presents an orange-whitish color. (**Photo 212**).

Habitat

Usually found on hard substrates, sometimes living on other organisms such as gorgonians or close to hydrozoans and other bryozoans. Occasionally found in well-shaded enclaves at depths of less than 5 m, but it is usually more abundant between 10 and 40 m.

Distribution

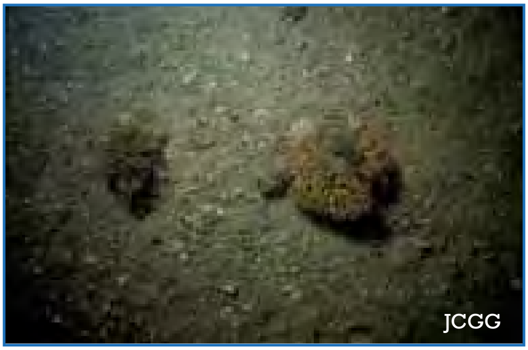
Along the eastern Atlantic, from Norway to Mauritania, and throughout the Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

A tolerant species, but with a preference for clean waters and moderate to strong currents (García-Gómez, 2007). Most abundant in structured and biodiverse (pre-coralline) seabeds inhabited by very sensitive species with narrow ecological valences (**photos 213 and 214**), yet it is also found in areas of turbid water, with high sedimentation rates (Foveau *et al.*, 2008) and moderate organic loads (**photos 215 and 216**). Studies also report that *O. ramulosa* is tolerant of TBTs (Hiscock *et al.*, 2010). Therefore, it does not represent a good indicator of clean waters (although it prefers them), nor does it have any practical use in the context of a coastal seabed environmental surveillance program. However, given the eye-catching and fragile nature of its colonies, as explained for the case of the Bryozoa *Pentapora fascialis*, monitoring this species could help to detect physical damage to sea floor biota caused by nets, anchors and under-trained or inexperienced divers, who accidentally cause damage with their flippers or by simply kneeling and/or resting on the seabed.

Phot. 213

Phot. 214



Phot. 215

Phot. 216

10.39. *Pentapora fascialis* (Pallas, 1766)

Phot. 217

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Bitectiporidae
Genus: *Pentapora*
Common name: Ross coral

Description

This Bryozoa is characterized by its erect colonies that arise from an encrusting base. Its branches are planar, rigid and bilaminar, and can divide dichotomously. In one of the classic morphotypes, the upper branches are reminiscent of moose antlers while the lower section tends to merge together and form a compact, uniform laminar structure. It has a bright orangey-pink color which fades when out of water. Examples can grow to 15 cm tall and 20 cm in diameter. The "foliar" morphotype is characterized by its very wide branches that neither have dichotomous divisions nor the appearance of moose antlers. In this case, the colonies take on the appearance of large rigid leaves as the laminae can join together and reach significant proportions.

Habitat

The species settles on rocky bottoms and detritic substrates with low levels of illumination. It prefers calm waters but can also be found in areas with moderate currents. Found from depths of 5 to 100 m.

Phot. 218

Distribution

In the Atlantic, from the west of the British Isles down into the Mediterranean where it is common.

Environmental sensitivity

A tolerant species, although it prefers clean and relatively calm waters (García-Gómez, 2007). It is found in both sea floors of high diversity and environmental quality (**photo 217**), as well as those with high levels of sedimentation, moderate organic load and persistently turbid waters (Harmelin and Capo, 2002) (**photos 218 and 219**). Therefore, it is not a species indicative of good environmental conditions and serves little purpose in a project monitoring the quality of coastal waters.

Nevertheless, since its eye-catching colonies (large and colorful) can be clearly identified during a routine dive, and because they break easily in the face of abrasive action from drag nets, anchors or inexperienced divers (who, due to a lack of training in marine conservation, often kneel on the seabed, for example, to take photographs or perform certain observations, or because they are incorrectly ballasted or have poor control over their buoyancy compensator) (Sala *et al.*, 1996; Garrabou *et al.*, 1998), then this species can be monitored by checking for reduced numbers or the destruction of their very stable, highly-structured habitats, which also comprise very beautiful seascapes.

Pentapora fascialis has fortunately demonstrated a capacity for very rapid recovery once the factors causing the damage have been eliminated or controlled (Sheehan *et al.*, 2013).

This species has also been considered as an appropriate indicator of a zone's thermal conditions. However, at least around the southern Iberian Peninsula this quality is hardly discernible, as *P. fascialis* was observed to be practically unaffected by abnormally high temperatures (Pérez *et al.*, 2000).

Environmental protection bodies

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al.*, 2008), under the category "Vulnerable".

Phot. 219

10.40. *Schizobrachiella sanguinea* (Norman, 1868)

Phot. 220

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Schizoporellidae
Genus: *Schizobrachiella*
Common name: None

Description

This species forms encrustations of one or multiple laminae that can develop into erect structures with folded and partly enclosed masses, creating tubular expansions. Covers areas of up to several cm^2 and is reddish, brown or slightly violet. Its shape depends on the movement of the water. (**Photo 220**).

Habitat

It is a coating species that settles on rocky surfaces and on the calcareous skeletons of other animals or algae from the genus *Lithothamnium*. Also found growing from the base of the phanerogam *Posidonia oceanica*. Typically inhabits depths of 5 to 50 m.

Distribution

The species is common to the Mediterranean and extends to the Strait of Gibraltar. It has also been observed off the south-eastern coasts of the British Isles and around the Canary Islands.

Environmental sensitivity

It is a tolerant species but prefers clean waters. Adapts to conditions of low, moderate and high hydrodynamism, as well as different levels of turbidity and organic load (Mariani *et al.*, 2003; Koçak, 2008), although it is sensitive to excessive sedimentation. As such, it is not a good species to use as an indicator of clean and rejuvenated waters. However, *Schizobrachiella sanguinea* can help to monitor biodiverse, well-structured seabeds because just a short time after colonies are partially covered by abnormal sedimentation (e.g., derived from dredging overflow) white zones appear corresponding to mass death of zooids (**photos 221 and 222**, before and after eliminating the sediment) (García-Gómez, 2007).

Phot. 221

Phot. 222

10.41. *Smittina cervicornis* (Pallas, 1766)

Phot. 223

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Smittinidae
Genus: *Smittina*
Common name: None

Description

This species grows in erect colonies with dichotomous branching and takes on an orangey-yellow color. The whole of its surface is covered by fine "hairs" corresponding to the zooids' tentacles. (**Photo 223**).

Habitat

Usually appears in coralline and detritic seabeds, growing on walls and stones. Its habitat range begins at 20 m, but it is most abundant at depths of 40 - 60 m.

Distribution

Throughout the Mediterranean, including the Strait of Gibraltar, and also in eastern Atlantic, from the British Isles to Gabon.

Environmental sensitivity

Smittina cervicornis has been observed in areas of low environmental quality, such as port facilities, and so it should not be used as a bioindicator species.

ANNELIDS

JCGG

10.42. *Sabella pavonina* Savigny, 1822

Phot. 225

Phylum: Annelida
Class: Polychaeta
Order: Sabellida
Family: Sabellidae
Genus: *Sabella*
Common name: Peacock worm

Description

This worm has an elongated body of up to 25 cm in length, its cross-section is sub-cylindrical as it is slightly flattened in the ventral area. Its body varies from an orangey-yellow to a gray-violet color. It has some feathery extensions protruding from the head arranged in horizontal stripes of varying colors. This animal lives within an erect tube formed by various layers of mucus, while the outer surface is covered with a layer of fine sedimentary particles. (**Photo 225).**

Habitat

Found in soft bottoms (**photo 226)** where it arranges the tube vertically in the substrate. Prefers zones with indirect lighting, such as cave entrances, and also sandy clearings between rocks or clumps of *Posidonia* (**photo 225).** Observed at depths from a few meters down to 25 - 30 m.

Distribution

Throughout the Mediterranean and Atlantic.

Environmental sensitivity

Sabella pavonina tolerates environments with varying degrees of turbidity, organic load and pollution. It is commonly found in degraded areas affected by human actions, such as port facilities (Sáiz-Salinas and Urkiaga-Alberdi, 1999; Dyrynda, 2005) or thermal power stations (Charubhun *et al.*, 2003). The species is also among the organisms which contribute to fouling in areas exposed to different types of disturbances, such as fisheries, discharges of agricultural residues or high levels of maritime traffic (Emara and Belal, 2004). Furthermore, it is capable of accumulating elevated concentrations of silver, a highly toxic metal, with no discernible harmful effects (Koechlin and Grasset, 1988).

Phot. 226

10.43. *Sabella spallanzanii* (Gmelin, 1791)

Phot. 227

Phylum: Annelida
Class: Polychaeta
Order: Sabellida
Family: Sabellidae
Genus: *Sabella*
Common name: Mediterranean fanworm, European fan worm or feather duster worm

Description

This worm has a long, cylindrical body, with a length of up to 30 cm. The rear end is thin while the front has feathery extensions forming up to 6 spiral loops which the worm can rapidly retract inside its tube. The tube is membranous and grows up to 50 cm long; it is cylindrical, formed from mucus secretions and fine sedimentary particles, and has a variable texture. The "feathers" vary in color. (**Photo 227).**

Habitat

Observed on rocky, soft and detritic bottoms as well as among *Posidonia* meadows. Also found growing in ports, both on the bottom and on dock walls. Inhabits depths from 5 to 40 m.

Distribution

Present throughout the Mediterranean and Atlantic, it has also extended to Australian coasts.

Environmental sensitivity

It is an invasive species in Australia and New Zealand (Patti and Gambi, 2001; Read *et al.*, 2011), being introduced in ports by means of ballast water discharged from ships. Furthermore, it tolerates environments with elevated sedimentation (Bocchetti *et al.*, 2004; Okuş *et al.*, 2007) **(photo 228)**, and even some toxic elements, such as arsenic (Fattorini and Regoli, 2004).

Phot. 228

10.44. *Salmacina dysteri* (Huxley, 1855)

Phot. 229

Phylum: Annelida
Class: Polychaeta
Order: Sabellida
Family: Serpulidae
Genus: *Salmacina*
Common name: Coral worm

Description

This gregarious polychaete forms white calcareous tubes. These are fragile, cylindrical and thin (1 mm in diameter), and they intertwine together to form hemispherical masses of up to 20 cm in diameter. The worm has a small, grayish body, barely 0.5 cm long, with a few colorless, feathery extensions emerging from the head. Its base is either red or yellow. (**Photos 229 - 231).**

Habitat

Found in a large variety of habitats, in fact it is observed on both rocky substrates and detritic bottoms, whether well-lit, shaded or semi-shaded (**photos 232, 233 and 235).** Also grows among *Posidonia* meadows. Found at depths from a few meters down to 600 m.

Distribution

Cosmopolitan species.

Environmental sensitivity

Salmacina dysteri is a species that tolerates different types of disturbances (Urkiaga-Alberdi *et al.*, 1999), such as turbidity, pollution and eutrophication. It is commonly found in ports (Knight-Jones *et al.*, 1991; Saiz-Salinas and Urkiaga-Alberdi, 1999; DeFelice *et al.*, 2001) (**photo 234)** and even adjacent to wastewater discharge points (Bailey-Brock and Krause, 2007).

Phot. 230

Phot. 231

Phot. 232

Phot. 233

Phot. 234

Phot. 235

10.45. *Serpula vermicularis* (Linnaeus, 1767)

Phot. 236

Phylum: Annelida
Class: Polychaeta
Order: Sabellida
Family: Serpulidae
Genus: *Serpula*
Common name: Calcareous tubeworm, fan worm, plume worm or red tube worm

Description

This worm is characterized by its long, cylindrical body of up to 7 cm. The color varies from orange to pinkish and the rear end has an attractive feathery plume with alternating pink and white stripes. It also has a funnel-shaped operculum with a serrated edge and the same color as the plume. The species lives inside a cylindrical, calcareous tube measuring up to 5 cm long and 0.6 cm wide. (**Photo 236).**

Habitat

Found inhabiting shady or semi-shaded and slightly turbulent, rocky bottoms (**photos 237 and 238)**. Also grows over mollusk shells. Distributed across depths of 0 to 250 m.

Distribution

Cosmopolitan species.

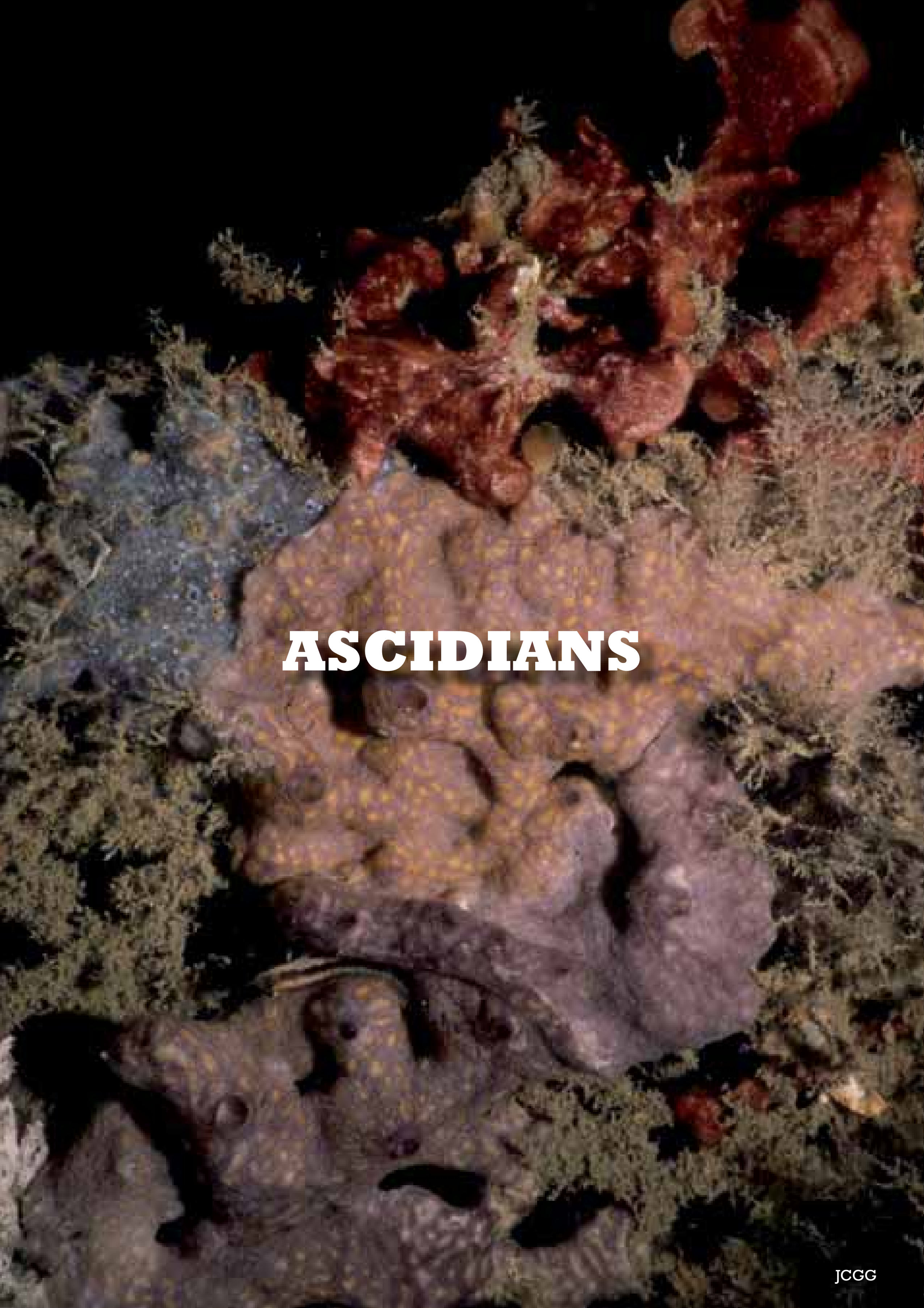
Environmental sensitivity

This species lives in clean waters and as such is sensitive to certain types of environmental disturbances, such as the presence of hydrocarbons (Chia, 1973). Nevertheless, its abundant presence has been observed in several artificial plate recolonization experiments, generally conducted in polluted environments (Schoener, 1983; El-Komi, 1991; Kocak and Kucuksezgin, 2000) or involving surfaces treated with antifouling chemicals (Jelic-Mrcelic *et al.*, 2006; Cima and Ballarin, 2008). Therefore, it does not make a very useful species for carrying out coastal water quality surveillance programs.

Phot. 237

Phot. 238

ASCIDIANS



JCGG

10.46. *Microcosmus nudistigma* Monniot C., 1962

Phot. 240

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Pyuridae
Genus: *Microcosmus*
Common name: None

Description

A solitary Ascidiacea measuring between 3 and 4 cm. The body is ventrally flattened giving it a trapezoidal shape. When it contracts it forms a crest-like fold in the dorsal area. It has a hard, leathery surface. Examples are colored reddish-yellow. (**Photos 240 and 241**).

Habitat

The species appears underneath stones in shallow waters. It also grows over other organisms, such as gorgonians, and in algal communities, both in well-lit or shaded environments. Observed in meadows of *Posidonia* as well as in coralline habitats. From the low-tide line down to 15 m.

Distribution

In the eastern Atlantic, from the coasts of Portugal to the Strait of Gibraltar. Also present in the western Mediterranean, along French and Spanish coasts.

Environmental sensitivity

Microcosmus nudistigma, akin to the other species from the genus *Microcosmus* described in this guide, tolerates adverse environmental conditions (abundant organic material, turbidity, pollution), thus it is not recommended for use in coastal water quality surveillance programs. Although there is no specific information in the literature regarding the matter, the species has been classified as tolerant based on the author's personal observations and expert opinion.

Notes

Different species in the *Pyuridae* family cannot be identified with 100% certainty using photographs alone, no matter how good their quality may be, as its members must be distinguished by studying elements of their internal anatomy, even at a genus-level. Although an experienced diver may be able to assign the specimens found in a certain location to a specific species, this identification should not necessarily be extended to other areas.

Mediterranean members of the *Pyuridae* family include several similar species, particularly in the *Microcosmus* and *Pyura* genera.

Phot. 241

10.47. *Microcosmus polymorphus* Heller, 1877

Phot. 242

Phylum:	Chordata
Subphylum:	Tunicata
Class:	Ascidiacea
Order:	Stolidobranchia
Family:	Pyuridae
Genus:	*Microcosmus*
Common name:	None

Description

This is a solitary ascidian species that grows to 6 - 7 cm long. The surface is slender and flexible but also rough; it is completely covered by other organisms and algae. Typically has an irregular, but sometimes globular, shape. (**Photos 242 and 243**).

Habitat

Found among algal communities in shady areas and calm waters, as well as in algal communities exposed to sunlight. Also inhabits coastal detritic and coralline habitats, semi-dark grottos, *Posidonia* meadows, gardens of Ascidiacea and ports. Grows at depths of between 15 and 30 m.

Distribution

Along the eastern Atlantic, from the British Isles to Morocco, including the Strait of Gibraltar. In the Mediterranean to as far as Italy and the Adriatic.

Environmental sensitivity

This species can be found in sedimentary bottoms with high levels of turbidity and sedimentation (Hartl and Ott, 1999), as well as artificial substrates (Mastrototaro *et al.*, 2008). Characterized by its capacity to accumulate heavy metals (Meziti *et al.*, 2007; Chebbi, 2010) and tolerate a moderate degree of pollution (Turón, 1988). *M. polymorphus* can, therefore, be classified as tolerant of marine pollution.

Notes

See "Notes" of *Microcosmus nudistigma.*

Phot. 243

10.48. *Microcosmus squamiger* Michaelsen, 1927

Phot. 244

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Pyuridae
Genus: *Microcosmus*
Common name: None

Description

This solitary Ascidiacea reaches a size of 4 to 5 cm long. It is reddish-brown with a more or less wrinkled, leathery surface that presents tubercles. Examples can be bare or covered by other organisms. They can be round with extensions at the base for anchoring to the substrate or they may be irregularly shaped because they are grouped with other individuals and are difficult to tell apart. The siphons are usually prominent, elongated and separated from one another. (**Photos 244 and 245**).

Habitat

Typically found on the coast, where it forms dense groups comprised of thousands of individuals. It lives on rocky bottoms, particularly in bays and ports covering concrete blocks and columns, but also covers large expanses of sandy/muddy habitat where it generates a substrate for other organisms to attach to and settle on. *M. squamiger* is an invasive species indigenous to Australia which competes strongly with native species. Observed from the low-tide line down to depths of 20 m.

Distribution

The species is broadly distributed; in the Mediterranean it is common in the waters around Italy, Morocco, France and Spain, as well as the Strait of Gibraltar. Also found in the Red Sea and the Indo-Pacific.

Environmental sensitivity

This species can tolerate large ranges of temperature and salinity, plus any type of environmental disturbance (Naranjo *et al.*, 1996; Carballo and Naranjo, 2002). In fact, its population increases in polluted areas (Mastrototaro *et al.*, 2008) and it colonizes all kinds of substrate, both natural and artificial (Turón *et al.*, 2007; Rius *et al.*, 2009). Hence, a significant presence of *M. squamiger* indicates that the water is probably suffering from some type of pollution.

Notes

See "Notes" of *Microcosmus nudistigma.*

Phot. 245

10.49. *Microcosmus vulgaris* Heller, 1877

Phot. 246

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Pyuridae
Genus: *Microcosmus*
Common name: None

Description

A solitary Ascidiacea of notable dimensions as it can reach 10 cm. It has a globular body with a very thick surface and irregular folds (**photo 246**), examples may be covered with other organisms, fragments of shells and/or sand. Ventrally, the species presents some elongated structures, measuring 4 - 5 cm wide, which it uses to attach itself to the substrate.

Habitat

Observed in settings with coarse sand and gravel, as well as in coralline, coastal detritic and ascidian seabeds. Normally found down to depths of 40 m.

Distribution

In the Mediterranean, from Italy and Greece to the Strait of Gibraltar, also common to the Adriatic.

Environmental sensitivity

Microcosmus vulgaris has been found in abundance in environments rich in organic material and with low oxygen levels (Okuş *et al.*, 2007; Steckbauer *et al.*, 2011). Besides its elevated resistance to anoxia (Riedel *et al.*, 2008), other factors, such as its capacity to accumulate certain heavy metals (Papadopoulou and Kanias, 1977) and a preference for zones of very little hydrodynamism (Ordines *et al.*, 2011), mean it is an inappropriate species for use in coastal water quality surveillance programs.

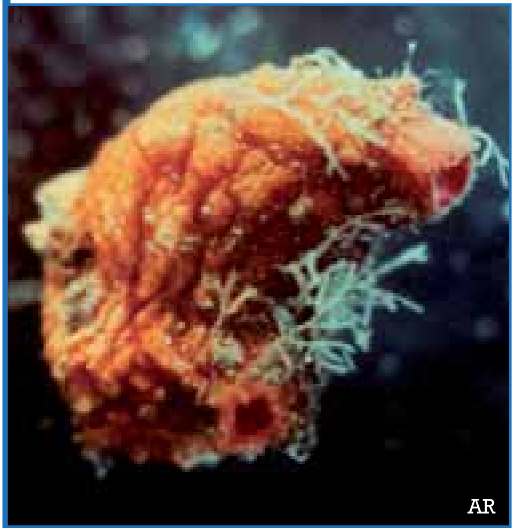
Notes

See "Notes" of *Microcosmus nudistigma.*

Environmental protection bodies

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Lesser Risk".

10.50. *Pyura dura* (Heller, 1877)



Phot. 247

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Pyuridae
Genus: *Pyura*
Common name: None

Description

This solitary ascidian grows to lengths of around 10 cm. The body is globular although slightly oval. It has a smooth, orangey-yellow surface with calcium deposits and is covered by small, irregular tubercles. (**Photos 247 and 248**).

Habitat

Tends to settle on rocky bottoms, such as coralline habitats, and in semi-dark grottos, but also found under stones and among algal communities, both in well-lit and shaded areas. Normally found in calm waters. Also grows among *Posidonia* meadows, coastal detritic bottoms and port environments. Observed from 3 to 15 m.

Distribution

In the eastern Atlantic, off Morocco and Senegal. Also found in the Mediterranean, from Italy to the Strait of Gibraltar.

Environmental sensitivity

Pyura dura is a species that exhibits a tolerance of typical disturbances: it is not significantly affected by abnormal water temperature increases (Pérez *et al.*, 2000; Lejeusne *et al.*, 2010), it is frequently found on artificial substrates (Mastrototaro *et al.*, 2008), it is resistant to antifouling chemicals (Jelic-Mrcelic *et al.*, 2006) and dominates in areas where there is high degree of pressure on the substrate due to trawler fishing practices (De Juan *et al.*, 2013). Thus, it is not a very useful species with respect to coastal water quality evaluations.

Notes

See "Notes" of *Microcosmus nudistigma.*

Phot. 248

10.51. *Pyura microcosmus* (Savigny, 1816)

Phot. 249

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Pyuridae
Genus: *Pyura*
Common name: None

Description

Solitary ascidian with an oval body measuring between 1 and 4 cm long. The surface is thick, wrinkled and covered with round or polygonal protrusions (**photos 249 and 250**). Examples can be covered with algae, sediments and/or other organisms and are usually reddish-brown in color. The siphons are long and very sensitive to light or any nearby disturbances, they have red and white longitudinal lines which are more apparent on the inner surfaces.

Habitat

This species grows over mollusk shells and rocks in a large variety of environments: it can be found in algal communities bathed in light and shaded locations in calm waters, in coastal detritic and coralline habitats, among *Posidonia* meadows, on sandy bottoms and in port scenarios (growing over artificial substrates). The species is also found under stones in shallow waters. Observed in depths ranging from 1 - 2 m down to 250 m.

Distribution

Along the eastern Atlantic, from the British Isles to Cape Verde. Throughout the Red Sea and the Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

This species of broad ecological valence is an example of a tolerant solitary ascidian (García-Gómez, 2007). It can be found in both clean waters as well as in environments disrupted by either a moderate to high organic load or high sedimentation rates (Naranjo *et al.*, 1996; Mastrototaro *et al.*, 2008). The species has also demonstrated a notable capacity to accumulate various heavy metals (Papadopoulou *et al.*, 1967).

In such circumstances these organisms become excessively abundant as their population explodes, when this occurs over rocks it is a sign that the seabed is of poor environmental quality. Underwater surveillance of our coasts should, therefore, check that *Pyura microcosmus* or similar species do not become progressively abundant on rocky surfaces where they were once absent or of limited presence. In any case, the warning of a disturbance event revealed by an abundance of this type of ascidians does not require their full taxonomical identification (which is complex), since a diagnosis of low environmental quality derives from observations of rocks covered with numerous examples, which also tend to be completely covered by algae or other epibionts.

Notes

See "Notes" of *Microcosmus nudistigma.*

Phot. 250

10.52. *Pyura squamulosa* (Alder, 1863)

Phot. 251

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Pyuridae
Genus: *Pyura*
Common name: None

Description

A solitary ascidian species that reaches sizes of between 2.5 and 4 cm. It has a leathery surface but less so than other species in the genus, it is also wrinkled and presents protrusions. Its color is reddish. (**Photos 251 and 252**).

Habitat

It can be found in a large variety of environments: coarse sand, coastal detritic and ascidian habitats, in ports, meadows of *Posidonia*, and among communities of algae living in both well-lit, turbulent waters as well as those living in shaded, calm waters. Inhabits depths of 3 to 10 m.

Distribution

Common throughout the eastern Atlantic, from the British Isles to Senegal. Also found in the Mediterranean, from Italy and Tunisia to the Strait of Gibraltar.

Environmental sensitivity

Pyura squamulosa, as with other species from the genus *Pyura*, has a broad ecological valence and can be found in both clean water and disturbed environments, thus it is not recommended for monitoring the quality of coastal waters.

Notes

See “Notes” of *Microcosmus nudistigma*.

Phot. 252

10.53. *Pyura tessellata* (Forbes, 1848)

Phot. 253

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Pyuridae
Genus: *Pyura*
Common name: None

Description

A small solitary species of Ascidiacea, it grows to lengths of just 5 mm. Its body is round but laterally flattened. It has a delicate surface covered by polygonal tubercles which give it a scaly appearance. The siphons are short and well-separated. (**Photos 253 - 255**).

Habitat

Grows underneath rocks, on the walls of semi-dark grottos, in coralline habitats, in meadows of *Posidonia* and on coastal detritic bottoms. Generally found in sites exposed to the action of the waves and currents, where there is no sedimentation over the substrate. It is observed from the shallows down to depths of 300 m.

Distribution

In the eastern Atlantic, from Scandinavia to Senegal. Also found in the Mediterranean, around Spanish and French coasts as well as the Strait of Gibraltar.

Environmental sensitivity

Pyura tessellata, as with other species from the genus *Pyura*, has a broad ecological valence and can be found in both clean water and disturbed environments, thus it is not recommended for use in coastal water quality surveillance programs.

Notes

See “Notes” of *Microcosmus nudistigma.*

Phot. 254

Phot. 255

10.54. *Polycarpa pomaria* (Savigny, 1816)

Phot. 256

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Styelidae
Genus: *Polycarpa*
Common name: None

Description

A dark brown, solitary ascidian that can form aggregates. It is conical and has a leathery texture. The delicate, wrinkled surface may be covered by sediment or shell fragments. It grows up to 5 cm long and 3 cm wide. The large siphons have a slightly square cross-section and white markings inside the entrance. (**Photo 256**).

Habitat

They develop in a large variety of environments, appearing in rocky or soft bottoms, plus zones exposed to the current or in calm waters. Also found under stones, in muddy sands alongside the genus *Caulerpa*, on detritic bottoms and frequently in ports. It inhabits a range from the intertidal zone down to 500 m.

Distribution

In the eastern Atlantic, from Scandinavia to Morocco, and also in the Arctic. Throughout the Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

The species has been defined as an invertebrate of highly-polluted waters (Turón, 1988) and is usually found among artificial port structures (Vázquez and Urgorri, 1992) and leisure marinas (Airoldi *et al.*, 2014) (**photo 257**). So, this species does not serve as a bioindicator according to the purposes established for this guide

Phot. 257

10.55. *Botrylloides leachii* (Savigny, 1816)

Phot. 258

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Styelidae
Genus: *Botrylloides*
Common name: Leach's compound ascidian

Description

A colonial ascidian with a gelatinous consistency. Observed in different colors including gray, orange, yellow or reddish-violet (**photos 258 - 262**). There is a pattern of long parallel, meandering lines observed across the surface. Examples are non-symmetrical and colonies can take on massive (up to 5 cm wide and 7 - 8 cm across the largest diameter) or laminar forms (the largest diameter can measure more than 50 cm).

Habitat

Observed encrusted on rocks and shells as well as growing over brown macroalgae, sponges and gorgonian species. Although it can live in zones of moderate hydrodynamism, it prefers waters rejuvenated by the currents. Found among the intertidal zone (where it can appear under loose stones, in very shaded areas) and down to depths of over 100 meters.

Distribution

A broadly distributed species, found throughout the Mediterranean and on both sides of the Atlantic and Pacific Oceans.

Environmental sensitivity

B. leachii is a tolerant species of broad ecological valence (García-Gómez, 2007), capable of resisting or settling in zones where the benthic diversity is significantly depleted (Megally, 1970; Turón, 1988; Carballo y Naranjo, 2002). Particularly tolerant of conditions involving elevated degrees of turbidity, organic load and sedimentation (Wollgast *et al.*, 2008; Sams *et al.*, 2013). In a situation of excessive sediment derived from the overflow of coastal aggregate dredging, which is generally harmful to benthic fauna if it persists for some time, this species has a surprisingly adaptive capacity to resist the impact.

Nevertheless, it is often observed in zones of high diversity, in biologically structured and, therefore, ecologically sensitive and vulnerable bottoms. In these types of seabeds, while it is easy to recognize with the help of this guide (even though its color and shape vary greatly), this species does not provide information about the water quality in these areas for the reasons mentioned above, thus it is not recommended for use as an ecological indicator of clean waters. However, observing this species may be useful, as it could help provide a more robust environmental evaluation if its abundance increases while other more sensitive benthic species decrease in number or disappear.

Phot. 262

Phot. 259

Phot. 260

Phot. 261

10.56. *Phallusia fumigata* (Grube, 1864)

Phot. 263

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Phlebobranchia
Family: Ascidiidae
Genus: *Phallusia*
Common name: Black sea squirt

Description

This solitary ascidian can grow up to 15 cm long. It has a long, cylindrical body which is wider at the base. The surface is thick, smooth and with a gelatinous texture. The species is black or dark green in color. (**Photos 263 - 267**).

Habitat

Tends to grow in crevices or cracks in the rocks in areas of moderate to strong hydrodynamism. Also found under rocks, in *Posidonia* meadows, among algal communities in well-lit and calm waters, in port settings, plus detritic and coralline habitats. Inhabits depths of 2 to 50 m.

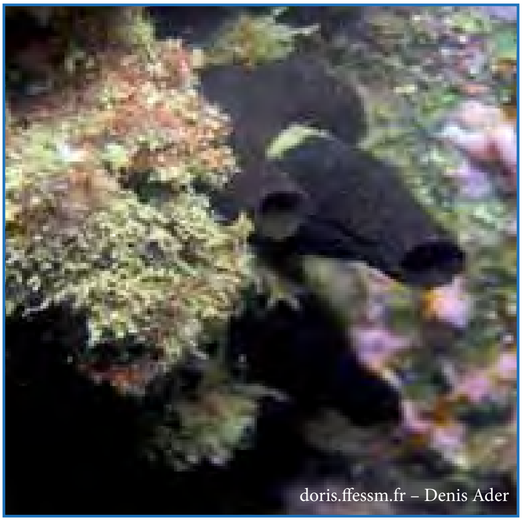
Distribution

Throughout the Mediterranean including the Strait of Gibraltar.

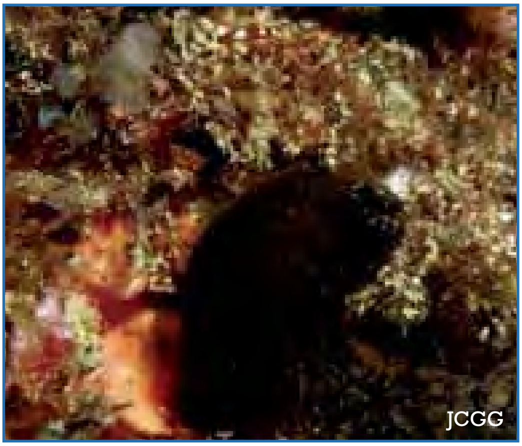
Environmental sensitivity

A tolerant species which can maintain its populations when faced with certain degrees of disturbance (Turón, 1988). While it is common over artificial substrates (Airoldi *et al.*, 2014), its most abundant populations are located in well-conserved natural zones (Naranjo *et al.*, 1996; López-González *et al.*, 1997).

Phot. 264



Phot. 265



Phot. 266

Phot. 267

10.57. *Clavelina lepadiformis* (Müller, 1776)

Phot. 268

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Clavelinidae
Genus: *Clavelina*
Common name: Pin-head squirt, light bulb tunicate or light bulb seasquirt

Description

The colonies of this ascidian are comprised of cylindrical, erect structures of up to 3 cm long, these are joined in a type of basal branch called a stolon. Colonies have a gelatinous texture and are transparent, the surface is striped with white lines, although occasionally these are yellow or pink. (**Photos 268 - 270**).

Habitat

Observed in infralittoral zones associated to both shade- and light-loving algal communities, as well as coastal detritic and coralline habitats. Frequently seen in ports and enclosed areas where there are high levels of sedimentation. Habit ranges from surface waters down to depths of 100 m.

Distribution

In the eastern Atlantic it extends from Scandinavian coasts to Morocco, while in the Mediterranean it is distributed from Tunisia and Italy to the Strait of Gibraltar, including the Spanish coast and around the Balearic Isles.

Environmental sensitivity

This species is considered transgressive because when the level of stress increases so does its population, as occurs in ports (Tarjuelo *et al.*, 2001; De Caralt *et al.*, 2002). It is often observed, even noted to be dominant, in areas with high levels of pollution and organic load (Saiz-Salinas and Urkiaga-Alberdi, 1999; Carballo and Naranjo, 2002; Okuş *et al.*, 2007).

Phot. 269

Phot. 270

10.58. *Pycnoclavella nana* (Lahille, 1890)

Phot. 271

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Clavelinidae
Genus: *Pycnoclavella*
Common name: Pin-head squirt

Description

Colonies of this Ascidiacea are comprised of free-living individuals of about 2 cm long, shaped like walking sticks and joined by basal stolons. They are transparent and gelatinous, with characteristic longitudinal white lines (although they are sometimes yellow or pink). Examples tend to appear in dense lawn-like bunches although they are occasionally found growing in isolation. (**Photos 271 - 273**).

Habitat

Often found growing on overhangs, roofs and also over artificial port structures where there is a certain degree of water rejuvenation, such as columns supporting quays. It is found up to 50 m.

Distribution

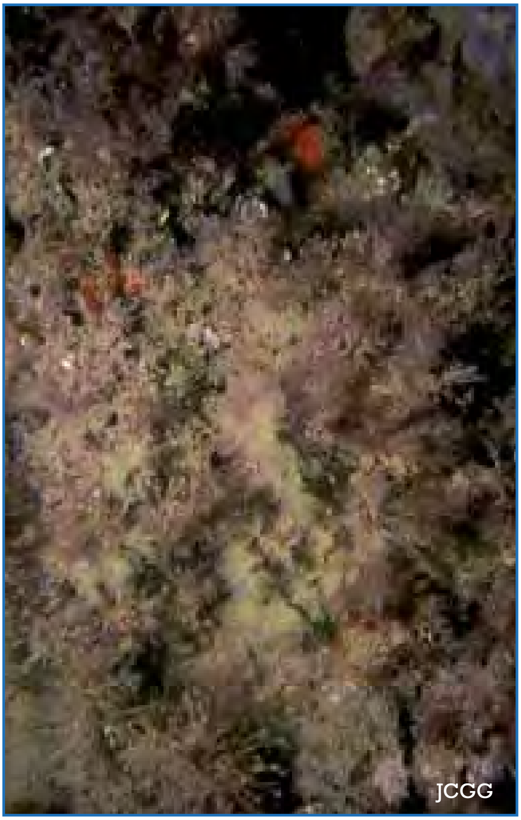
In the eastern Atlantic, from the south of Norway to the Azores. In the Mediterranean it extends from the coasts of France, the Iberian Peninsula and the Balearic Isles to the Strait of Gibraltar.

Environmental sensitivity

A tolerant species that can withstand a certain degree of environmental disturbance (Naranjo *et al.*, 1996; Okuş *et al.*, 2007).

Notes

Clavelina lepadiformis is a very similar species. *Pycnoclavella nana* was formerly cited as *Clavelina nana.*



Phot. 272

Phot. 273

10.59. *Diplosoma listerianum* (Milne-Edwards, 1841)

Phot. 274

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Didemnidae
Genus: *Diplosoma*
Common name: None

Description

This is a colonial ascidian species. Colonies, which have an encrusting, laminar form, vary in size and are capable of covering large surfaces. They have a gelatinous texture and are transparent, sometimes with a whitish pigmentation. The surface is smooth. (**Photos 274 and 275**).

Habitat

The species settles on rocky bottoms that are well-lit, shaded or semi-shaded and with a moderate to strong hydrodynamism. It appears on vertical walls and in crevices, in meadows of *Posidonia* and *Caulerpa prolifera*, as well as in coastal detritic habitats and coastal lagoons. Examples grow over both natural and artificial substrates, such as blocks of concrete and columns in port areas. Habitat ranges from the low-tide line down to 30 m.

Distribution

In the eastern Atlantic, from Scandinavia to South Africa, and throughout the Mediterranean, both eastern and western, including the Strait of Gibraltar. Also distributed around the western Atlantic and the Indo-Pacific.

Environmental sensitivity

The species *Diplosoma listerianum* can tolerate certain degrees of disturbance (Mastrototaro *et al.,* 2008; Wollgast *et al.,* 2008) but it prefers well-conserved sites. It is commonly found inside ports (Lambert and Lambert, 1998; Pérez-Portela *et al.*, 2013) and has a good level of tolerance to sedimentation (Sams *et al.*, 2013).

Phot. 275

10.60. *Diplosoma spongiforme* (Giard, 1872)

Phot. 276

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Didemnidae
Genus: *Diplosoma*
Common name: None

Description

The species is characterized by its encrusting colonies of up to 7 mm thick and which can cover large areas. It presents grayish coloration with patches of a white pigment. It has a delicate, gelatinous texture with a smooth surface. (**Photos 276 and 278**).

Habitat

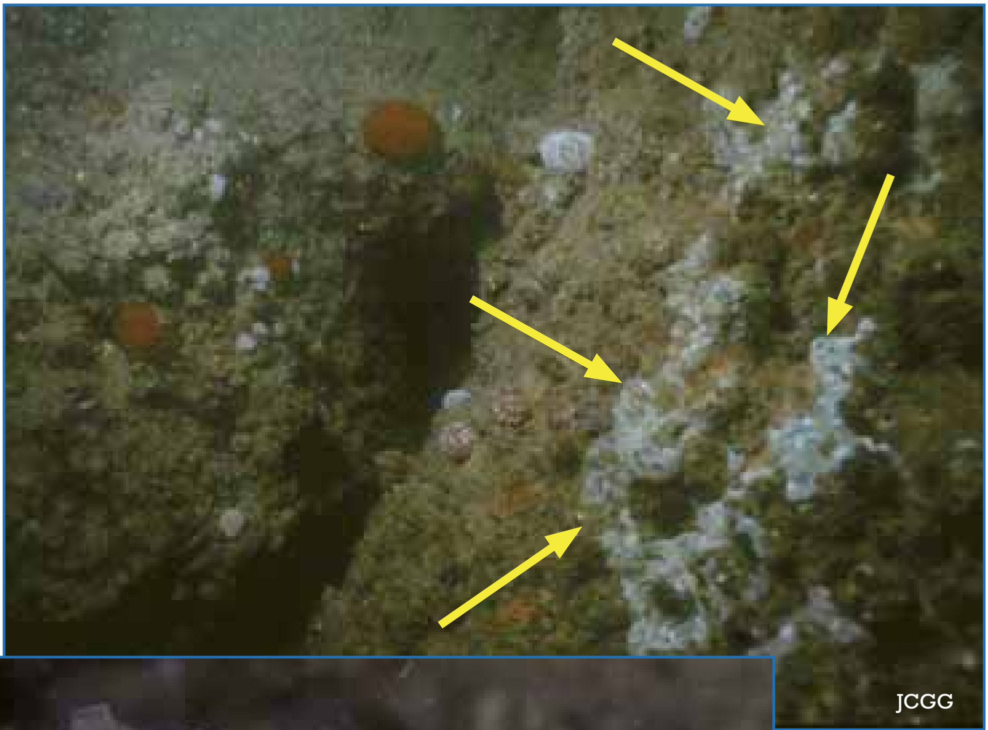
Inhabits rocky seabeds, crevices and overhangs, also found in well-lit zones and those of variable hydrodynamism. It can grow over other organisms such as molluscs and gorgonians. Favorite locations include gravel or coralline habitats, *Posidonia* meadows, at the base of *Laminaria* species, coastal detritic bottoms and port settings. From the low-tide line down to 30 m.

Distribution

In the eastern Atlantic, from the British Isles to the northern coasts of Spain. Across the Mediterranean including the Strait of Gibraltar.

Environmental sensitivity

D. spongiforme is a bioindicator of areas that have been subjected to intense stress (transformation of the substrate, water stagnation, and excessive sedimentation) for long periods of time (Naranjo *et al.*, 1996). It can frequently be found growing over artificial structures and together with other disturbance-tolerant species (Turón, 1988; Mariani *et al.,* 2003; Rius-Viladomiu, 2008) (**photo 277**). Its resistance to the presence of antifouling chemicals, such as TBTs, has also been cited (Hiscock *et al.*, 2010).



Phot. 277

Phot. 278

10.61. *Trididemnum cereum* (Giard, 1872)

Phot. 279

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Didemnidae
Genus: *Trididemnum*
Common name: None

Description

A colonial species of Ascidiacea. Colonies are large, coating and somewhat massive in form. The overall color is whitish, but examples also present some brown or grayish patches. (**Photos 279 and 280**).

Habitat

Colonies settle in both exposed and sheltered zones, such as vertical walls, overhangs and crevices. Also found on algal communities in both well-lit and shaded environments, *Posidonia* meadows, coralline, sandy/muddy or coastal detritic habitats, ports and coastal lagoons. Inhabits depths of a few meters down to 30 m.

Distribution

In the eastern Atlantic, from Scandinavia to the northern coasts of Spain. Found in both the eastern and western Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

Although reference studies have observed this species to be present in pollution-free zones and practically absent from polluted ones (Naranjo *et al.*, 1996), it has repeatedly been cited growing over artificial substrates (Vázquez and Urgorri, 1992; Mastrototaro *et al.*, 2008; Airoldi *et al.*, 2014). It has also demonstrated resistance to antifouling chemicals (Cima and Ballarin, 2008). Thus, for our purposes *T. cereum* is not classified as a good indicator species.

Phot. 280

10.62. *Aplidium turbinatum* (Savigny, 1816)

Phot. 281

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Polyclinidae
Genus: *Aplidium*
Common name: None

Description

Colonies of this species are mushroom-shaped and slightly pedunculate. They have a fleshy-gelatinous consistency and are colored orangey-yellow. Practically no sand adheres to their surface. (**Photos 281 - 283**).

Habitat

Associated with both light- and shade-loving algae in infralittoral communities in areas of calm water, also found among *Posidonia* meadows, coralline habitats and growing over rhizoids of the *Laminaria* spp., *L. ochroleuca* and *L. hyperborea*. Observed from the low-tide line down to depths of 20 m.

Distribution

Extends from the Strait of Gibraltar to the Mediterranean coasts of Spain and Italy. The species is distributed throughout the eastern Atlantic, from Norway to the Canary Islands, including the British Isles, France, Portugal and the northern coasts of Spain.

Phot. 282

Environmental sensitivity

Populations of *Aplidium turbinatum* have been discovered growing in similar or even larger numbers on artificial substrates than on natural ones (Mastrototaro *et al.*, 2008), in areas experiencing eutrophication and anthropogenic impacts (discharges, maritime traffic, industrial activities and aquaculture).

Phot. 283

10.63. *Morchellium argus* (Milne-Edwards, 1841)

Phot. 284

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Polyclinidae
Genus: *Morchellium*
Common name: None

Description

This colonial Ascidiacea is characterized by several, 5 mm diameter, club-like “heads” emerging from the colonies, which are joined by a basal peduncle (stem) of varying lengths. Colonies are orange and have a fleshy-gelatinous consistency. The basal part of the colony is typically coated with sand. (**Photos 284 and 285**).

Habitat

Morchellium argus generally grows over rocky substrates with differing degrees of exposure and where sedimentation can be elevated (**photo 286**). Found abundantly in ports where it can cover the vertical services of concrete blocks and columns of breakwaters and quays. Tends to live in association with well-lit algal communities or growing over other organisms, such as bivalves, barnacles and other ascidians. It has also been observed in *Posidonia* meadows, at the base of *Laminaria ochroleuca* and in gravel bottoms. Examples are found from the low-tide line down to 18 m.

Distribution

In the eastern Atlantic, from the British Isles to Portugal. Distributed around the western Mediterranean, as far as the Strait of Gibraltar.

Environmental sensitivity

M. argus is tolerant of environmental stress, but is also found in pristine zones and those of a high ecological value (Garrabou, 1997). The species can tolerate some intense disturbances (transformation of the substrate, water stagnation, excessive sedimentation) over long periods of time (Naranjo *et al.*, 1996), and it has even been observed to favor such conditions as populations were seen to increase in affected areas (Carballo and Naranjo, 2002).

Notes

Species formerly cited as *Synoicum argus.*

Phot. 285

Phot. 286

10.64. *Synoicum blochmanni* (Heiden, 1894)

Phot. 287

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Polyclinidae
Genus: *Synoicum*
Common name: None

Description

Colonial ascidian, always a characteristically bright red color, it forms in a group of structures with globular ends (sometimes finger-like) arranged closely together and joined at the base, giving the appearance of a group of red balloons (between 3 and 20) standing on a common holdfast. It can grow to different sizes, but normally they do not exceed 3 - 4 cm in diameter and 10 cm tall. The zooids, which form circular or star-shaped groups of 10 to 15 units, are difficult to perceive from the outside due to the homogeneity and intensity of the red coloration exhibited by this species. When the zooids are active the globular structures have a slightly roughened service and the red coloration takes on a darker, matt tone (**photo 287**). The dormant form displays a brighter red color and the surface is smooth (**photo 288**).

Habitat

It prefers to inhabit shady, rocky bottoms, on both horizontal and vertical surfaces. It can also be observed on biodetritic or gravel seabeds and in association with phanerogam meadows. Found living equally in systems with low degrees of organization and biodiversity, as in species-rich and highly-structured systems (coralline habitats). An infralittoral species that is normally observed from depths of around 10 - 15 m down to the first circalittoral zones.

Distribution

Throughout the western Mediterranean including the Strait of Gibraltar. Also in the eastern Atlantic (Galicia).

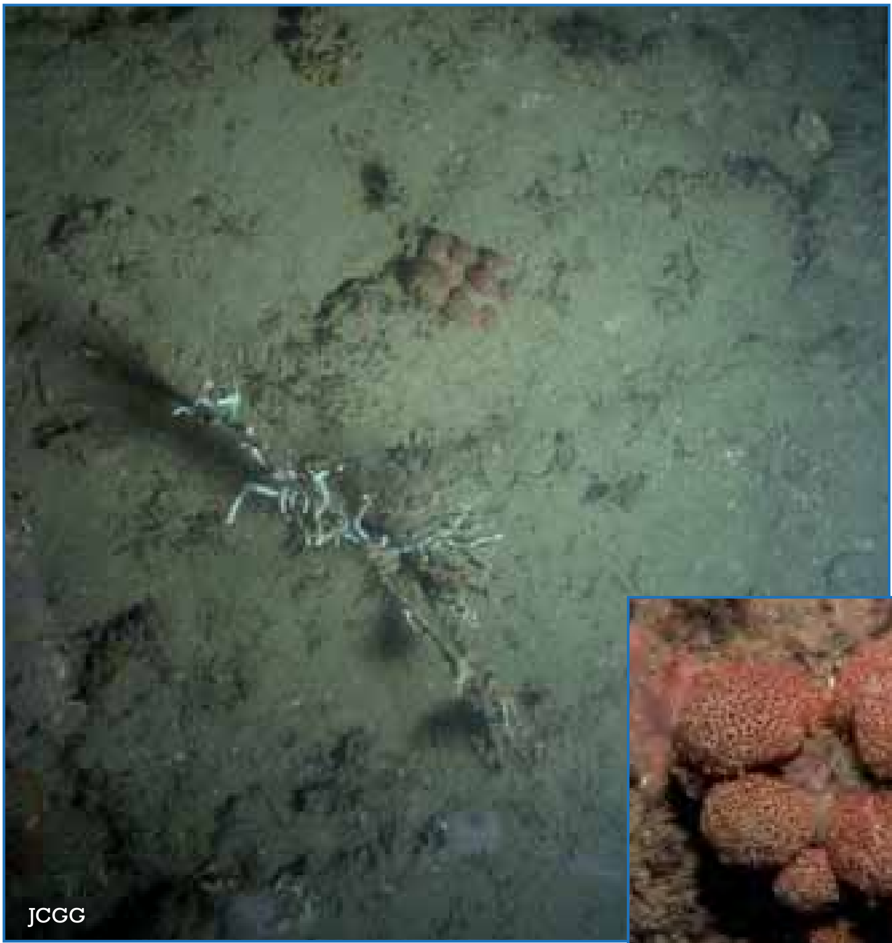
Environmental sensitivity

Despite its coloration and appearance, it is a tolerant species of broad ecological valence and major adaptive plasticity (García-Gómez, 2007), not only in terms of the type of substrate but also the prevailing environmental conditions (Naranjo *et al.*, 1996; Carballo and Naranjo, 2002). Nevertheless, it prefers clean, biodiverse and well-structured bottoms (**photo 289**), even though the competition for space may be greater. The species also requires waters that are not excessively turbulent, as it has shown a negative correlation with the speed of the current (Ordines *et al.*, 2011).

It settles on seabeds subjected to moderate sedimentation with no apparent external signs of stress, as evidenced by the amount of sediment that covers the colonies and which can mask their characteristically eye-catching red coloration (**photos 290 and 291).** Therefore, among other possible tolerances, it is a species that can withstand the effects, explained in **chapter 8.4**, of overflow from coastal aggregate dredging (as long as it does not persist for too long), which is particularly harmful to suspension-feeding organisms anchored to the seabed (especially if there is a very high rate of sedimentation over an extended period of time). We do not recommend concentrating on this species in bottoms of high ecological value, attention should instead be paid to more sensitive species that can warn of these types of impacts sooner.

Phot. 288

Phot. 289



Phot. 290

Phot. 291

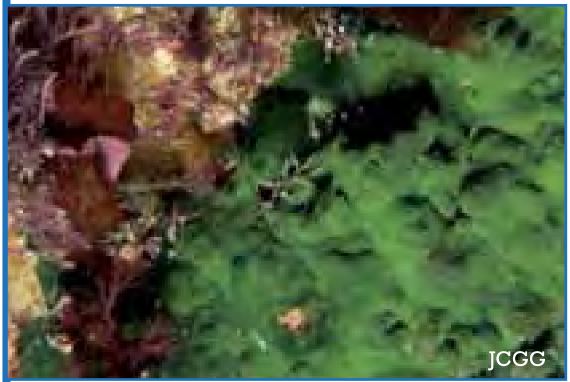
11 SENSITIVE OR STENOIC (SESSILE) BENTHIC SPECIES


JCGG

MACROALGUES

JCGG

11.1. *Palmophyllum crassum* (Naccari) Rabenhorst, 1868



Phot. 294

Phylum: Chlorophyta
Class: Chlorophyta incertae sedis
Order: Palmophyllales
Family: Palmophyllaceae
Genus: *Palmophyllum*
Common name: None

Description

A bright green encrusting alga. Constructed from rounded cells grouped into a common gel and can grow up to 20 cm in diameter and 1 mm thick. It extends horizontally and has a rounded or slightly fan-shaped profile. The surface is quite stripey. (**Photos 294 and 295**).

Habitat

Found growing over rocks and stones, frequently appears in association with encrusting calcareous algae. Also grows on the shady underside of rocks, rocky walls and covering caves. Examples can be observed at the base of marine phanerogams and large algae. The species is typically found in communities with low lighting levels. Settles in a range from the surface down to depths of 130 m.

Distribution

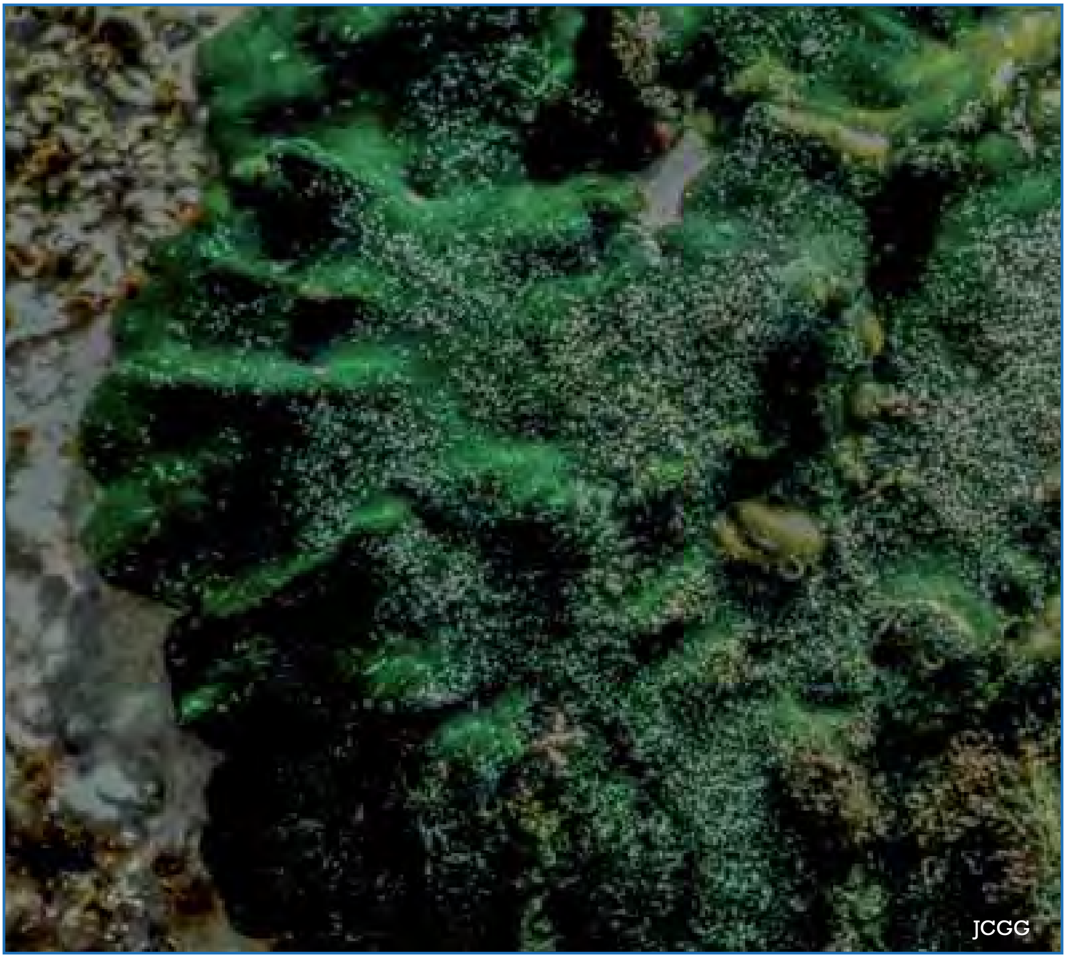
Present throughout the Mediterranean including the Strait of Gibraltar.

Environmental sensitivity

A species sensitive to disturbances, it is usually present in ecosystems of a high environmental quality, such as Marine Protected Areas (Badalamenti *et al.*, 2011; UNEP(DEPI)/MED, 2011), areas dominated by belts of *Cystoseira*

(Munda, 1993) or coralline habitats (Ballesteros, 2006; Cecchi and Piazzi, 2010).

P. crassum avoids living in bottoms with moderate to high organic loads and where there is an elevated rate of sedimentation. Therefore, in shaded zones such as cave entrances and overhangs, it is easy to monitor whether its presence decreases over time or if it disappears entirely from the enclaves that are chosen as sites for environmental surveillance. It is better when the species has more than just a token presence (i.e., only minimum coverage in comparison with the rest of the epibenthic biota) on the surface selected for its temporal monitoring, instead it should be well represented and also present on other shaded, rocky surfaces in the immediate vicinity.



Phot. 295

11.2. *Cystoseira baccata* (S. G. Gmelin) P. C. Silva, 1952

Phot. 296

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Fucales
Family: Sargassaceae
Genus: *Cystoseira*
Common name: None

Description

A very dark seaweed, perennial, the main axis is elliptical and grows up to 5 cm long, the apex is smooth, protruding and narrower than the rest. Alternating primary branches arranged in a single plane stem from the main axis, while the secondary branches grow in all directions. The final branches are fine and sometimes bifurcated. The main axis has a zigzag appearance caused by shedding primary branches. The alga can grow up to 1 m in height. Some individuals have air bladders that can form in chains and serve as floats. It anchors to the substrate via a thick conical disk. (**Photos 296 - 300**).

Habitat

A species that lives over horizontal rocky substrates. It is distributed from the surface, in the intertidal zone, down to subtidal depths where algal communities begin to disappear.

Distribution

In the eastern Atlantic, from the British Isles to Mauritania, including the Strait of Gibraltar.

Environmental sensitivity

Cystoseira baccata is considered to have requirements for a high-quality environment (Díez *et al.*, 1999), corresponding as it does to pollution-free zones of utmost structural complexity (Gorostiaga *et al.*, 2004), since it exhibits a negative correlation with pollution and will not tolerate high levels of exposure (Díez *et al.*, 2003). It is also cited as characteristic of natural environments, in contrast to invasive and opportunist species (Juanes *et al.*, 2008), and as a species that forms part of the final stages of ecological succession (Orfanidis *et al.*, 2001, 2003).

Environmental protection bodies

Included in the Spanish List of Specially Protected Wildlife (LESRPE), in the expansion performed according to Order AAA/75/2012.

Phot. 297

Phot. 299

Phot. 298

Phot. 300

11.3. *Cystoseira nodicaulis* (Withering) M. Roberts, 1967

Phot. 301

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Fucales
Family: Sargassaceae
Genus: *Cystoseira*
Common name: None

Description

A non-cespitose perennial alga (does not form tufts) that grows up to 50 cm tall. Its main axis anchors to the substrate by means of a conical disk. The apex of the axis is smooth and prominent, with oval, conical, or elongated reserve structures forming on top of this, these may be smooth or covered by small tubercles, and they remain when the branches fall. Branches stem from the axis in all planes, the primary branches lead on to short secondary branches. All of the branches present some spiny appendices. (**Photos 301 - 304**).

Habitat

A species that is found in calm environments, which can survive in turbid or muddy waters. Inhabits a range from the low-tide line down to 10 m.

Phot. 302

Distribution

Throughout the eastern Atlantic, from the British Isles to Senegal. Only found on Spanish and Tunisian coasts of the Mediterranean, as well as the Strait of Gibraltar.

Environmental sensitivity

The complex, well-structured forests of species in the genus *Cystoseira* are indicators of high ecological status, thus a decrease in their abundance tends to imply a decline in water quality (Arévalo *et al.*, 2007). The species *Cystoseira nodicaulis* is usually found in areas of high environmental quality, together with other sensitive species such as *C. baccata* or *C. tamariscifolia* (Guiry, 1973; Rindi and Guiry, 2004), and is characteristic of the final stages of ecological succession (Orfanidis *et al.*, 2001, 2003). Nevertheless, Roberts (1977) reported that this species can also survive in turbid or muddy waters.

Environmental protection bodies

Included in the Spanish List of Specially Protected Wildlife (LESRPE), in the expansion performed according to Order AAA/75/2012.

Phot. 303

Phot. 304

11.4. *Cystoseira amentacea var. stricta* Montagne, 1846

Phot. 305

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Fucales
Family: Sargassaceae
Genus: *Cystoseira*
Common name: None

Description

A flexible alga that grows to between 20 and 40 cm tall. Characterized by its basal axis from which emerge several erect, cylindrical axes, with spiny apices and protruding pores. The primary branches are also cylindrical and longer than the secondary ones, which tend to emerge high up rather than from the base of the primary branches. All of the branches have spiny apices, these present some compact structures that are up to 2 cm long and covered with pimples (**photos 305 and 306**). A perennial alga that sheds its branches in autumn.

Habitat

Inhabits well-lit, turbulent surface waters and can form dense belts. It is distributed throughout the upper sublittoral zone.

Distribution

In the western Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

Well-structured communities of *Cystoseira amentacea* var. *stricta* are bioindicators of sites with a high ecological status (Ballesteros and Pardo, 2004) and their loss has been defined as a good indicator of the anthropogenic effects associated with coastal urbanization (Mangialajo *et al.*, 2008). For these reasons, *C. stricta* has been granted strict protection in Annex I of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (Susini *et al.,* 2007). As with other species in the genus *Cystoseira amentacea* var. *stricta* typifies the final stages of ecological succession (Orfanidis *et al.*, 2001, 2003).

Environmental protection bodies

Included in the Spanish List of Specially Protected Wildlife (LESRPE), in the expansion performed according to Order AAA/75/2012.

Phot. 306

11.5. *Cystoseira tamariscifolia* (Hudson) Papenfuss, 1950

Phot. 307

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Fucales
Family: Sargassaceae
Genus: *Cystoseira*
Common name: Rainbow wrack

Description

This perennial alga can grow up to 1 m tall and is anchored to the substrate via a disk or some thick bushy branches which may be partially joined together or independent. The main axis is cylindrical, 3 - 10 mm in diameter and has a spiny apex that protrudes slightly. Short, cylindrical or flattened branchlets may emerge from the base. There is abundant branching; the primary branches are cylindrical and have progressively shorter secondary branches arranged from their base to their apex. The species has a blue-green iridescence (**photo 307**). A perennial species that sheds its plumes in autumn/winter before reproducing them again in spring.

Habitat

A species that can appear in association with various species of *Laurencia* and *Cystoseira baccata*. Found growing over rocky seabeds (**photo 308**). Distributed from the low-tide line down to 10 - 15 m.

Distribution

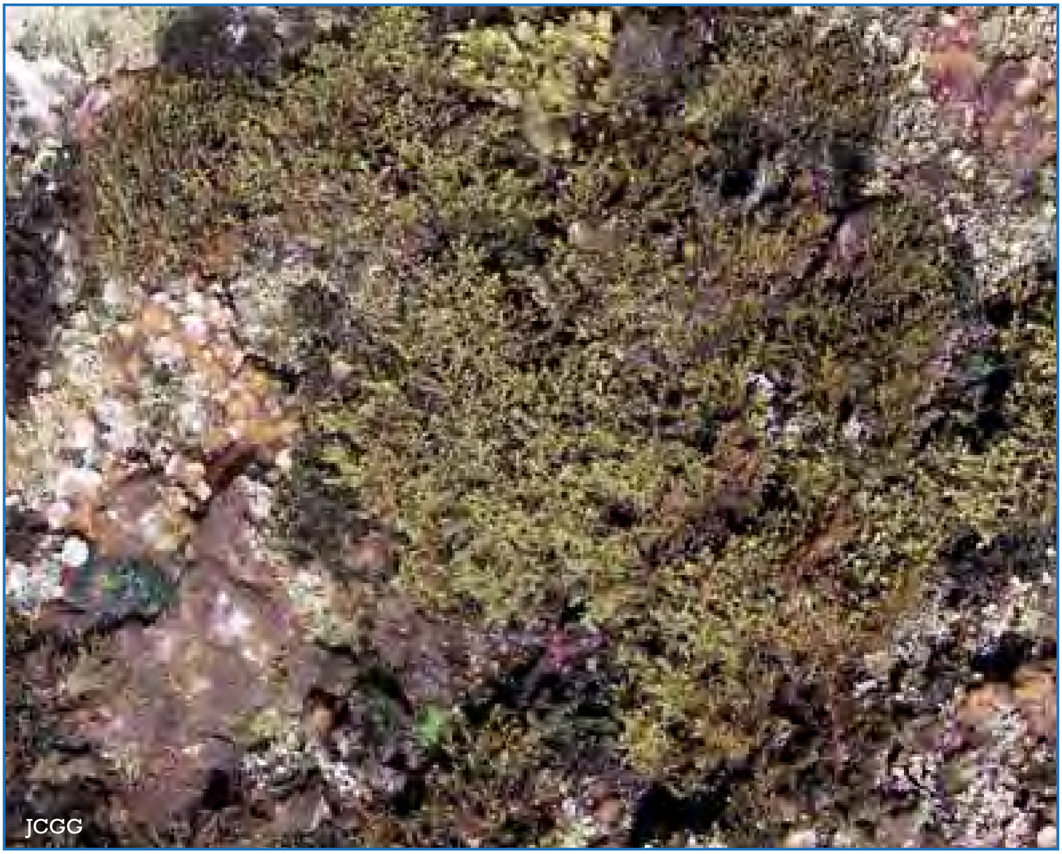
In the eastern Atlantic, from the British Isles to Mauritania. Only found in Mediterranean zones influenced by the Atlantic (Spain, Malta, Sicily, Algeria), including the Strait of Gibraltar.

Environmental sensitivity

Cystoseira tamariscifolia is considered a species that requires a high-quality environment (Díez *et al.*, 1999; Ruiz-Tabares *et al.*, 2003; Arévalo *et al.*, 2007) and is characteristic of the final stages of ecological succession, corresponding to scenarios of maximum structural complexity (Ballesteros and Pardo, 2004; Gorostiaga *et al.*, 2004). Its disappearance from apparently undisturbed areas is considered to be one of the first signs of a zone's degradation (Díez *et al.*, 2012).

Environmental protection bodies

Included in the Spanish List of Specially Protected Wildlife (LESRPE), in the expansion performed according to Order AAA/75/2012.



Phot.308

11.6. *Cystoseira usneoides* (Linnaeus) M. Roberts, 1968

Phot. 309

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Fucales
Family: Sargassaceae
Genus: *Cystoseira*
Common name: None

Description

Perennial alga that attaches to the substrates via holdfasts. As with *C. tamariscifolia*, which is also perennial, examples shed their plumes in autumn/winter to leave just a basal section. It then grows vigorously throughout the spring and summer - from its small base it can reach over 1 meter long. It presents a branched cylindrical central axis that is weakly anchored to the substrate via some cylindrical structures, these sometimes form a disk. The primary and secondary branches are also round, whereas some very fine (2 - 4 mm wide), flat branches emerge from the base of the alga. Secondary branches are covered by small appendices of different shapes: curved, straight, needle-like or bifid. There is a chain of air bladders on the surface of the alga which it uses as a means of flotation. Some elongated receptacles (either smooth or rough) that serve as a reserve structure are observed at the base of the branches. There are also some cylindrical receptacles, finishing in a fine point and sometimes with a spiny surface, can be found on the apices of the smallest branches. (**Photo 309**).

Phot. 310

Habitat

This infralittoral species reproduces throughout the year and tends to form complex communities with other species on rocky substrates. It is frequently observed growing around the southern Iberian Peninsula together with *Laminaria* spp. It primarily settles on well-lit, horizontal or gently sloping enclaves. Can be found below depths of 3 m, but rarely at depths of more than 20 m. Examples can be observed at low tide in large intertidal pools, practically touching the surface of the water. The species can form dense underwater forests. (**Photo 310**).

Distribution

From France to the Cape Verde Islands in the Atlantic plus all areas of the Mediterranean influenced by the Atlantic, such as the coasts of the Iberian Peninsula, Algeria, Malta and the Straits of Messina and Gibraltar.

Environmental sensitivity

This species is sensitive to increases in turbidity and organic load, hence it tends to disappear from zones where these types of impact occur (García-Gómez, 2007), although it is possible to find examples in artificial habitats which enjoy good ecological conditions (Pérez-Cirera *et al.*, 1989). If a diver notices any population decreases or the total disappearance of this species in areas where it is normally observed to be common or abundant, then it could be related to an environmental degradation process.

As with others from the genus *Cystoseira,* this species is characteristic of the final stages of ecological succession (Bermejo *et al.*, 2012) and its appearance in complex, well-structured populations is indicative of elevated ecological status (Arévalo *et al.*, 2007). In the region of the Alboran Sea, *C. usneoides* even forms its own biocenosis: coralligenous biocenosis in association with *Cystoseira usneoides* (Templado *et al.*, 2009).

Environmental protection bodies

Included in the Spanish List of Specially Protected Wildlife (LESRPE), in the expansion performed according to Order AAA/75/2012.

11.7. *Fucus spiralis* Linnaeus, 1753

Phot. 311

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Fucales
Family: Fucaceae
Genus: *Fucus*
Common name: Spiral wrack or flat wrack

Description

This perennial alga grows between 1 and 50 cm tall and anchors to the substrate via a disk-shaped holdfast from which emerges a round peduncle (stem). This gives way to an axis which divides dichotomously in a single plane. All the branches form in blades measuring between 2.0 and 2.5 cm wide. The blade-like branches have an internal mid-rib and the edges can be slightly serrated or smooth. The species presents some spherical or cylindrical reproductive bladders at the ends of these blades. The overall color is olive brown. (**Photo 311**).

Habitat

A species that lives in areas which are either protected or exposed to the waves. It can tolerate different degrees of salinity and even changes to the salinity, so it can be found in estuaries. Forms belts of up to several cm wide. While it inhabits the upper eulittoral zone. (**Photos 312 and 313**).

Distribution

Found in the northwestern and eastern Atlantic, in the latter from the Arctic to Mauritania. In Mediterranean waters it only penetrates to as far as the coasts of Malaga on the southern coasts of Spain.

Environmental sensitivity

Sensitive species that demands rejuvenated and clean waters for survival (García-Gómez, 2007), also characteristic of the ultimate stages of ecological succession (Bermejo *et al.*, 2012). Across its distribution zone, it can settle and form a very typical belt in the intertidal zone. These belts are unmistakable and can be observed by simply walking over the rocks at low tide, thus the species is easily monitored. Dwindling numbers of this species, without subsequent recoveries, from the rocky enclaves of a single coastal stretch where they are permanently observed would represent a warning sign that must be investigated. If this were to occur, it would be a good idea to confirm the observations with similar ones concentrating on other intertidal species (e.g., the calcareous alga *Lithophyllum byssoides*, or even the red anemone *Actinia equina*, both covered in this guide) before informing the competent authorities. On the other hand, the species' populations tend to increase and expand when the environmental conditions improve from an initial state representing a certain degree of degradation (Bokn *et al.*, 1992; Hardy *et al.*, 1993).

Among other disturbance factors, its sensitivity to contamination from heavy metals (Stromgren, 1980) or hydrocarbons (Thomas, 1973) has also been reported.

Phot. 312

Phot. 313

11.8. *Halopteris filicina* (Grateloup) Kützing, 1843

Phot. 314

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Sphacelariales
Family: Stypocaulaceae
Genus: *Halopteris*
Common name: None

Description

An erect alga of up to 10 cm tall, color ranges from yellowish-brown to olive green. Its main axis anchors to the substrate by means of a basal disk. The axis is straight and gives way to several ramifications opening regularly in a single plane. It has an overall appearance of fine, rigid feathers. (**Photos 314 and 315**).

Habitat

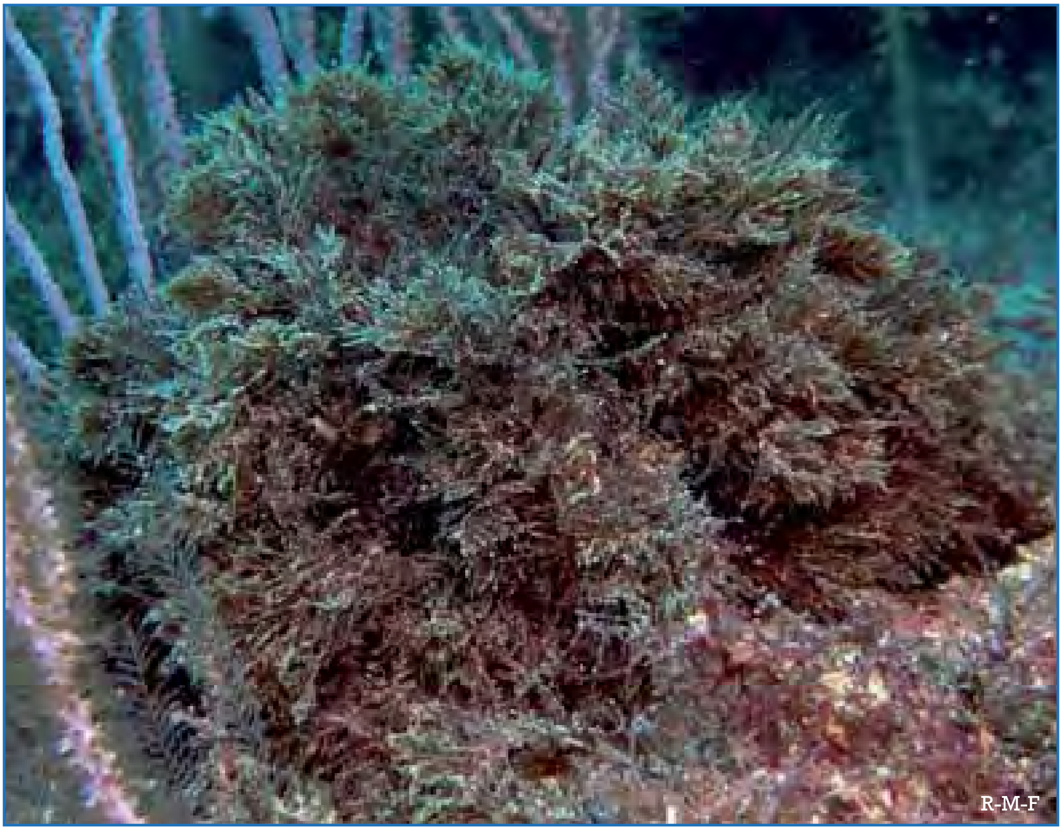
Found in rocky bottoms with moderate amounts of light and relatively calm waters. Also found in association with *Laminaria* spp. Distributed over a range of a few meters down to 40 m.

Distribution

In the eastern Atlantic, from Scotland to the Canary Islands. Also inhabits the Pacific Ocean, the Mediterranean, including the Strait of Gibraltar and the Black Sea.

Environmental sensitivity

H. filicina is cited as characteristic of natural environments, in contrast to invasive and opportunist species (Giangrande, 1988; Juanes *et al.*, 2008), and is typically found in communities associated to a good environmental condition, such as maërl beds (Ramos-Esplá and Luque, 2004) or Mediterranean coralline habitats (Ballesteros and Karim, 2003). This species experiences a significant mid-term decrease in abundance following pollution events (Echavarri-Erasun *et al.*, 2007).



Phot. 315

11.9. *Laminaria ochroleuca* Bachelot de la Pylaie, 1824

Phot. 316

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Laminariales
Family: Laminariaceae
Genus: *Laminaria*
Common name: None

Description

This is one of the largest algae found in the European littoral (it can grow to over 6 m tall). The base is attached to the substrate via some mutually connected, thick, cylindrical branches (forming a conical trunk). A smooth, rigid, flexible and round stem which narrows towards the apex emerges from this holdfast; rather wide, leathery blades that are divided into longitudinal segments emerge from the stem. Examples present a yellowish-brown color. (**Photos 316 - 318**). A perennial species, but adults renew their blades every year.

Habitat

It settles on rocky bottoms and in both turbulent and calm waters but at temperatures below 15 °C. Massive collections forming beautiful underwater forests can be encountered. In the Alboran Sea, while there are narrow bathymetric belts where *Laminaria ochroleuca* and *Saccorhiza polyschides* (sheet 11.11) coexist, the former is, however, more often found at depths below 25 m, contrary to the latter. Around the north of Spain it can live in shallower, rocky seabeds. Examples can be found washed up on the beaches after autumn storms.

Distribution

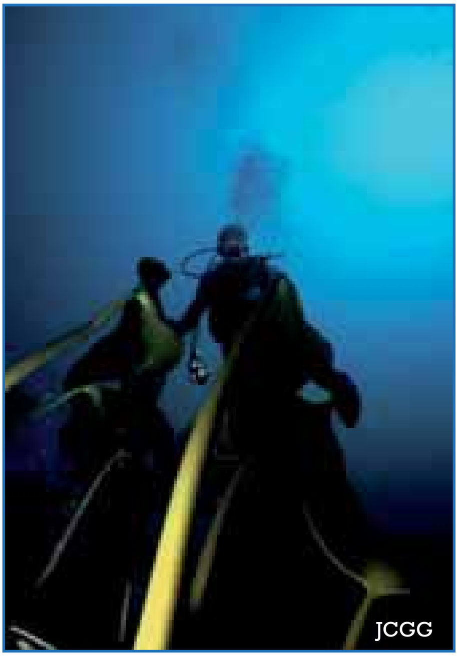
In the eastern Atlantic, from the British Isles to Morocco. Less commonly observed in the Mediterranean, but it is abundant in the Alboran Sea and the Strait of Gibraltar. Also found in the depths of the Strait of Messina.

Environmental sensitivity

As does *Saccorhiza polyschides*, this species requires clean (Borja *et al.,* 2004) and continually rejuvenated waters (in the Alboran Sea, it is basically associated to areas with intense currents) (García-Gómez, 2007). Its environmental sensitivity, therefore, is similar also to that of *Saccorhiza polyschides*, with well-defined populations living in undisturbed areas (Juanes *et al.*, 2008).

Nevertheless, it is obviously less susceptible to human influence because its habitat is relegated to greater depths (and, therefore, greater distances from the coast), thus it is situated a long way from the harmful effects that can be generated by, for example, civil engineering works or coastal pollution. However, recommendations for underwater surveillance are similar to those proposed for *S. polyschides* because if the alga is observed to be absent from areas where it was previously abundant then the event must be cause-related and not just a one-off. Such observations should be reported to the competent authorities so they may investigate the origin(s).

Laminaria ochroleuca, is threatened by Global Warming as it is a species characteristically found in cold waters and which is very sensitive to temperature increases (Hiscock *et al.,* 2004; Guinda *et al.,* 2012; Smale *et al.,* 2013).



Phot. 317

Phot. 318

11.10. *Phyllariopsis brevipes* (C. Agardh) E. C. Henry and G. R. South, 1987

Phot. 319

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Tilopteridales
Family: Phyllariaceae
Genus: *Phyllariopsis*
Common name: None

Description

An erect alga measuring between 15 and 30 cm long, with a width of 4 to 25 cm. It has a short, round peduncle (stem) which is anchored to the substrate via a basal holdfast disk. A slender blade, with serrated edges and which narrows towards the end, emerges from the peduncle. It is light olive green, somewhat translucent and has numerous clumps of brown hairs. (**Photos 319 - 321**). Present throughout the year.

Habitat

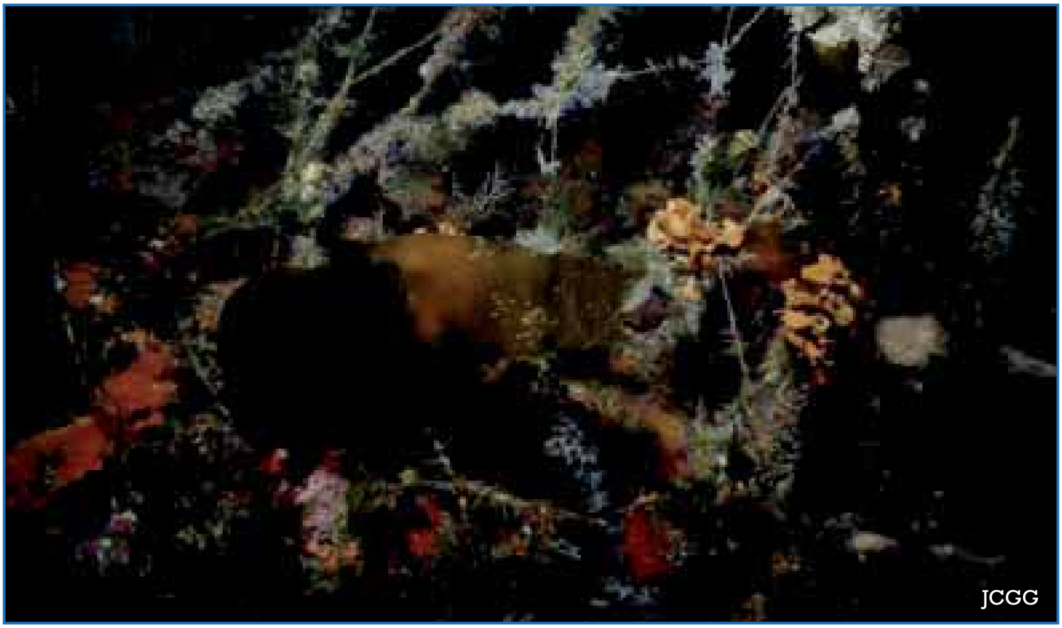
Found across rocky, shaded seabeds, frequently at the base of vertical walls and always at sites with very turbulent water. Its habitat range covers depths from 1 - 2 m to 130 m.

Distribution

In the eastern Atlantic, from the northern coasts of the Iberian Peninsula to as far as Morocco. Throughout the western Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

This species is usually found in association with ecosystems that are highly vulnerable to a wide range of disturbances, such as maërl beds (Ramos-Esplá and Luque, 2004) or Mediterranean coralline habitats (Ballesteros and Karim, 2003; Ballesteros, 2006; Astruch *et al.*, 2012) where it plays a very important structural role (UNEP(DEPI)/MED, 2007).



Phot. 320

Phot. 321

11.11. *Saccorhiza polyschides* (Lightfoot) Batters, 1902

Phot. 322

Phylum: Ochrophyta
Class: Phaeophyceae
Order: Tilopteridales
Family: Phyllariaceae
Genus: *Saccorhiza*
Common name: Furbelows

Description

One of the largest seaweeds growing in the European littoral (it can reach up to 5 m long). The holdfast is hollow, swollen, bulbous and covered in short, strong anchoring hooks. Emerging from the holdfast is an erect, flexible, flattened stem, approximately 8 cm wide; this is crowned by a highly developed lamina, which in turn appears to be divided. Dark brown in color. (**Photos 322 - 325**). An annual species that loses all of its structures, apart from the bulbous section, in autumn and then regenerates itself in spring.

Habitat

Found attached to well-lit, rocky surfaces where the water is in constant motion, generally in areas with strong currents. In the Alboran Sea it is normally found over a depth range of 0 - 25 m, although it has been observed at greater depths, sometimes even more than 40 m. Around the north of Spain it settles in lower intertidal zones of turbulent water, surviving significant periods of exposure. It is often found in abundance on beaches after autumn storms.

Distribution

It can be considered rare in the Mediterranean (western Italy and Greece), with the exception of the Alboran Sea and the Strait of Gibraltar, both areas clearly influenced by the Atlantic, where it forms emblematic underwater forests. Mainly distributed throughout the eastern Atlantic, from Norway to Morocco.

Environmental sensitivity

This species requires clean and rejuvenated waters, especially in areas with currents, and is classified as a species characteristic of good environments, with conspicuous, well-defined populations that present no association with disturbances (Juanes *et al.*, 2008; Bermejo *et al.*, 2012).

An increase in turbidity and organic load can lead to its disappearance or diminished presence (García-Gómez, 2007). In areas very close to the coastline, in shallow waters, it is particularly sensitive to any reductions in the hydrodynamism, whether caused by, for example, civil engineering works that intercept, minimize or annul coastal currents (e.g., seawalls in areas outside ports and harbors). With respect to the species' surveillance, divers should monitor seabeds with dense patches or genuine forests of S. polyschides, but they must bear in mind that these forests are not present throughout the year, given the cyclic nature of this algal species already mentioned before. It is preferable for divers to concentrate their observations primarily in spring and summer. If, for example, from one summer to the next Saccorhiza polyschides is initially present in dense formations or at certain levels of abundance (underwater areas with token or low numbers of the species should, as a general rule, always be discounted from surveillance or monitoring programs) and then these formations are later seen to disappear, then the event could be related to anthropogenic causes such as those described above. In the Mediterranean, it is considered to be threatened by the effects of pollution.

Global warming is another threat to *S. polyschides* because the species is characteristically found in cold waters and is very sensitive to temperature increases (Guinda *et al.,* 2012; Smale *et al.,* 2013).

Phot. 323

Phot. 324

Phot. 325

11.12. *Gelidium corneum* (Hudson) J.V. Lamouroux, 1813

Phot. 326

Phylum: Rhodophyta
Class: Florideophyceae
Order: Gelidiales
Family: Gelidiaceae
Genus: *Gelidium*
Common name: None

Description

A perennial, robust alga that can grow up to 35 cm tall. Examples are dark red. The central axis is cylindrical at the base but flattens along its length until it becomes a 2 mm wide strip at the top. Branches emerge in a single plane near the top of the seaweed, the tips widen giving the branches a spatula-like appearance. (**Photos 326 and 327**).

Habitat

The species prefers shaded zones with turbulent waters. It lives on rocks and is located in the upper infralittoral zone, just below the low-tide line, although it can occasionally be exposed to the air.

Distribution

In the eastern Atlantic, from the British Isles to Mauritania. In the western Mediterranean, as far as the Strait of Gibraltar.

Environmental sensitivity

Gelidium corneum requires a high-quality environment (Díez *et al*., 1999; Gorostiaga *et al.*, 2004) and serves as a useful bioindicator of sites of undisturbed quality (Gorostiaga and Díez, 1996). *G. corneum* has shown a negative correlation with pollution events (Díez *et al*., 2003) and is highly sensitive to excessive sedimentation (Gorostiaga *et al.*, 1998).

Notes

Gelidium corneum was formerly cited as *G. sesquipedale*.

Phot. 327

11.13. *Halichrysis depressa* (J. Agardh) F. Schmitz, 1889

Phot. 328

Phylum: Rhodophyta
Class: Florideophyceae
Order: Rhodymeniales
Family: Rhodymeniaceae
Genus: *Halichrysis*
Common name: None

Description

An eye-catching species due to its golden iridescence and metallic sheen. Examples are composed of numerous leaf-like laminae with irregularly lobed edges, these can present slits and are slightly serrated. Some areas of the leaves may be joined together. The species grows up to 11 cm tall. It attaches to the substrate by means of some essentially discoid but sometimes stalked axes. (**Photos 328 - 330, 334**).

Habitat

This alga settles on natural rocky formations in horizontal or gently sloping enclaves, it prefers the shade and is often found in underwater cave entrances or below overhangs (**photos 331 - 333**). Examples are observed from 5 m down to a maximum depth of 25 m.

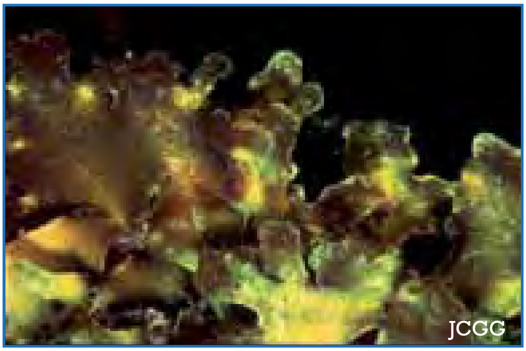
Distribution

In the eastern Atlantic, from the Canary Islands to the African coasts of Ghana and Equatorial Guinea, and in the Strait of Gibraltar. Also cited in Australia, New Zealand and Pakistan.

Environmental sensitivity

This species has very strict environmental requirements, thus its *in situ* temporal monitoring can provide useful information which serves to detect changes in the ecosystem. It can be monitored by selecting some underwater enclaves that include the largest possible number of examples in the smallest controllable space (e.g., over an area of 5 m^2).

Phot. 329



Phot. 330

Phot. 331

Phot. 332

Phot. 333

Phot. 334

11.14. *Osmundea pinnatifida* (Hudson) Stackhouse, 1809

Phot. 335

Phylum: Rhodophyta
Class: Florideophyceae
Order: Ceramiales
Family: Rhodomelaceae
Genus: *Osmundea*
Common name: Pepper dulse

Description

This species of alga grows to between 3 and 10 cm tall and has a fleshy consistency. The axis is approximately cylindrical and measures 1 to 2.5 cm wide; it branches 4 or 5 times, either alternately or irregularly, and in a single plane. The primary branches are compressed and further divide into flattened branches. Examples are brownish-red. (**Photos 335 - 337**).

Habitat

It forms in clumps on rocks, in cracks and in pools. Tends to prefer exposed zones with calm waters. Found from the intertidal zone down to depths situated below the low-tide line.

Distribution

In the eastern Atlantic, from the British Isles to Morocco and Senegal. Also common to the Mediterranean, including the Strait of Gibraltar, the Black Sea and the coasts of India, Yemen and Pakistan.

Environmental sensitivity

References have documented *O. pinnatifida's* sensitivity to hydrocarbon pollution (Baker *et al*., 1931; Díez *et al.*, 2007). Various studies have classified the species as characteristic of zones in good condition (Juanes *et al*., 2010;

García *et al.*, 2011) and as an indicator of the final stages of ecological succession (Gorostiaga *et al.*, 2004).

Notes

The species was formerly cited as *Laurencia pinnatifida.*

Phot. 336

Phot. 337

11.15. *Lithophyllum byssoides* (Lamarck) Foslie, 1900

Phot. 338

Phylum: Rhodophyta
Class: Florideophyceae
Order: Corallinales
Family: Corallinaceae
Genus: *Lithophyllum*
Common name: *Marine lichen* (Spanish name)
(also cited as *Lithophyllum lichenoides*)

Description

Clear violet or whitish, calcareous, encrusting alga that grows in massive morphologies. The surface is covered by numerous upright laminae with folds that can join together to produce numerous alveoli reminiscent of a honeycomb. The laminae can be spiny, scaly or in the shape of a cockscomb **(photo 338**). As they are fragile, they tend to break when subjected to abrasions.

Habitat

The species comprises important formations on natural rocks in the upper mid-littoral zone, including cornices (the so-called "trottoirs"); it generally prefers well-lit zones exposed to the waves. (**Photos 339 and 340**).

Distribution

Principally in the west of the Mediterranean, including the Strait of Gibraltar, it is observed less frequently in the east. In the eastern Atlantic, from the coasts of France to Morocco. Also cited in the Indian Ocean.

Environmental sensitivity

This species requires clean and turbulent waters (Mannino, 2003; Torras et al., 2003). It has been recommended for use as a bioindicator (Sfriso y Facca, 2011; Bermejo *et al.*, 2013) because it is sensitive to both organic pollution and sedimentation. Thus its environmental surveillance is straightforward because it can be monitored when exposed at low-tides without having to dive simply by taking ordinary photographs of specific areas of abrasion platforms or outcrops inhabited by the species. These images can be enough to detect temporal changes that could be attributable to enigmatic environmental disturbances in the water column. Note that this intertidal species has a very fragile structure, it is extremely vulnerable to human footsteps as they cause multiple fractures and so must be avoided (García-Gómez, 2007). If a large-scale decline in numbers is observed, which does not appear to be caused by abrasion (footsteps), then this environmental information should be supported by observing similar events in other intertidal species (e.g., the brown alga Fucus spiralis (sheet 11.7) or the red anemone Actinia equina (sheet 11.29), which are both addressed in this guide).

Environmental protection bodies

Included in the Barcelona Convention (Annex II: List of endangered or threatened species) and in the Berne Convention (Annex II: strictly protected fauna species).

Included in the Spanish and Andalusian Lists of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011, and LAESRPE, Decree 23/2012).

Phot. 339

Phot. 340

11.16. *Mesophyllum expansum* (Philippi) Cabioch y M. L. Mendoza, 2003

Phot. 341

Phylum: Rhodophyta
Class: Florideophyceae
Order: Corallinales
Family: Hapalidiaceae
Genus: *Mesophyllum*
Common name: None

Description

This calcareous alga grows up to 30 cm in diameter. It is laminar, with a smooth surface, a rounded profile and lobed, slightly serrated edges. Examples are violet. **(Photos 341 and 342**).

Habitat

Usually found in rocky, poorly-lit and moderately turbulent bottoms **(photos 343 and 344**). Also observed on soft substrates forming part of the detritic habitats of free-living calcareous algae (maërl beds). Often grows from the base of clumps of *Posidonia*. Inhabits depths from 10 to 100 m.

Distribution

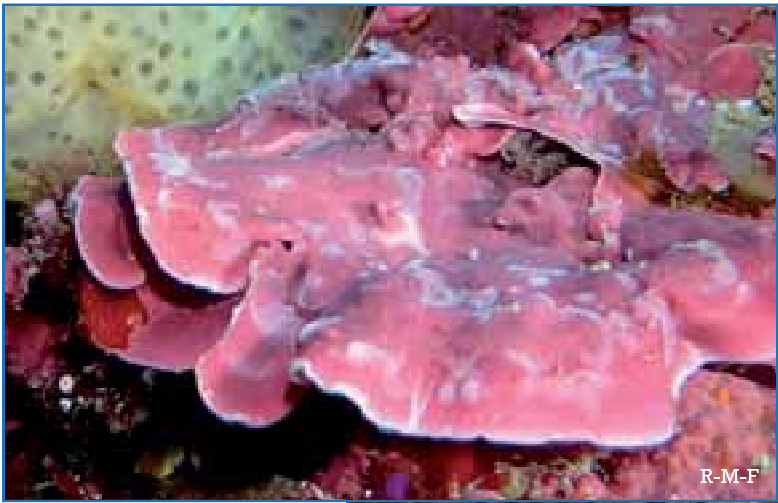
Throughout the Mediterranean including the Strait of Gibraltar, and eastern Atlantic, from the British Isles to Mauritania.

Environmental sensitivity

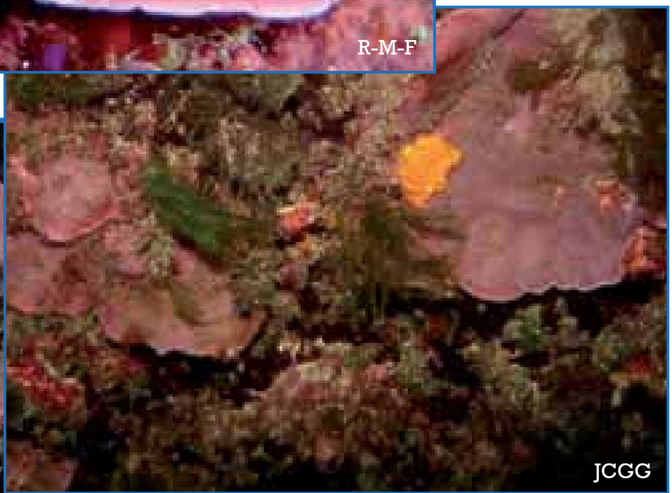
A species of narrow ecological valence which requires clean and rejuvenated waters (García-Gómez, 2007). It forms a very important part of mäerl, coralline and pre-coralline habitats (Boisset-López, 1992; Sardá *et al.*, 2012), where it even establishes its own type of community (Ballesteros, 1992). It is sensitive to organic pollution (Boisset-López, 1989) and sedimentation, while it is also particularly vulnerable, due to its fragility, to excessive or uncontrolled diving practices in its surroundings (Lloret *et al.*, 2006).

Notes

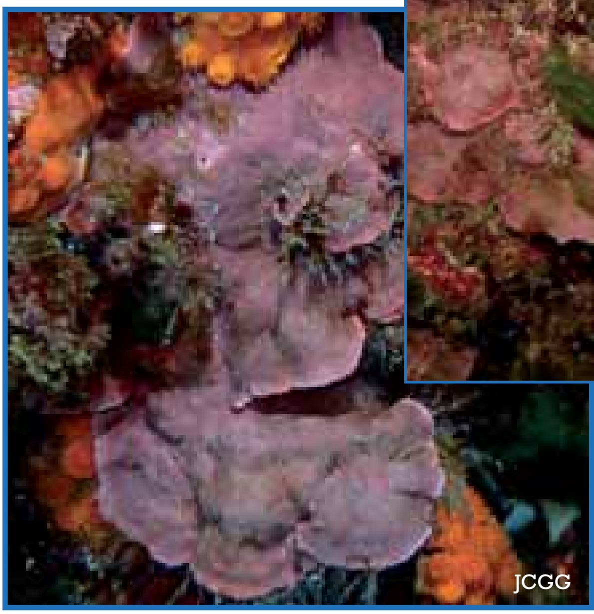
Species formerly cited as *Lithophyllum expansum.*



Phot. 342



Phot. 343



Phot. 344

11.17. *Peyssonnelia rosa-marina* Boudouresque y Denizot, 1973

Phot. 345

Phylum: Rhodophyta
Class: Florideophyceae
Order: Peyssonneliales
Family: Peyssonneliaceae
Genus: *Peyssonnelia*
Common name: None

Description

An encrusting alga whose entire surface of the thallus is attached to the substrate, with formations of around 40 cm in diameter. It has a calcified structure, apart from at the edges, which means the species is rigid but also brittle. Examples are characterized by a rounded/spherical profile and leaf-like lobes, similar to a rose. The color varies from light pink to deep red. **(Photos 345 and 346**).

It sometimes presents a very defined pattern of concentric, radial striations (personal communication from De la Rosa and Altamirano).

Habitat

Inhabits shaded zones where there is moderate to strong hydrodynamism. Often appears coating rocks in hard substrate habitats. The species is more loosely attached in soft detritic bottoms. Present at depths of 10 m down to 100 m.

Distribution

Throughout the Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

P. rosa-marina is commonly associated with maërl seabeds and coralline areas with a high degree of conservation (Ramos-Esplá and Luque, 2004; Virgilio *et al.*, 2006; Klein and Verlaque, 2009), while its absence is notable in zones with a certain degree of eutrophication (Chryssovergis and Panayotidis, 1995). Furthermore, the genus has been classified as characteristic of the ultimate stages of ecological succession (Orfanidis *et al.*, 2001, 2003).

Notes

To the novice diver, it is impossible to differentiate species in the ***Peyssonneliaceae*** family with 100% certainty using photographs alone, no matter how good their quality may be. Hence a study at a tissular and cellular level is highly recommended. Although an experienced diver may be able to assign the specimens found in a certain location to a specific species, this identification should not necessarily be extended to other areas.

Phot. 346

11.18. *Peyssonnelia rubra* (Greville) J. Agardh, 1851

Phot. 347

Phylum: Rhodophyta
Class: Florideophyceae
Order: Peyssonneliales
Family: Peyssonneliaceae
Genus: *Peyssonnelia*
Common name: None

Description

An alga that reaches diameters of up to 10 cm. It is only slightly calcified and has a membranous texture. The color ranges from reddish-purple to an intense red near the top and whitish underneath. It forms in the shape of a fan, with several lobes that are rolled downwards and which may be overlapping. **(Photos 347 and 348**).

Habitat

Prefers rocky seabeds with low light levels, such as caves, underneath rocky outcrops or large blocks of stone. Also grows from the base of clumps of *Posidonia*. It can anchor to algae or calcareous debris in detritic habitats. Observed at depths of 10 m down to 100 m.

Distribution

In the Atlantic and Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

This species is often associated to maërl beds and coralline areas with a high degree of conservation (Virgilio *et al.*, 2006; Klein and Verlaque, 2009; Piazzi and Balata, 2011), as well as zones of high environmental quality dominated by belts of *Cystoseira* (Munda, 1993). Similar to other species in the genus

Peyssonnelia, it is characteristic of the final stages of ecological succession (Orfanidis *et al.*, 2001, 2003).

Notes

Please refer to "Notes" of *Peyssonnelia rosa-marina*.

Phot. 348

11.19. *Peyssonnelia squamaria* (S. G. Gmelin) Decaisne, 1842

Phot. 349

Phylum: Rhodophyta
Class: Florideophyceae
Order: Peyssonneliales
Family: Peyssonneliaceae
Genus: *Peyssonnelia*
Common name: None

Description

A kidney-shaped, slightly calcified, laminar species of alga with a membranous consistency. It anchors to the substrate at one or two sites and is colored light red with yellowish or brown surface tones (personal communication from De la Rosa and Altamirano). It also forms lobes which may be arranged in a spiral or overlapping each other. Examples reach heights of 8 cm. **(Photos 349 and 350**).

Habitat

Grows in shaded, rocky locations with moderately turbulent waters. Also found in detritic habitats growing over loose rocks or calcareous algae, as well as among *Posidonia* meadows. Observed from the surface down to depths of 40 m.

Distribution

In the Atlantic and Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

It is frequently associated to maërl seabeds, coralline habitats and areas with a high degree of conservation (Giangrande, 1988; Ramos-Esplá and Luque, 2004; Piazzi and Balata, 2011), as well as zones of high environmental quality dominated by belts of *Cystoseira* (Munda, 1993).

Similar to other species in the genus *Peyssonnelia*, *P. squamaria* is characteristically observed in the final stages of ecological succession (Orfanidis *et al.*, 2001, 2003).

Notes

Please refer to "Notes" of *Peyssonnelia rosa-marina*.

Phot. 350

11.20. *Sphaerococcus coronopifolius* Stackhouse, 1797

Phot. 351

Phylum: Rhodophyta
Class: Florideophyceae
Order: Gigartinales
Family: Sphaerococcaceae
Genus: *Sphaerococcus*
Common name: None

Description

This alga reaches heights of 25 cm and forms treelike clumps. The main axes are cylindrical and darker towards the bottom, while near the top they flatten out and become a bright red color; examples can have spiny, forked branchlets around the edges. Branching is dichotomous, disperse and in a single plane. The species anchors to the substrate via a discoid basal holdfast from which emerge the main stems. **(Photos 351 and 353**).

Habitat

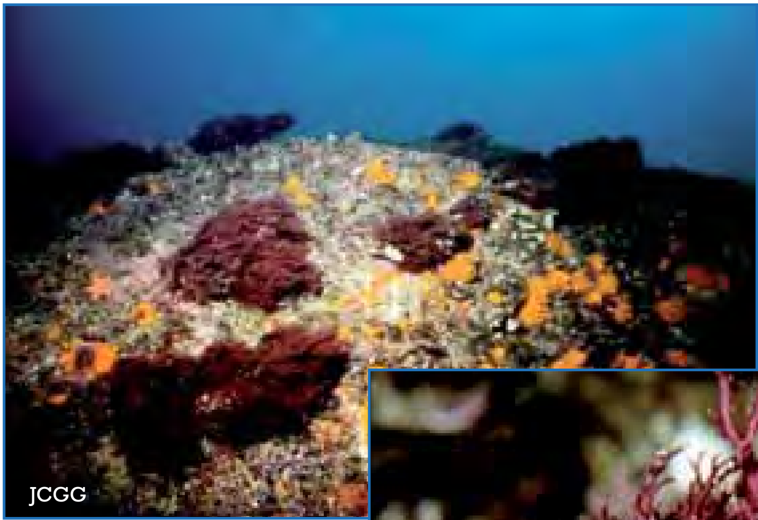
Found in semi-shaded rocky bottoms, where the waters are calm or moderately turbulent **(photos 352, 354 and 355**). Observed from the surface down to depths of 30 m.

Distribution

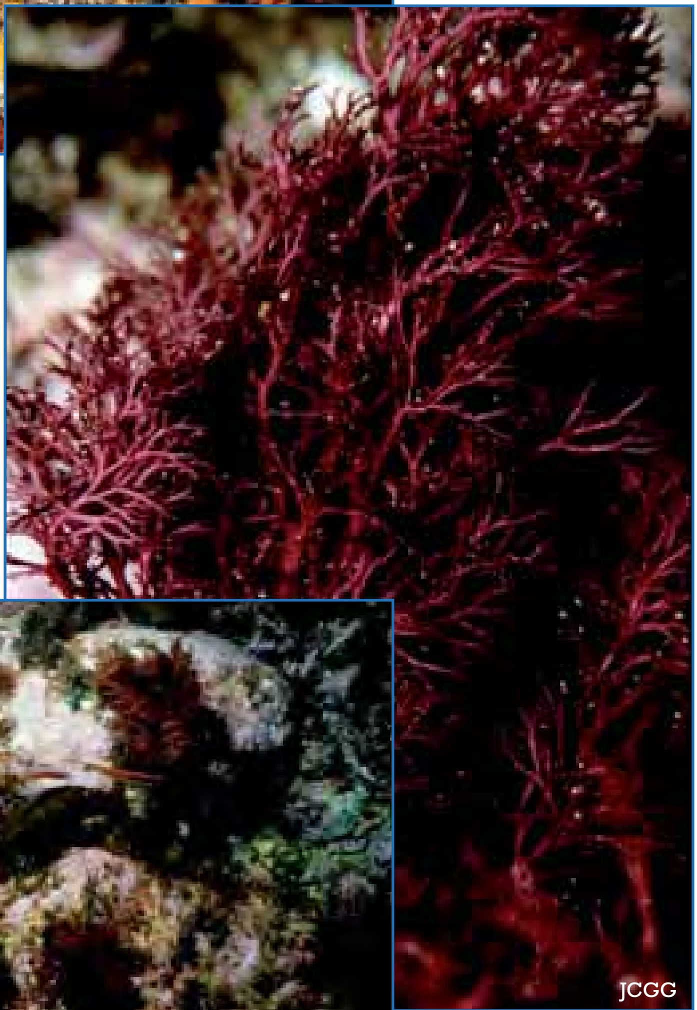
In the eastern Atlantic, from the British Isles to Morocco. Throughout the Mediterranean, including the Strait of Gibraltar. Also present in the Black Sea.

Environmental sensitivity

A pollution-sensitive (Gorostiaga *et al.*, 2004) and, particularly, sedimentation-sensitive species, as *Sphaerococcus coronopifolius* disappears in the event of abnormally elevated sedimentation rates (Balata *et al.*, 2007). It is often found in deep, turbulent waters which present good environmental conditions (Tittley and Neto, 2000; Guinda *et al.*, 2012).



Phot. 352

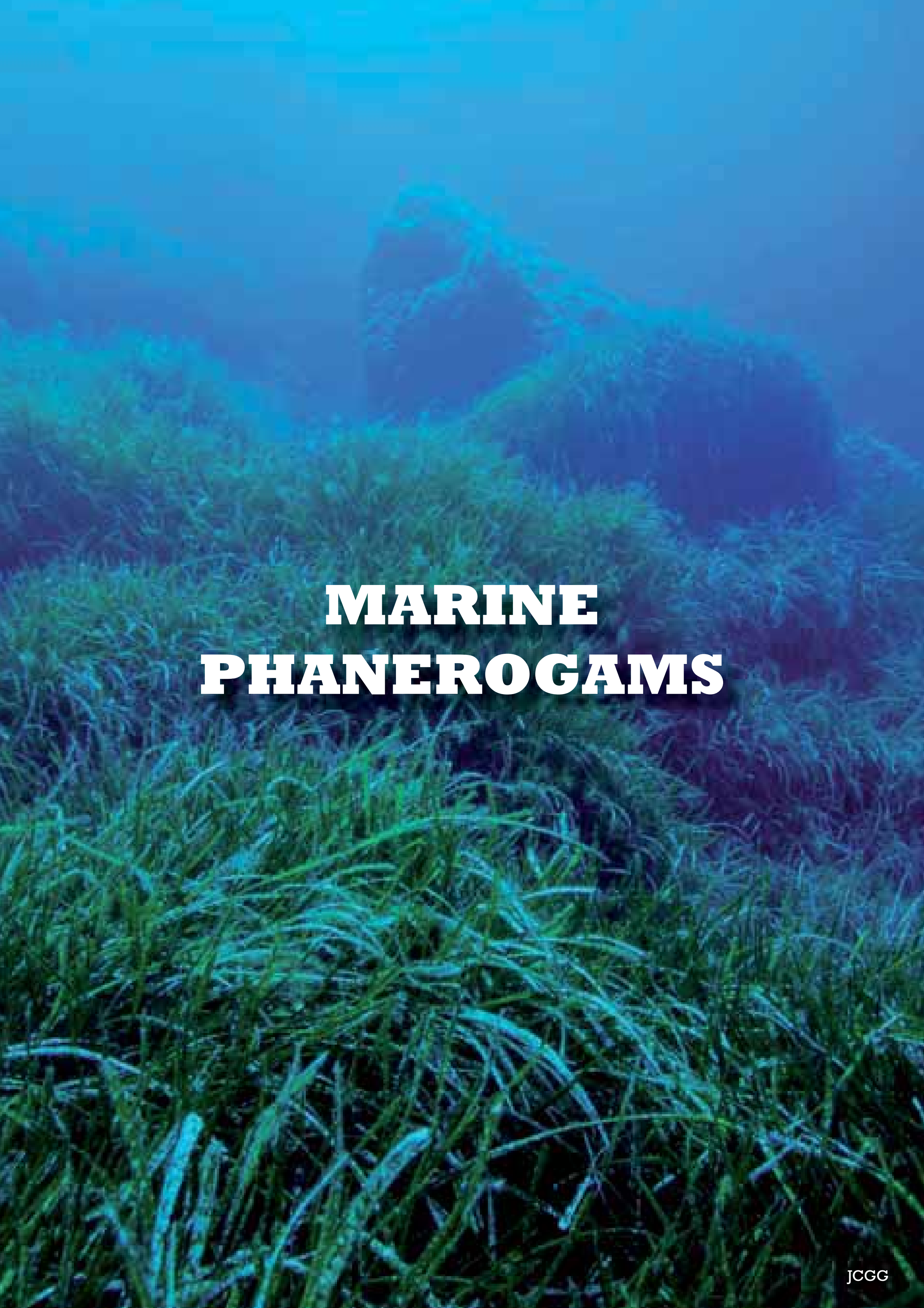


Phot. 353

Phot. 354

Phot. 355

MARINE PHANEROGAMS



JCGG

11.21. *Cymodocea nodosa* (Ucria) Ascherson, 1870

Phot. 357

Phylum: Tracheophyta
Order: Alismatales
Family: Cymodoceaceae
Genus: *Cymodocea*
Common name: Little Neptune seagrass

Description

An herbaceous plant characterized by a system of long horizontal thalluses that are buried in the sediment and from which smaller vertical thalluses emerge at certain points. The vertical thalluses are slender and herbaceous, colored pink or orange, and have a series of nodes at more or less regular intervals. The horizontal thalluses, however, are thicker and longer. Roots branch out from the nodes of both types of thallus and may or may not present high degrees of branching. They are whitish and have absorbent branching out at their ends. The roots have two functions: anchorage and nutrition. Blade-like leaves group together in bundles at the ends of both types of thallus, they measure up to 60 cm long and 0.4 cm wide (**photos 357 - 359**). The leaves are ribbon-like with a round, obtuse apex and have between 7 and 9 parallel veins. Each bundle consists of 2 to 7 leaves. It is also worth noting that the base of the leaves are surrounded by a sheath, so when the leaf dies and falls off it leaves a circular scar in the shape of a ring which forms a new node. There are two types of flower, both are small and solitary. Some are male, singular and located at the end of a stalk measuring up to 10 cm long. The female flowers are sessile and covered by pods formed from modified leaves. The fruits are round, laterally compressed and have a small peak.

Habitat

The species usually grows on sandy or sandy/muddy substrates and is rarely seen on rocky or maërl beds, while it is also found in coastal lagoons. Unlike *Posidonia oceanica*, the meadows do not elevate the level of the seabed and only grow in a horizontal plane. It is a colonizing plant which can form relatively dense meadows and may appear alone or together with other species, such as the alga *Caulerpa prolifera,* and also in zones of confluence with meadows of *P. oceanica* or *Zostera marina*. Observed from surface waters down to depths of 30 m.

Phot. 359

Phot. 358

Distribution

In the eastern Atlantic, from the south of Portugal to Senegal, including the Canary Islands and Madeira. Also inhabits the Mediterranean, including the Strait of Gibraltar, reaching as far as the Black Sea but without penetrating into it.

Environmental sensitivity

Although the species has a reputation of being more tolerant and resistant than *Posidonia oceanica*, which tends to require sediments enriched with organic material, because it can bear situations of anoxia and elevated hydrogen sulfide concentrations in the interstitial water, the truth is that this species should, in overall terms, be considered sensitive (Sánchez-Lizaso, 2004b; Barsanti *et al.*, 2007), since it cannot tolerate wastewater discharges and is very susceptible to coastal civil engineering works or any measurable increases in system turbidity that prevail for a significant period of time (García-Gómez, 2007). As an example, over three decades ago similar impacts caused a mass loss of formations of *Cymodocea nodosa* in the Bay of Algeciras (off the southern coast of Spain), estimated at 4 km^2 of coverage lost from shallow, soft bottoms. The species never managed to reintroduce itself to the zone and even today remains completely absent (Sánchez Moyano et al., 1998; García-Gómez, 2007) (**fig. 29 and photo 360**). Given the above, *C. nodosa* has frequently been used as an indicator of the possible degradation of coastal habitats (Orfanidis *et al.*, 2007, 2010; Oliva *et al.*, 2012).

Although meadows of this species are less stable than those of *P. oceanica*, and while in open littoral zones its peripheral areas are more likely to suffer natural variations, the suggestions for monitoring *P. oceanica* can also be applied, in general terms, to the surveillance of *C. nodosa* in European littoral waters. The deepest edges of meadows should be used for monitoring as they are the most vulnerable to turbidity increases (see **chapter 5.2**).

The two remaining Mediterranean species of marine phanerogams mentioned in **chapter 5.2**, *Zostera marina* and *Z. noltii*, can also be monitored following procedures similar to those described for *Posidonia oceanica* and *Cymodocea nodosa*.

Environmental protection bodies

Included in the Spanish and Andalusian Lists of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011, and LAESRPE, Decree 23/2012).

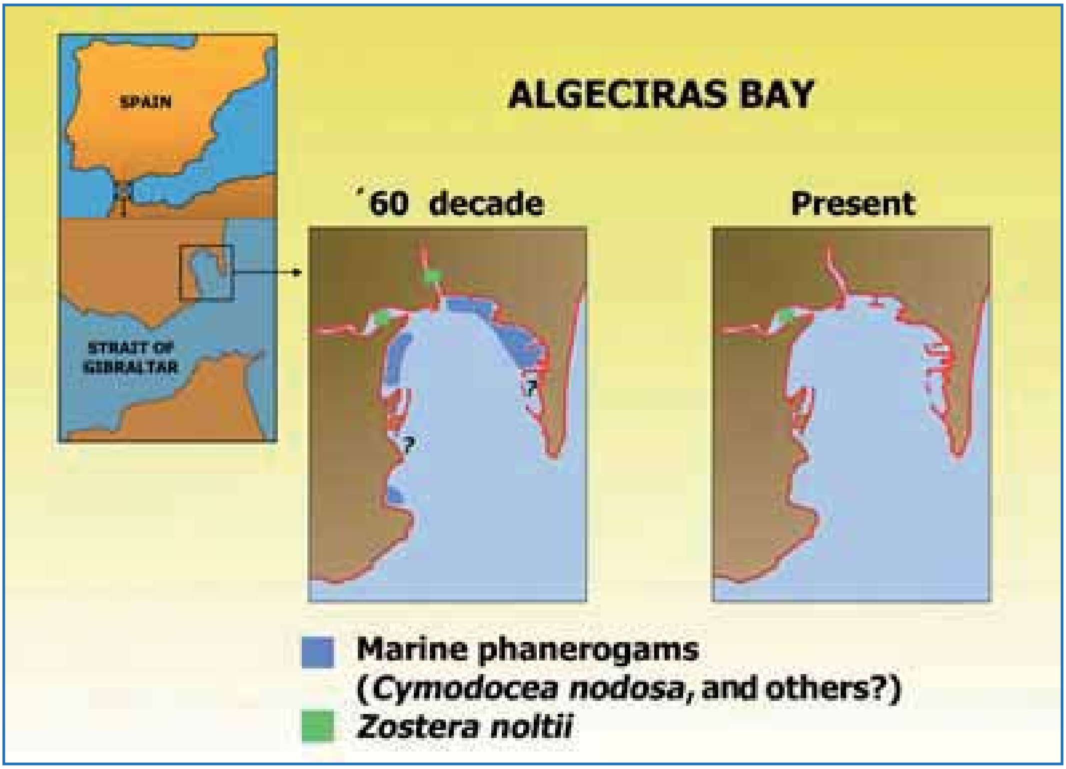


Fig. 29

Phot. 360

11.22. *Posidonia oceanica* (Linnaeus) Delile, 1813

Phot. 361

Phylum: Tracheophyta
Order: Alismatales
Family: Posidoniaceae
Genus: *Posidonia*
Common name: Neptune grass

Description

An herbaceous plant comprised of an intricate network of horizontal and vertical thalluses, it is typically coated with sediment. The 'twiggy' thalluses can reach a thickness of 1 cm, they are slightly compressed and covered by scales derived from the base of old leaves. Roots stemming from the thalluses are robust, numerous and reach lengths of 10 to 15 cm. The roots anchor the plant to the substrate and so examples in areas of elevated hydrodynamism have more roots. The leaves stem from the end of the thalluses and are grouped in bundles of 4 - 10 units. They look like ribbons, measuring around 1 cm wide and between 20 and 140 cm long. The youngest parts (basal section) are a brighter green than the older parts (distal section), which are dark or brownish-green and often covered by other organisms. Each leaf is clearly composed of two distinct parts, the leafstalk or petiole and the blade. The former is mechanically strong and does not fall off when the leaf is shed, remaining joined to the thallus where it forms the scales covering the plant. The blade is responsible for photosynthesis. There are 3 to 5 hermaphrodite flowers grouped in the centre of each bundle of leaves. The fruit is quite fleshy and takes on the appearance and color of an olive, hence in Spanish it is commonly known as "the sea olive".

Habitat

Lives in shallow waters or open zones which experience an elevated level of hydrodynamism. Meadows of *P. oceanica* typically grow in a horizontal plane (**photo 361**), but can also grow in a vertical plane (**photos 362 and 363**). In the latter case, the meadow's elevation can produce terraces that constitute a latticework of rhizomes which can surpass two meters. The rate of elevation can be as much as 1 cm per year, the meadows are capable of reaching the surface where they form so-called "*Posidonia* reefs". The species can also grow on rocky bottoms but it prefers sandy seabeds, it particularly likes large bays or areas of lesser hydrodynamism. Depending on the water's transparency, examples are found from surface depths down to 40 m.

Phot. 362

Distribution

Endemic throughout the Mediterranean.

Environmental sensitivity

The species is indicative of clean, unpolluted and well-oxygenated waters (García-Gómez, 2007; Montefalcone, 2009; López and Royo *et al.*, 2011). It is particularly sensitive to a progressive increase in turbidity, especially if this also implies an elevated organic load (Cancemi *et al.*, 2003) and high rate of sedimentation (Ruiz and Romero, 2003; Sánchez-Lizaso, 2004a).

Environmental surveillance of *P. oceanica* should basically concentrate on marking the peripheral zones of its meadows and monitoring whether these borders remain stable or whether they retreat (**fig. 30**). Observations can also be made of zones inside the meadows in order to evaluate the density, appearance and length of the leaves. Sometimes these border regressions are natural and limited, hence the border being monitored should subsequently be checked for stabilization. Surveillance of the deepest zone, as explained previously (**chapter 5.2**), yields results that are especially sensitive to measurable increases in turbidity, e.g., those caused by an increased level of organic load dumped into the littoral system. The leaves of this species are often covered with epibionts. However, the abnormal presence of generalist algae growing over them could be just a short-term, atypical event (a one-

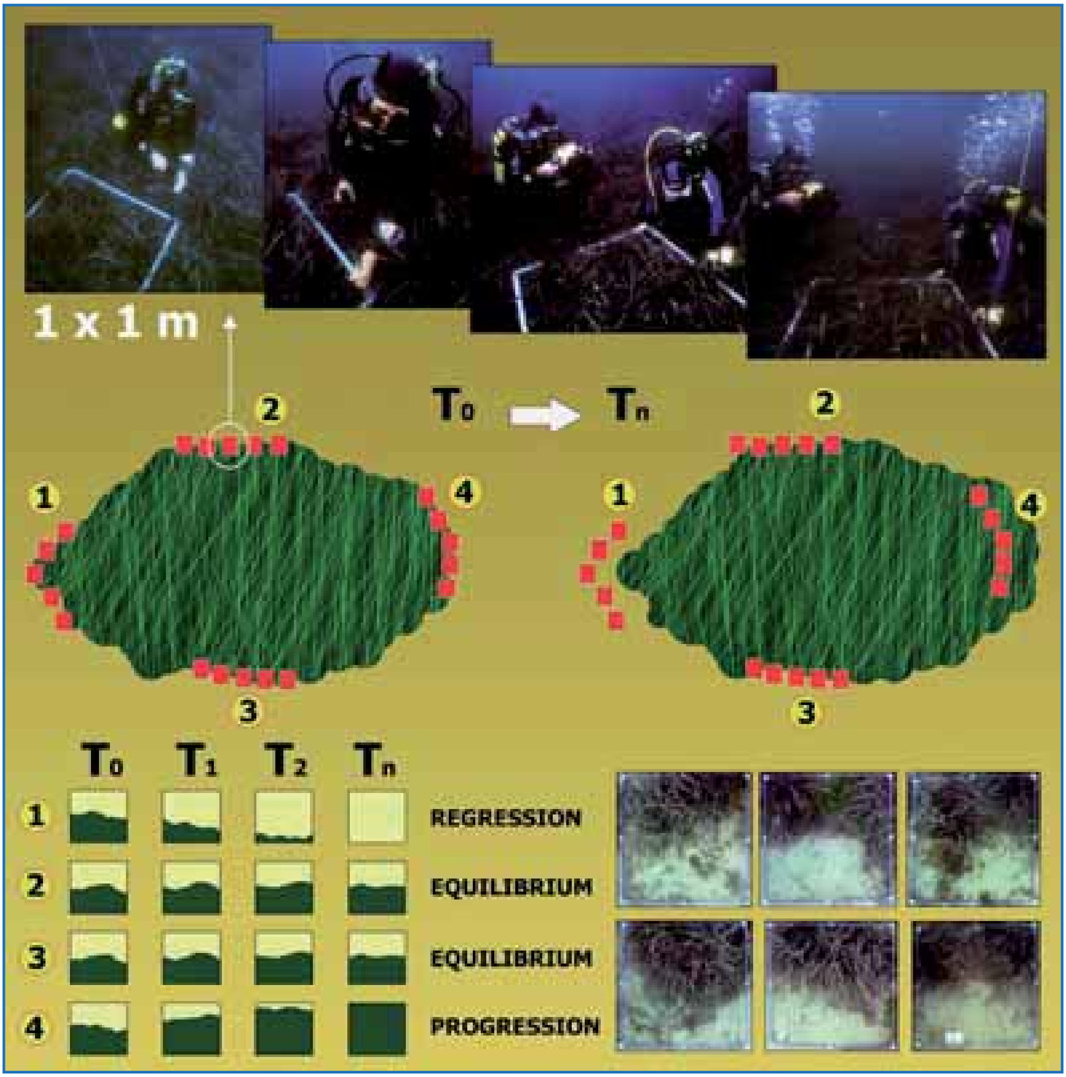


Fig. 30

Phot. 363

off excess of nutrients in the environment) but, if it is a semi-continuous or increasingly persistent upsurge in nutrients (e.g., as a consequence of the nearby appearance of previously absent human discharges), it could also trigger a regression process with measurable losses of meadow area plus the decline or collapse of part of the associated biodiversity. The leaves' appearance and the presence of other unusual epibionts which were not reported previously can also provide clues that a process of negative change might be occurring in the system. The species does not tolerate large variations in salinity, although it can bear a wide range of temperatures, from 10 to 28 °C.

A series of black-and-white photographs (Astier and Tailliez, 1978) clearly illustrates the severe negative effects of a wastewater discharge point on *Posidonia oceanica*, at a considerable distance (**photo 364**) and at 600 m from the discharge point, both at depths of 26 m. The surviving clumps are literally covered in generalist macroalgae (**photos 365 and 366**).

In terms of environmental monitoring and surveillance, this is one of the most emblematic species in the Mediterranean, not only because its meadows are sensitive to anthropogenic disturbances but also because *P. oceanica* forms one of the most highly valued ecological habitats of all those present in the Mediterranean.

Environmental protection bodies

Included in the EU Council Directive 92/43/EEC (Annex I: Natural habitat types of community interest whose conservation requires the designation of special areas of conservation).

Included in the Spanish and Andalusian Lists of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011, and LAESRPE, Decree 23/2012).

Phot. 364

Phot. 365

Phot. 366

SPONGES

JCGG

11.23. *Aplysina aerophoba* (Nardo, 1833)

Phot. 368

Phylum: Porifera
Class: Demospongiae
Order: Verongida
Family: Aplysinidae
Genus: *Aplysina*
Common name: Yellow tube sponge

Description

This species is a massive sponge that forms tubular lobes which are around 6 cm long and have a pore at the end. It has thick walls and a smooth surface that is soft to the touch. Diameters can reach as much as 30 cm. The color is yellow, but it changes to dark violet when in contact with the air. (**Photo 368**).

Habitat

This species prefers well-lit habitats due to the presence of a symbiont cyanobacteria and so it is found from the shoreline down to 30 - 40 m, generally on either rocky or sandy, horizontal substrates (**photo 369**). Its main predator, the opisthobranch *Tylodina perversa*, is often observed moving over its surface.

Distribution

It is a cosmopolitan species.

Environmental sensitivity

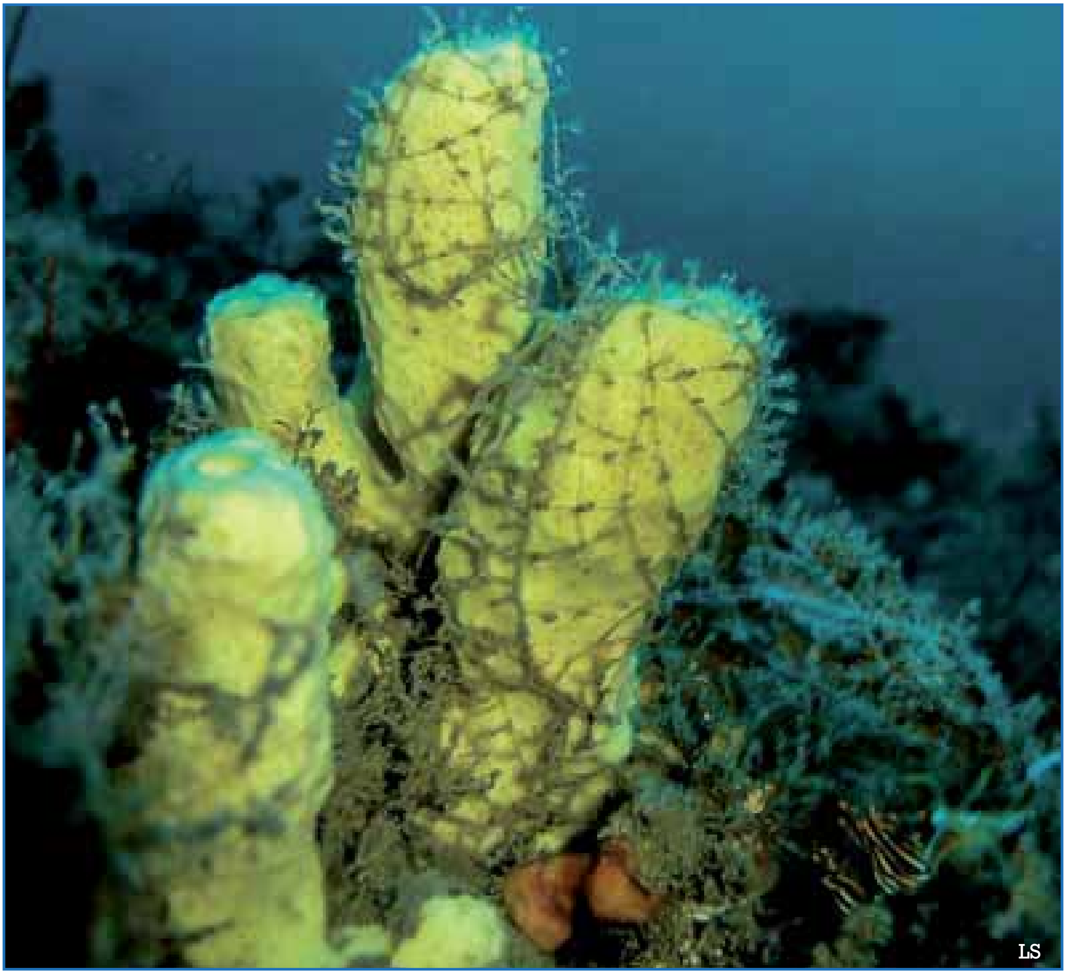
A. aerophoba can be found, including abundantly, in areas of high environmental quality, such as Marine Protected Areas (Tunesi *et al.*, 2008) or meadows of *Posidonia* with an abundant presence of *Cystoseira* spp. (Ben

Mustapha *et al.*, 2002). The species has also demonstrated sensitivity to water temperature increases (Friedrich *et al.*, 2001; Ahn *et al.*, 2003; Webster, 2007).

Environmental protection bodies

Included in the Spanish List of Specially Protected Wildlife (LESRPE), in the expansion performed according to Order AAA/75/2012.

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".



Phot. 369

11.24. *Axinella damicornis* (Esper, 1794)

Phot. 370

Phylum: Porifera
Class: Demospongiae
Order: Halichondrida
Family: Axinellidae
Genus: *Axinella*
Common name: Yellow sponge

Description

This light yellow sponge presents a branched appearance, the peduncle (stem) from which the branches emerge tends to be short and hard. The branches are generally flat but sometimes look like fingers. It has an elastic, flexible consistency. Branches often fuse together giving the appearance of moose antlers. Examples grow to a height of between 4 and 10 cm, with a maximum diameter of 5 cm. (**Photos 370 and 371**).

Habitat

Typically found in environments with limited light. In shallow waters it tends to be found in crevices, caves or on overhangs. As the depth increases it settles on more horizontal substrates, whether they be hard or sandy, and even in detritic/muddy, muddy and maërl habitats. Although it can exceptionally be found in very dark enclaves of shallow, rocky bottoms, this species is normally observed at depths of 20 to 50 meters in the zone around the Strait of Gibraltar, while it has been cited at even greater depths in other geographical areas. Examples are frequently colonized by the anthozoan *Parazoanthus axinellae,* the two species appear to share a symbiotic relationship.

Distribution

Throughout the Atlantic and Mediterranean including the entire coast of the Iberian Peninsula.

Environmental sensitivity

A. damicornis has a narrow ecological valence and strict requirements in terms of water quality (must be clean and rejuvenated), it is very sensitive to environmental disturbances and vulnerable to strong currents (Bell and Barnes, 2000; Ordines *et al.*, 2011). The species tends to disappear from zones subjected to persistent increases in turbidity caused by either urban discharges or the overflow from aggregate dredging in the littoral. It is absent from seabeds with a high rate of sedimentation and an elevated organic load. The species is, therefore, characteristic of unpolluted and biodiverse bottoms in a good state of conservation (Hiscock *et al.*, 2010; Altug *et al.*, 2011; Templado *et al.*, 2012).

Notes

Studies have observed that *Axinella damicornis* contains antitumor agents, hence it is currently being used in the pharmaceutical industry.

Phot. 371

11.25. *Axinella polypoides* Schmidt, 1862

Phot. 372

Phylum: Porifera
Class: Demospongiae
Order: Halichondrida
Family: Axinellidae
Genus: *Axinella*
Common name: Common antlers sponge

Description

Tends to form a treelike shape with a thick and hard base from which stem flexible and cylindrical branches, although these are sometimes flat. There are secondary branches which, if they fuse together, can appear like fans or antlers. Examples are yellow or orangey-yellow and reach sizes of around 50 cm. The surface is velvety and has quite visible, star-shaped pores. (**Photos 372 and 373**).

Habitat

Found in deep infralittoral and circalittoral bottoms, inhabiting both rocky and sandy substrates. It generally settles on horizontal or slightly sloping surfaces. In well-lit areas it prefers to shelter in grottos, cracks and crevices. On rare occasions it can be observed in shallow waters, growing on very shaded surfaces of rocky bottoms, but in the Strait of Gibraltar it is normally found at a depth of at least 20 meters.

Distribution

In the eastern Atlantic, from the south of Norway to the Mediterranean, including the Strait of Gibraltar and the entire coast of the Iberian Peninsula.

Environmental sensitivity

As with *A. damicornis* from the same genus, *A. polypoides* has a narrow ecological valence, is very sensitive to environmental disturbances (Moreno *et al.*, 2008b), requires clean and rejuvenated waters and is absent from seabeds with high sedimentation rates and elevated organic loads. The species is characteristic of well-conserved, pollution-free bottoms (Tunesi *et al.*, 2008; Altug *et al.*, 2011; Templado *et al.*, 2012). It has also been used as an indicator of increasing water temperatures (Bianchi *et al.*, 2012). Given the ease with which examples can be located and identified while diving, this species is recommended for underwater monitoring.

Notes

Haliclona oculata is a similar species.

Environmental protection bodies

Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".

Phot. 373

11.26. *Haliclona (Halichoclona) fulva* (Topsent, 1893)

Phot. 374

Phylum: Porifera
Class: Demospongiae
Order: Haplosclerida
Family: Chalinidae
Genus: *Haliclona*
Common name: None

Description

A light orange, encrusting sponge which reaches up to 10 cm along its largest axis and is around 1 cm thick. It has a globular body from which erect tubes emerge, or sometimes lateral branches, both of which have pores at the ends. The surface is irregular while it has a soft consistency. (**Photos 374 and 375**).

Habitat

Found in areas with reduced light levels such as overhangs and cavities, generally on vertical or slightly inclined surfaces. Also grows over other species of sponge and the rhizomes of the phanerogam Posidonia oceanica. The species has been cited in deep detritic bottoms. It prefers zones of elevated hydrodynamism. It is distributed over a range from 0 to 120 m.

Distribution

A typically Mediterranean species but also extends to the Cape Verde Islands in the Atlantic, thus it is also present in the Strait of Gibraltar.

Environmental sensitivity

This species is sensitive to changes in environmental conditions, such as an increased amount of solids or particles in suspension (Carballo *et al.*, 1996). It is, therefore, a species indicative of optimal conditions. However, it does appear to be tolerant of warmer waters, as it was not affected by temperature abnormalities that caused mass deaths in other sensitive marine species (Verdura *et al.*, 2013).

Phot. 375

11.27. *Ircinia oros* (Schmidt, 1864)

Phot. 376

Phylum: Porifera
Class: Demospongiae
Order: Dyctioceratida
Family: Irciniidae
Genus: *Ircinia*
Common name: None

Description

This sponge has a massive/conical form, with a diameter of 6 - 12 cm. The surface is spiky and it has a firm, soft and compressible consistency. It is resistant to tears and breaks. Each specimen tends to have one or two round pores of up to 1 cm in diameter located at the highest point of the sponge. Coloration varies in function of light exposure, it is usually dark gray or brown in well-lit areas and lighter when found in caves and crevices (**photos 376 and 377**).

Habitat

Commonplace in caves, crevices and overhangs; never found in zones that are fully exposed to sunlight. Inhabits both horizontal and vertical substrates. Can be observed at surface levels and in coralline habitats. Reproduction is in July and August. Found at depths between 1 and 150 m.

Distribution

Across the Mediterranean including the Strait of Gibraltar.

Environmental sensitivity

The species is sensitive to environmental disturbances (Carballo *et al.*, 1996), thus its presence indicates that the environment is in optimal conditions (Garrabou, 1997). Studies have also observed it to suffer different mortality events, both partial and massive, in association with abnormally high temperatures (Perez *et al.*, 2000; Lejeusne *et al.*, 2010).

Phot. 377

11.28. *Sarcotragus spinosulus* Schmidt, 1862

Phot. 378

Phylum: Porifera
Class: Demospongiae
Order: Dyctioceratida
Family: Irciniidae
Genus: *Sarcotragus*
Common name: None

Description

This sponge has a massive, regular morphology, it is near-spherical but slightly flattened and the size varies between 10 and 25 cm. It has a soft, elastic consistency but it is very resistant to breakages. The surface is even, reticulated and rough to the touch. The color varies between dark gray and black, towards the interior it is lighter, almost whitish (**photos 378 and 379)**.

Habitat

Develops on both horizontal and vertical rocky substrates, on overhangs and in cave entrances. Also found under stones and growing over algae and anthozoans. Its habitat range covers depths of 1 to 300 m.

Distribution

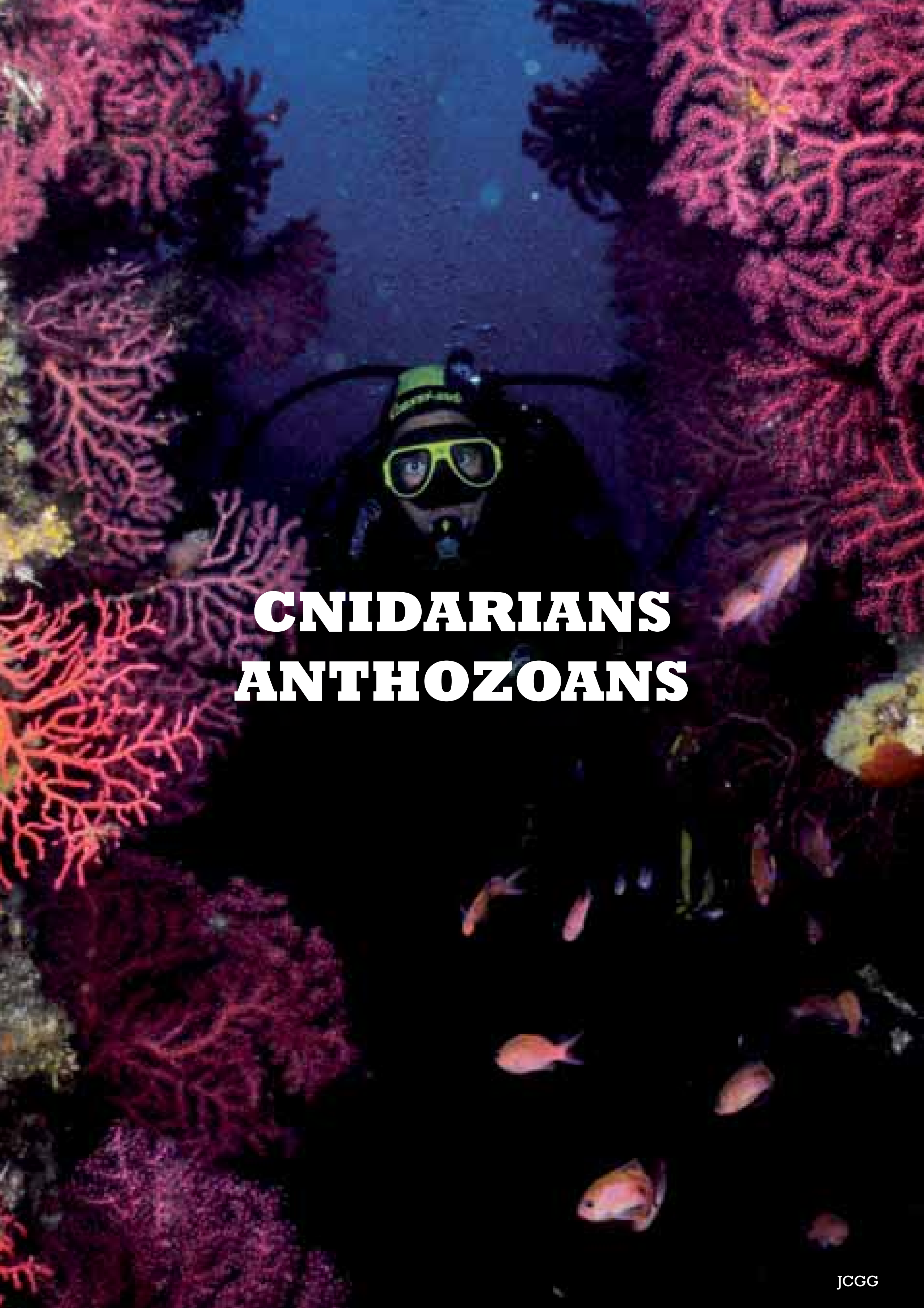
Throughout the Atlantic and the Mediterranean, including the Strait of Gibraltar.

Environmental sensitivity

Sarcotragus spinosulus is sensitive to environmental disturbances (Carballo *et al.*, 1996) and is usually found in zones with good environmental conditions (Corriero *et al.*, 2004). Nevertheless, it has been cited as capable of accumulating high quantities of arsenic (Araújo *et al.*, 1999).

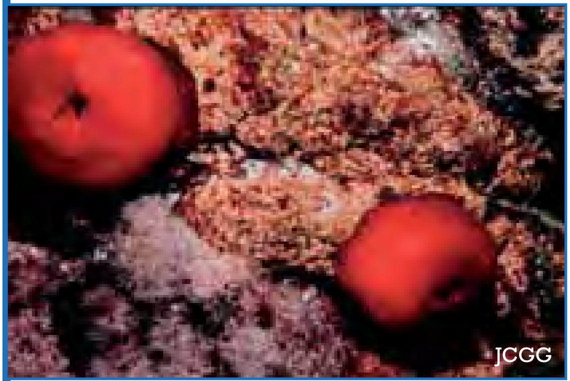
Phot. 379

CNIDARIANS ANTHOZOANS



JCGG

11.29. *Actinia equina* (Linnaeus, 1758)



Phot. 381

Phylum: Cnidaria
Class: Anthozoa
Order: Actiniaria
Family: Actiniidae
Genus: *Actinia*
Common name: *Sea tomato* (Spanish name) or beadlet anemone (English)

Description

This species of anemone is bright red, growing to heights of up to 8 cm and diameters of approximately 7 cm. It has numerous short tentacles (up to 192) which widen near the base and have rounded tips.

Habitat

Typically found attached to rocky substrates in the intertidal zone, preferably in well-lit or only slightly shaded areas. It is exposed at low tide, but appears as a bright red globular structure with no sign of the tentacles because they are retracted to avoid drying out (**photos 381 - 384**). When the tide comes in and covers the specimen, the species reveals itself to be an anemone by extending its tentacles ready to capture food (**photo 385**). Although it can be found both in either cracks/crevices exposed to the waves, or underneath stones and on horizontal or slightly sloping surfaces, it prefers to live on vertical walls. Thanks to its elevated capacity for internal water retention it can withstand prolonged periods without being submerged. Also observed at depths of just a few meters, with citations of examples at 20 meters (at these depths the coloration can vary to include green or orangey examples).

Distribution

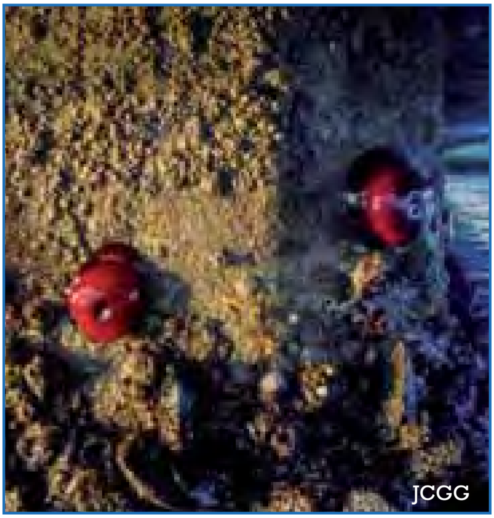
Throughout the Mediterranean and eastern Atlantic, from the north of Europe to as far as the equator along the western coast of Africa.

Environmental sensitivity

This species needs a habitat with very clean and well-oxygenated water, so it is considered to be a good indicator of unpolluted waters (Smith, 1968; García-Gómez, 2007). Its absence from areas where it was previously abundant could be a sign of negative changes in the water quality (Cha *et al.*, 2013).

Actinia equina is a sensitive species, it is affected by exposure to hydrocarbon pollution (Ormond and Caldwell, 1982) and is also considered to be a good indicator for monitoring contamination in coastal environments derived from heavy metals (Shiber, 1981; Gadelha *et al.*, 2010).

This species is easily monitored, as can be deduced from the photographs. A periodic stroll (at low tide) among coastal areas where numerous examples are present can be enough to perceive significant changes in the species' abundance or its total disappearance. If this were to occur, it should be confirmed with similar observations of other intertidal species (e.g., the brown alga *Fucus spiralis* or the red alga *Lithophyllum bissoides,* both covered in this guide).



Phot. 382

Phot. 384

Phot. 383

Phot. 385

11.30. *Alicia mirabilis* Johnson, 1861

Phot. 386

Phylum: Cnidaria
Class: Anthozoa
Order: Actiniaria
Family: Aliciidae
Genus: *Alicia*
Common name: Berried anemone

Description

This is a solitary anthozoan species which changes its appearance over the course of each day. During the daytime it contracts (**photos 386 and 387)** into a brown cone shape covered by withdrawn tentacles and some tubercles which collectively give it the appearance of a cauliflower. Individuals extend their tentacles at night-time and appear like palm trees (**photos 388 and 389).** The cream-colored, translucent trunk can reach heights of 30 cm and is covered with gold and orange tubercles and protrusions. The numerous tentacles are long and can retract a long way, they are cream with a chestnut-colored band close to the base.

Habitat

Tends to settle on well-lit, horizontal or slightly sloping substrates, whether they be rock, gravel or sand/mud, as well as in coralline habitats. Reproduction occurs from June to October. It sometimes appears to be free from the substrate due to its weak attachment. It is observed over a range of 3 to 50 m.

Distribution

In the western Mediterranean up to the Strait of Gibraltar and also in the eastern Atlantic, from Portugal to the Canary Islands. Also present in the Red Sea.

Environmental sensitivity

This species is typically found, although not usually in abundance, in well-conserved, biodiverse zones (Ocaña et al., 2000). To illustrate why *Alicia mirabilis* is included in this guide, the species is beginning to extend its ditribution and to be more present in the Adriatic Sea (Kružić, 2002; Kružić et al., 2002) and this new introduction could be linked to climate change (Pećarević et al., 2013).

Notes

The tentacles can cause a very painful sting.

Phot. 387

Phot.388

Phot. 389

11.31. *Ellisella paraplexauroides* Stiasny, 1936

Phot. 390

Phylum: Cnidaria
Class: Anthozoa
Order: Alcyonacea
Family: Ellisellidae
Genus: *Ellisella*
Common name: None

Description

A reddish or orangey colonial species with white or yellowish polyps. The colonies have little branching (occasionally none at all), with the few branches that stem from the base arranged vertically in straight lines. Colonies have a very strong, coenenchyme axis. The calyxes (cups) of the polyps are small, prominent and arranged in two irregular series on either side of the axis. Examples can grow to over 2 meters in height, making it the largest gorgonian in the whole of the Mediterranean and eastern Atlantic. (**Photos 390 - 393**).

Habitat

Settles on horizontal or slightly sloping, rocky substrates. Preferably in bottoms with a certain amount of current. The species pertains to the circalittoral, commonly between 50 and 150 meters, although it is also found in shallower waters with specimens even observed at depths of 15 m, as long as the incident light is sufficiently attenuated by the turbidity. It tends to be a rare and sporadic species which does not usually form dense groups of individuals.

Distribution

Distributed along the western coast of Africa from Angola to Morocco, including the Canary Islands and reaching as far as the south of Portugal. It is scarcely present in the Mediterranean, although examples have been observed around Algeria, Tunisia, the Strait of Gibraltar and some islands in the Alboran Sea.

Environmental sensitivity

Very little is known about the environmental sensitivity of *Elisella paraplexauroides*. However, its complex structure, its association with species-rich sites and its vulnerability to human activities (Angiolillo *et al.*, 2012), especially those related to unregulated fishing (Maldonado *et al.*, 2013), make it an obvious choice for inclusion in this guide.

Environmental protection bodies

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al.*, 2008), under the category "Endangered".

Phot. 391

Phot. 392

Phot. 393

11.32. *Astroides calycularis* (Pallas, 1766)

Phot. 394

Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia
Family: Dendrophylliidae
Genus: *Astroides*
Common name: Star coral

Description

It tends to create colonies with a massive form, though occasionally it may be treelike. The skeleton is calcareous and the polyps cylindrical, tending to grow next to each other. If polyps appear joined together, then the overall shape may appear polygonal. The tentacles are small and pointed. The entire colony presents a bright orange color (**photo 394**).

Habitat

Grows over rocky substrates, generally on overhangs vertical walls and roofs (**photo 395**). It sometimes grows on cave floors or sufficiently deep horizontal surfaces where the incident light is very attenuated. Examples can be found on completely shaded, rocky surfaces in intertidal zones, where the pounding of the waves is moderate or even high (**photos 396 and 397**). It is observed down to depths of 50 meters.

Distribution

Well represented in the western Mediterranean including the Strait of Gibraltar. In Atlantic waters it has been observed along north African coasts and around the south of the Iberian Peninsula (the Bay of Cadiz).

Environmental sensitivity

Astroides calycularis is sensitive to marine pollution (Moreno *et al.*, 2008a), particularly any increases in organic load or turbidity. **Figure 31** illustrates the gradual disappearance of this species into the Bay of Algeciras (in 2001) when water quality diminishes; orange circles indicate the abundance of colonies in the four transects between 5 and 20 meters deep (personal observation).

It is a good indicator species with respect to coastal water quality (García-Gómez, 2007; Terrón-Sigler *et al.*, 2014), characteristic of warm zones it will only tolerate small temperature changes (Grubelić *et al.*, 2004; Bianchi, 2007). The species provides an indication of impacts due to excessive sedimentation of an anthropogenic origin because colonies become heavily impregnated with sediment. Correspondingly, **photos 398 and 399** illustrate,

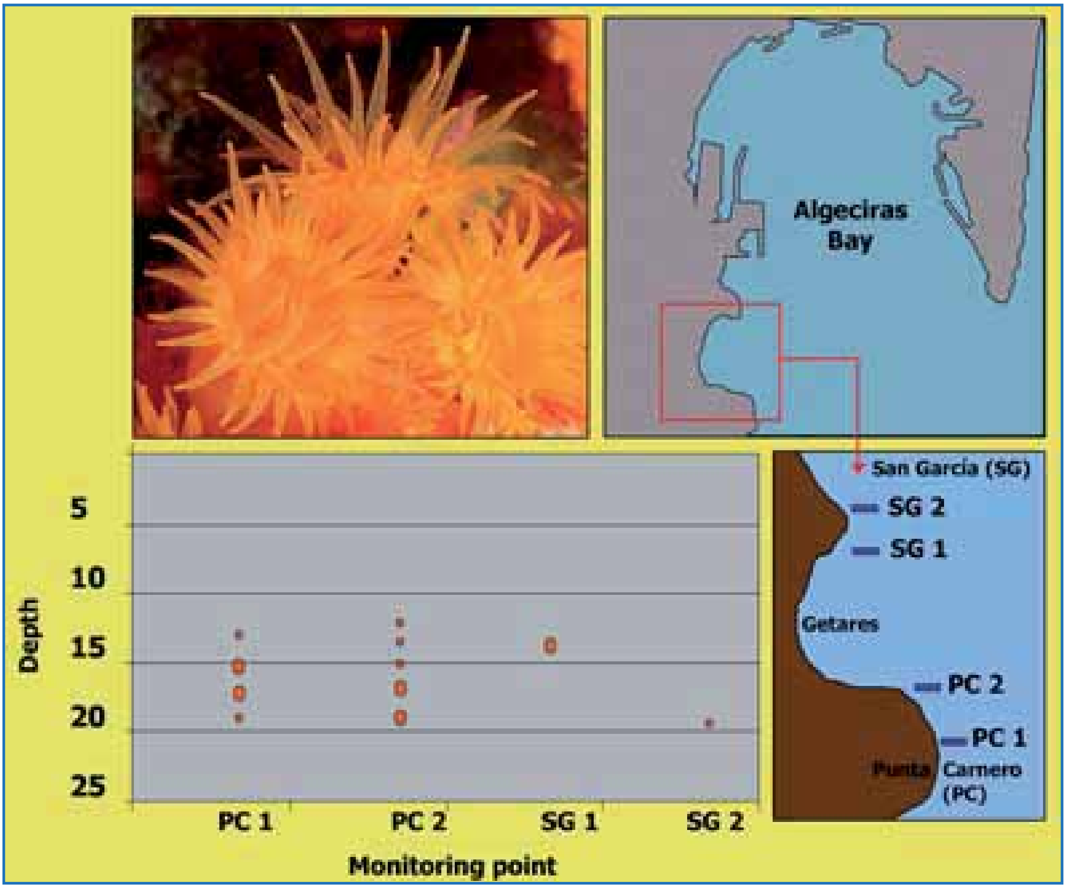


Fig. 31

Phot. 395

Phot. 396

Phot. 397

at the scale of a wide-angle lens and macro photography respectively, an excess of sedimentation derived from the overflow of suction dredgers involved in aggregate extraction processes along coastal seabeds. *In situ* death of colonies can also be identified by the calcareous skeleton of the polyps (**photos 400 and 401**).

They are also vulnerable to damage caused by mechanical actions (e.g., dragged anchors), including any knocks from divers (Di Franco *et al.*, 2009).

Phot. 398

Phot. 399

In areas covered by a gradient of environmental impact, this species' distribution indicates the points where the water quality starts to improve. The species is easy to monitor, mainly thanks to its eye-catching colonies which can completely cover shaded walls of pre-coralline habitats. Partial or mass death of its polyps reveals its calcareous skeleton and the disappearance of previously abundant colonies may be related to an anthropogenic disturbance.

In the Mediterranean it is considered to be a species in regression, mainly due to anthropogenic factors (Moreno *et al.*, 2008a). The fact that *A. calycularis* is an excellent indicator of clean waters, while also being protected, make it a species of choice for any environmental surveillance initiative seeking to protect the coastal seabeds it inhabits, whether at a scientific, technical or voluntary level.

Phot. 400

Phot. 401

Environmental protection bodies

Included in the Barcelona Convention (Annex II: List of endangered or threatened species) and in the Berne Convention (Annex II: strictly protected fauna species).

Included in the Spanish Catalogue of Threatened Species, under the category "Vulnerable".

Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al.*, 2008), under the category "Vulnerable".

11.33. *Dendrophyllia ramea* (Linnaeus, 1758)

Phot. 402

Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia
Family: Dendrophylliidae
Genus: *Dendrophyllia*
Common name: Yellow coral

Description

This coral forms in large, treelike colonies measuring up to 1 m tall. It has an orangey, fragile and calcareous skeleton. A central axis of up to 10 cm wide stands on a plate that anchors to the substrate, the axis tapers towards the top. There is often abundant branching growing in all directions. Examples have white or slightly yellowish, long and round polyps. The surface is porous (**photos 402 and 403**).

Habitat

It usually establishes itself on horizontal or slightly sloping enclaves of semi-shaded rocky bottoms that are subjected to moderate or elevated hydrodynamism (currents) (**photo 404**). While it has been cited in both shallow waters and at depths of more than 100 meters, in the Alboran Sea it is typically found at depths of 25 - 30 m or more.

Distribution

Distributed from the south of the western Mediterranean to the Strait of Gibraltar and throughout the eastern Atlantic, ranging from Portugal and the Gulf of Guinea.

Environmental sensitivity

Dendrophyllia ramea requires clean waters, normally settling in highly biodiverse and structured bottoms in an excellent state of conservation

(Ocaña *et al.*, 2000). It is never observed in either polluted waters or those subject to environmental stresses of an anthropogenic origin. Nevertheless, it displays a notable tolerance to excessive sedimentation phenomena, even surviving burial, so long as these phenomena take place habitually and continuously, such as those occurring in the mouths of large rivers, and not occasional, one-off events (**photo 405**).

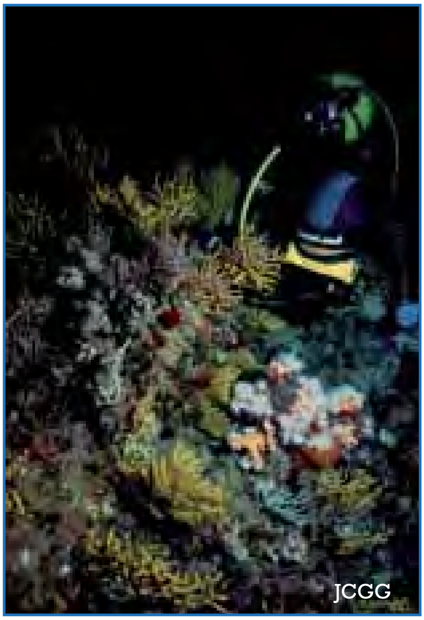
However, this slow-growing species is very sensitive, especially when considering the large sizes its colonies can reach, to dragged anchors and certain fishing techniques that have a major impact by fracturing large pieces. It is also threatened by the unscrupulous actions of certain divers who often capture and remove examples for decorative purposes (given the particular beauty of its calcareous skeleton).

This species is, therefore, very vulnerable and highly endangered, and as such it has been granted various degrees of protection (Giménez-Casalduero *et al*., 2011). It should be monitored by divers who wish to be involved in the environmental surveillance of coastal seabeds.

Environmental protection bodies

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".

Phot. 403



Phot. 404

Phot. 405

11.34. *Leptopsammia pruvoti* Lacaze-Duthiers, 1897

Phot. 406

Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia
Family: Dendrophylliidae
Genus: *Leptopsammia*
Common name: Sunset cup coral

Description

A solitary species of coral, although sometimes its individuals appear to be joined, thus forming a false colony. The polyps have a calcareous, conical base which is slightly smaller than the apex. Polyps have a height of around 2 cm and a diameter of 1.5 cm. Examples are orangey-yellow (**photo 406**). The species has as many as 96 translucent tentacles which are a much lighter yellow than the main body, as shown in the photographs.

Habitat

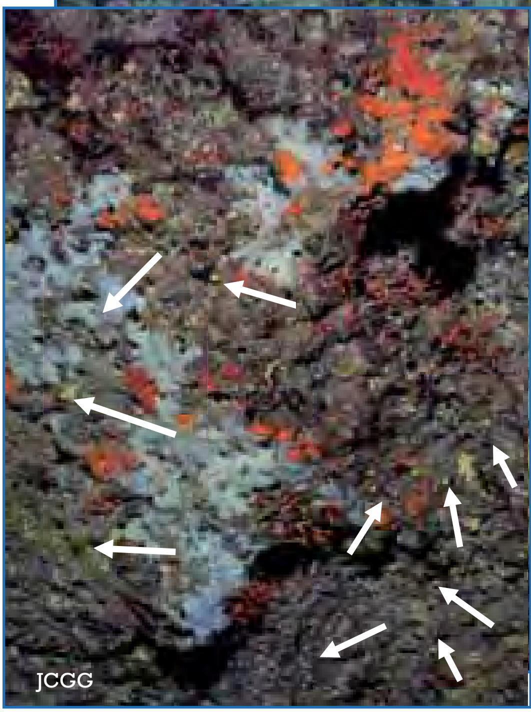
The species settles in well-shaded zones, growing on vertical walls, overhangs, deep crevices and in caves (**photos 407 and 408**). It is characteristic of coralline habitats with a high degree of concretion, spatial organization and biodiversity. Although on rare occasions it can be found in shallow waters, the species is normally encountered from 15 - 20 m down to depths of 150 m.

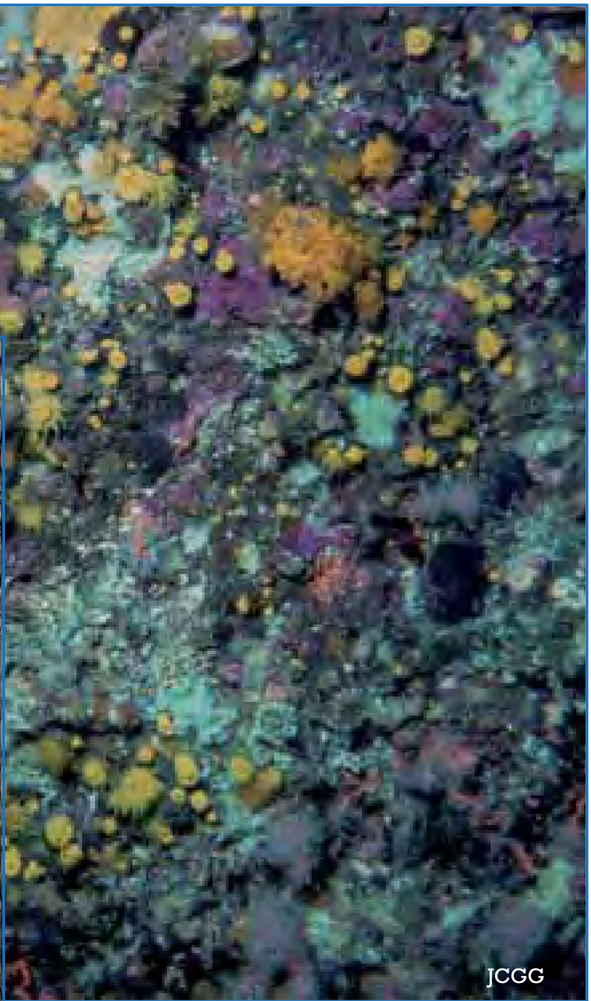
Distribution

It is distributed throughout the whole of the Mediterranean, including the Strait of Gibraltar. Also common to the eastern Atlantic, cited as far north as the British Isles.

Environmental sensitivity

Leptopsammia pruvoti needs clean and well-oxygenated waters to survive (Garrabou, 1997), so it is generally absent from seabeds that experience environmental stress of a physico-chemical nature (García-Gómez, 2007). It is sensitive to sedimentation (Balata *et al.*, 2005) and pollution derived from organic material in the water column, hence it is usually considered to be a species of special interest for environmental surveillance and management programs (Hartnoll, 1998). The species tends to be abundant on the surfaces it manages to colonize, thus it is vulnerable to impacts caused by recreational diving, such as the collection of specimens or damaging blows (Milazzo *et al.*, 2002; Lloret *et al.*, 2006).





Phot. 408

Phot. 407

11.35. *Phyllangia americana mouchezii* (Lacaze-Duthiers, 1897)

Phot. 409

Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia
Family: Caryophylliidae
Genus: *Phyllangia*
Common name: *Little coral* (Spanish name)

Description

A small, encrusting colonial anthozoan species. Each colony is formed by 20 to 40 (or possibly less) translucent, light brown or whitish polyps. The colony has a calcareous skeleton and is composed of a white holdfast strongly anchored to the substrate from which stem 3-cm tall, trunk-like polyps with calcareous bases. (**Photo 409**).

Habitat

Grows over natural rock or the dead skeletons of its own species, on vertical walls or in crevices (**photos 410 - 412).** It prefers shaded environments although it can be found in areas exposed to sunlight. Found from depths of 3 - 30 m.

Distribution

It is common to the Mediterranean including the Strait of Gibraltar. Distribution in the eastern Atlantic extends from Portugal to Senegal.

Environmental sensitivity

The species is usually found in well-conserved, biodiverse zones (Ocaña *et* al., 2000) and is sensitive to disturbances caused by coastal civil works (Moreno and López-Gonzalez, 2008), discharges and pollution, particularly those colonies living in shallower waters. It is also sensitive to threats arising from the ever-increasing number of recreational divers, such as damage caused by flippers or its indiscriminate collection. Furthermore, *Phyllangia americana mouchezii* has been used as an indicator species in studies concerning water temperature rises (Bianchi *et al*., 2012), as it did not appear to be affected by thermal anomalies which caused mass deaths in other cnidarian species (Verdura *et al.*, 2013).

Environmental protection bodies

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".

Phot. 410

Phot. 411

Phot. 412

11.36. *Corallium rubrum* (Linnaeus, 1758)

Phot. 413

Phylum: Cnidaria
Class: Anthozoa
Order: Alcyonacea
Family: Coralliidae
Genus: *Corallium*
Common name: Red coral or precious coral

Description

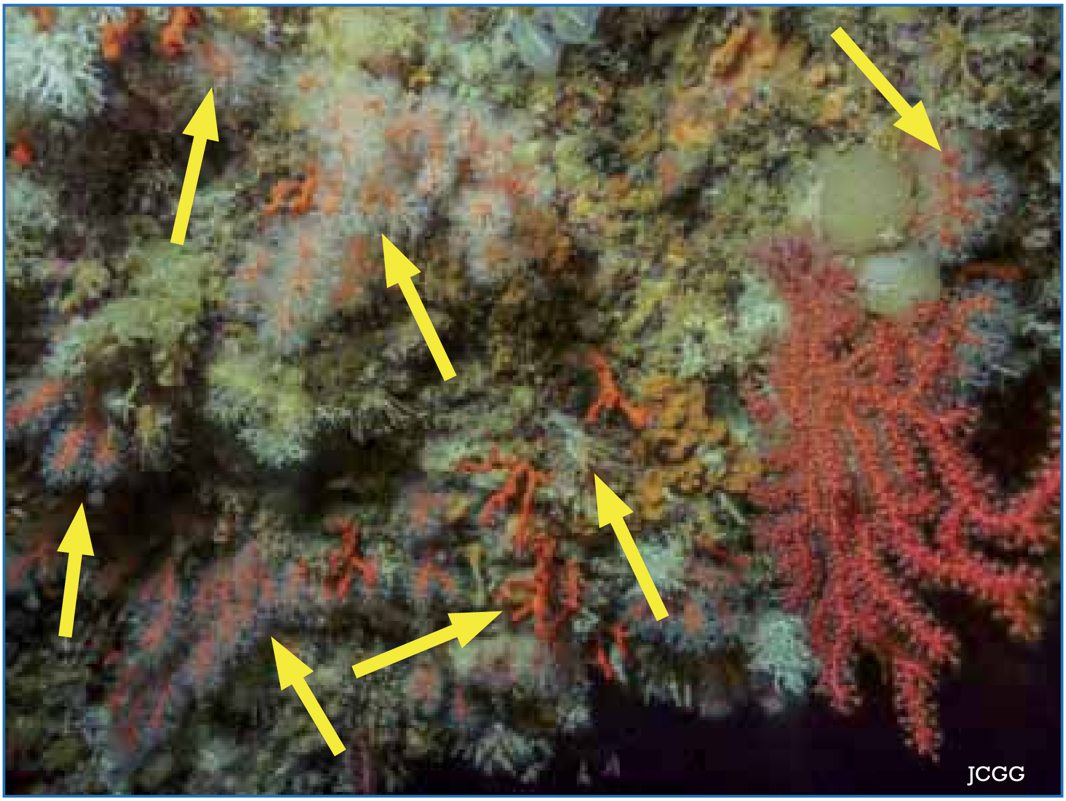
This colonial species is characterized by its rigid, compact, calcareous skeleton. It grows in a treelike form with branches emerging in all directions (**photo 414**, several small colonies indicated with arrows, but avoid confusion with the large, red organism on the left, which is *Paramuricea clavata*). Although colonies can reach up to 50 cm tall, they generally grow to heights of between 4 and 16 cm. It is primarily red (**photo 413**) but it has transparent, whitish polyps that almost completely obscure the red coloration of the "branches" when they are fully protracted, i.e., at maximum extension. In this situation, the overall colony appears almost white, and somewhat translucent, meaning it can easily go unnoticed. In other words, colonies with retracted or extended polyps have a very different appearance, as seen in **photo 415** (inside the circles). **Photos 416 and 417** present a section of a *C. rubrum* colony with retracted polyps (giving it a bright red color) plus the associated shrimp *Ballsia gasti*, this often goes unnoticed thanks to its red coloration that provides perfect camouflage against the coral.

Habitat

The species typically dwells in environments with very little light such as crevices, caves and vertical walls in deep waters, as well as in coralline habitats and rocky communities on the platform. Bathymetrically, it has a range of 10 to 200 m but is generally found below depths of 40 m, making it a rarely observed species.

Distribution

Amply distributed throughout the Mediterranean, including the Strait of Gibraltar. Also found in the eastern Atlantic, from Portugal to Senegal, as well as around the Canary Islands.



Phot. 414

Environmental sensitivity

It lives in well-structured, rocky bottoms that are bathed in clean, rejuvenated waters; the species appears to be sensitive to pollution and any decline in water quality (García-Gómez, 2007). Nevertheless, its main threats derive from large-scale collections by divers or the practice of illegal fishing techniques (Garrabou and Harmelin, 2006). Furthermore, *C. rubrum* is extremely threatened by phenomena associated with climate change, such as increases in water temperature (Garrabou *et al.*, 2001, 2009; Torrents *et al.*, 2008) or acidity (Bramanti *et al.*, 2013). Surveillance of walls of coral should concentrate on areas that the observer can control and where the red coral is abundant, to avoid potential mid-term problems associated with mass extractions, or detachments or breakages in the surrounding fauna (caused by the mechanical action of small picks used to remove specimens). *Corallium rubrum* is the species, of all those included in this guide, which could represent certain difficulties and risks in order to monitor its condition. This is because it is normally found at depths of greater than 40 meters, which exceeds the maximum depth recommended by this guide, thus we only recommend this species for expert divers who have experience diving at depths below this level.

Phot. 415

Notes

Examples have been used in jewelry for thousands of years thanks to its glassy and easily workable consistency. This means it has disappeared from shallow waters and is rare in deeper zones because it is collected both indirectly, using specifically designed techniques, and directly, by diving (which requires significant preparation and professional skill given the depths involved).

Environmental protection bodies

Included in the Barcelona Convention (Annex III: List of species whose exploitation is regulated) and in the Berne Convention (Annex III: protected fauna species).

Included in the EU Council Directive 92/43/EEC (Annex V: Animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".

Phot. 416

Phot. 417

11.37. *Paramuricea clavata* (Risso, 1826)

Phot. 418

Phylum: Cnidaria
Class: Anthozoa
Order: Alcyonacea
Family: Plexauridae
Genus: *Paramuricea*
Common name: Violescent sea-whip

Description

An arborescent gorgonian that grows up to 1 m tall. Its branches divide dichotomously in a single plane forming a fan-like colony. It has a flexible coenenchyme structure. Examples can be dark red or a uniform violet (**photos 418 - 420**), although specimens are also observed with these colors turning yellow at the ends of branches (**photos 421 and 422**). With respect to bicolor colonies, they usually present the contrast of both colors. However, if yellow dominates throughout the colony (**photo 423)** it can give the impression that it is uniquely this color, yet when observed carefully the dark red or violet can always be noted prevailing close to the central axis and basal zone (but never the opposite way round).

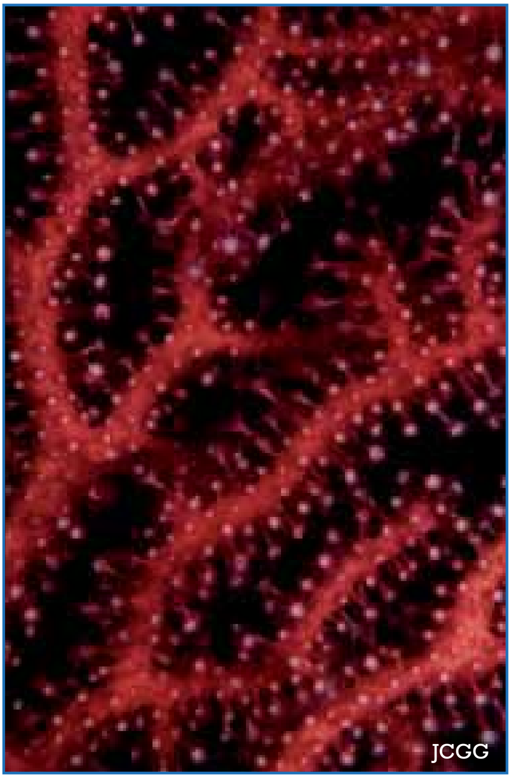
Habitat

Typically found in rocky and semi-shaded seabeds, growing on vertical walls (**photo 426)**, blocks and also shipwrecks. It settles in areas with constant currents and orientates the colonial fan perpendicular to these currents. Found more abundantly in deep waters (30 m) where its density increases to form genuine "forests". It grows slowly, about 1 cm/year, so it requires a long time to reach the maximum height mentioned above (1 m). Normally examples are observed from 15 m (occasionally in shallower waters, on very well-shaded vertical walls) down to 50 m.

Distribution

In the western Mediterranean, including the Alboran Sea and the Strait of Gibraltar.

Phot. 419



Phot. 420

Phot. 421

Phot. 422

Environmental sensitivity

Paramuricea clavata is sensitive to marine pollution and temperature increases. It is particularly sensitive to increasing levels of organic load (García-Gómez, 2007). An excellent indicator species for monitoring coastal water quality because its distribution depends on a narrow range of requirements for environmental conditions (Linares *et al.*, 2008). Nevertheless, large colonies (**photo 424**) can usually tolerate, assuming it is not a prolonged event, the trial of excessive sedimentation derived from the overflow of aggregate extraction dredging operations which are occasionally carried out in the littoral zone. But this is not the case for smaller colonies (**photos 425**) which are more vulnerable because they have fewer polyps and are closer to the substrate. On the other hand, climatic anomalies, such as abnormal heating of the water column in a short period of time (generally associated with climate change), produce mass death events in this species, thus demonstrating its vulnerability to such phenomena (Perez *et al.*, 2000; Ballesteros, 2006; Garrabou *et al.*, 2009; Lejeusne *et al.*, 2010).

The species can be monitored with particular ease, not only thanks to the size and color of the colonies, but also because they are perfectly recognizable on specific vertical walls where colonies can be individually marked and monitored.

Phot. 423

Phot. 425

Phot. 424

Notes

Small colonies can be mistaken for red coral (*Corallium rubrum*), with the difference lying in the color of their polyps (whitish in red coral, when extended) and the overall shape of their colonies (*P. clavata* is fan-like, but red coral is treelike).

Phot. 426

Environmental protection bodies

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".

11.38. *Parazoanthus axinellae* (Schmidt, 1862)

Phot. 427

Phylum: Cnidaria
Class: Anthozoa
Order: Zoantharia
Family: Parazoanthidae
Genus: *Parazoanthus*
Common name: Yellow encrusting anemone

Description

A yellow and orange species of colonial anemone (**photo 427**). Each polyp has between 28 and 32 tentacles arranged in two circles. Colonies grow to heights of 2 to 3 cm, while they can cover a varying surface area, including large extensions, depending on the amount of substrate available. The polyps are very close together and sometimes arranged in lines or groups.

Habitat

The species covers rocky substrates in shaded environments, equally comfortable on walls, cave floors and growing over other organisms (**photo 433**). Frequently observed in association with sponges from the genus *Axinella*. While on rare occasions it can be observed in shallow waters (at 5 - 10 m in well-shaded enclaves), it is normally found at depths of at least 20 meters and has even been cited at below 300 meters.

Distribution

Distributed throughout the Mediterranean and eastern Atlantic, from the British Isles to the coasts of Africa, including the Strait of Gibraltar.

Environmental sensitivity

Requires clean and rejuvenated waters, thus it is a good indicator of waters with these conditions (Garrabou, 1997; Ocaña *et al.*, 2000; Burton *et al.*, 2008). The species is very susceptible to excessive sedimentation caused by dredging operations (García-Gómez, 2007), especially if the colonies are located on horizontal surfaces (Balata *et al.*, 2005), as illustrated by the series of images in **photos 428 - 432.** Significant reductions or the complete disappearance of their colonies in a specific part of the littoral could be a sign of a disturbance event (Cerrano *et al.*, 2006), in which case it should be characterized and its origins determined.

Phot. 428

Phot. 429

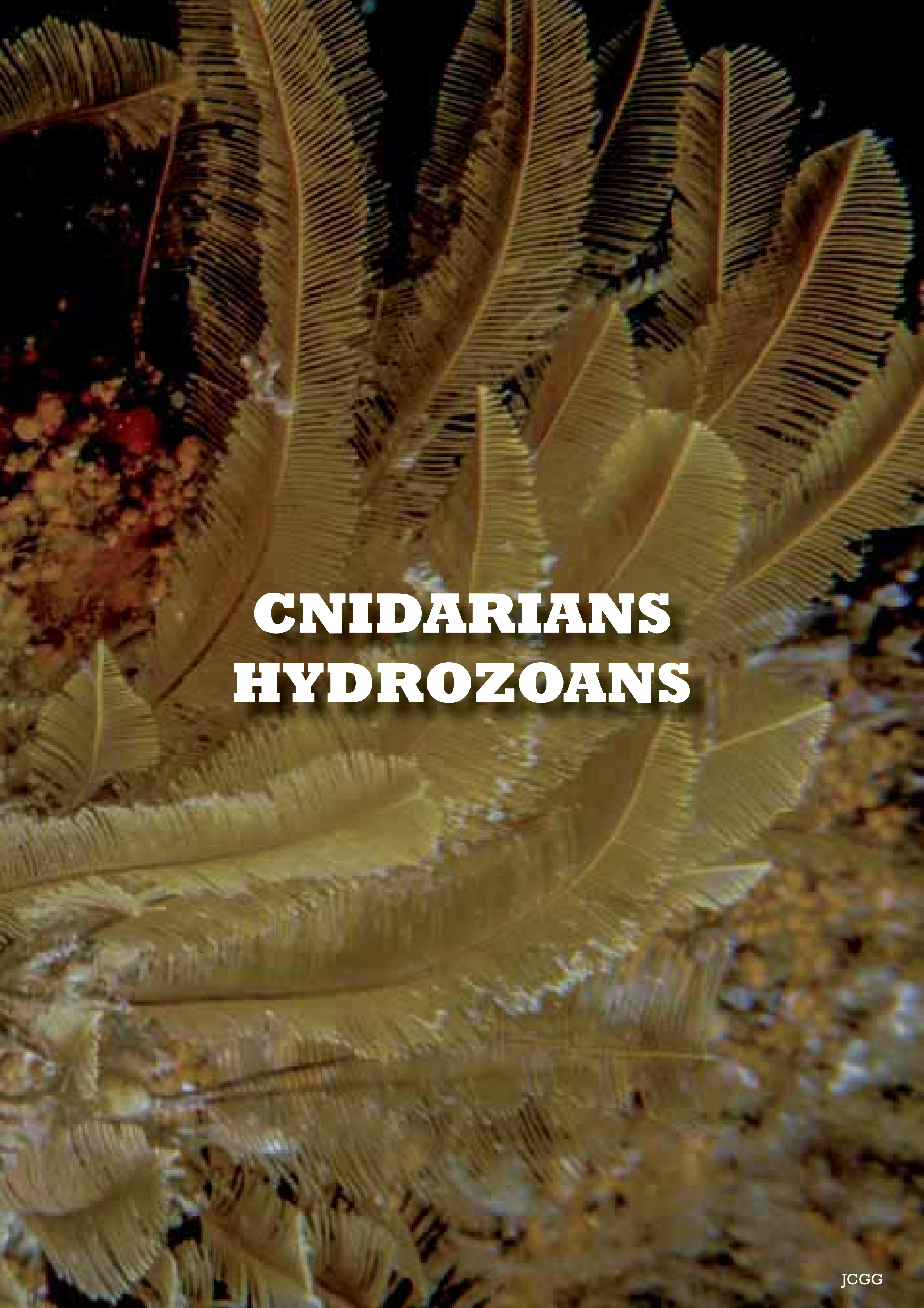
Phot. 430

Phot. 431

Phot. 432

Phot. 433

CNIDARIANS
HYDROZOANS



JCGG

11.39. *Aglaophenia spp.* Lamouroux, 1812

Phot. 435

Phylum: Cnidaria
Class: Hydrozoa
Order: Leptothecata
Family: Aglaopheniidae
Genus: *Aglaophenia*
Common name: None

Description

This hydroid forms feathery colonies, of between 3 and 15 cm, with a yellowish thallus (hydrocaulus) from which branches emerge in a single plane. Sheathless polyps are arranged along the branches. (**Photos 435 and 436**).

Habitat

Species of the genus *Aglaophenia* colonize rocky floors and substrates, preferably in shaded locations, such as cave entrances or crevices. The majority of Mediterranean species of *Aglaophenia* are typically found in deep waters starting in the circalittoral, particularly in zones with strong currents.

Distribution

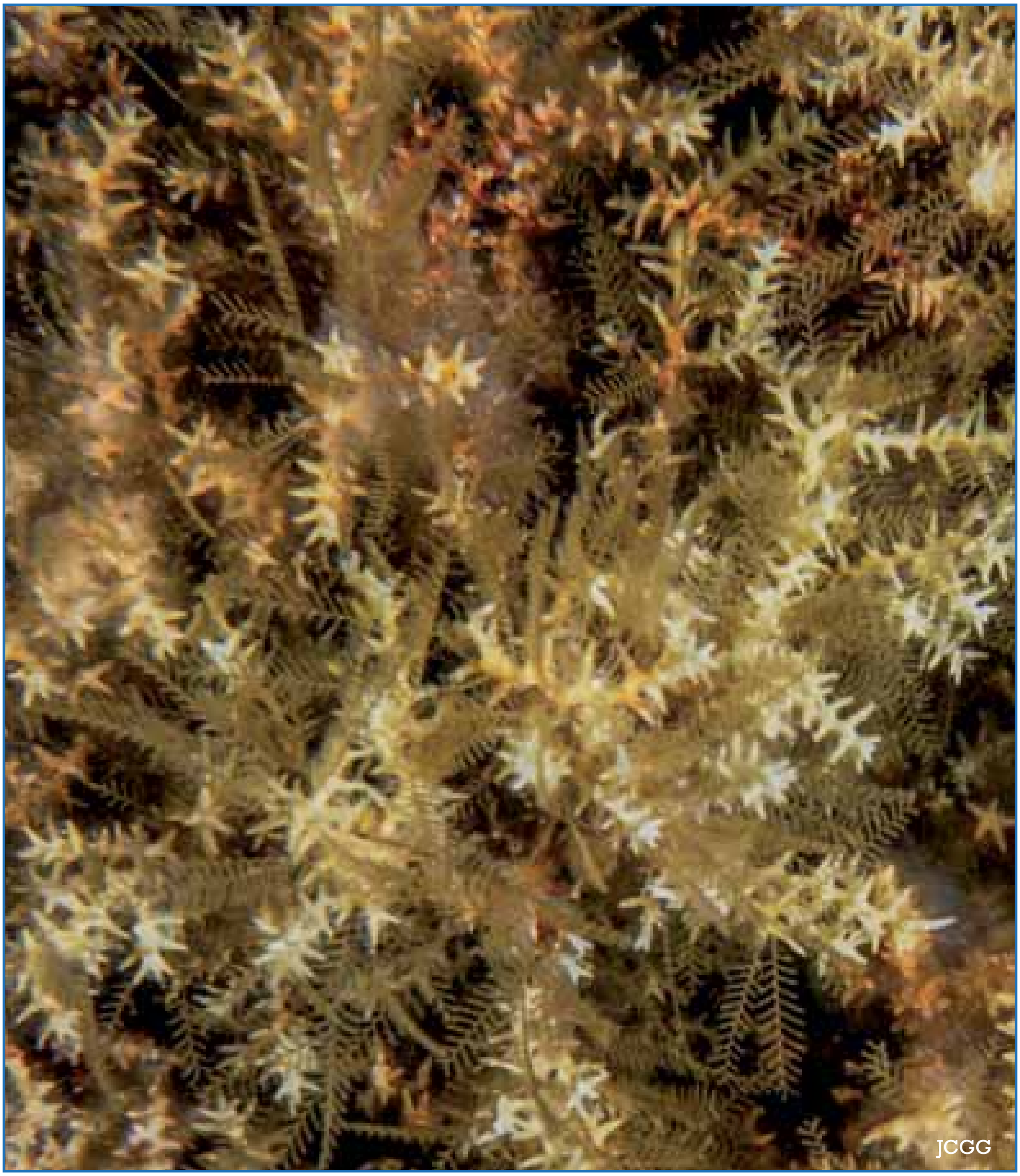
Mediterranean and Atlantic.

Environmental sensitivity

Species belonging to this genus demonstrate sensitivity to wastewater pollution (Arévalo *et al.*, 2007; Pinedo *et al.*, 2007). Their presence has also shown a negative correlation with turbidity (Urkiaga-Alberdi *et al.*, 1999).

Notes

We can highlight *Aglaophenia picardi, A. pluma, A. kirchenpaueri,* and *A. octodonta* as among the most frequently observed species.



Phot. 436

11.40. *Gymnangium montagui* (Billard, 1912)

Phot. 437

Phylum: Cnidaria
Class: Hydrozoa
Order: Leptothecata
Family: Aglaopheniidae
Genus: *Gymnangium*
Common name: Yellow feathers

Description

This colonial Hydrozoa takes on a typical feather-like form, growing to almost 10 cm tall and 2 cm wide. Each colony comprises a single axis from which emerge slender branches with no further divisions. Branching occurs in just one plane giving the colony the appearance of a feather. Examples are a light to dark chestnut. (**Photos 437 - 439**).

Habitat

Settles on rocky bottoms, for example overhangs and vertical walls. Also grows over other organisms, such as sponges, algae, bivalves and other hydrozoans. Inhabits a range from 10 to 40 m.

Phot. 438

Distribution

Throughout the eastern Atlantic, extending from the British Isles all the way to the coasts of South Africa. Also found in the Strait of Gibraltar.

Environmental sensitivity

This species' abundance decreases until its disappearance according to geographical areas of gradient, from external zones, with turbulent and rejuvenated waters, to internal ones, with less hydrodynamism and greater anthropogenic pressures, such as, turbidity, organic load, etc. (author's personal observations).

Phot. 439

11.41. *Pseudoplumaria marocana* (Billard, 1930)

Phot. 440

Phylum: Cnidaria
Class: Hydrozoa
Order: Leptothecata
Family: Plumulariidae
Genus: *Pseudoplumaria*
Common name: None

Description

Colonies have a thick, polysiphonic (several central tubes) and highly branched stem that grows up to 22 cm long. Branching occurs in a single plane, with either an opposite or irregular distribution. There are two longitudinal rows of small nematothecae running parallel to the axial tubes (**photo 440**). Easily confused with *Polyplumaria flabellata*.

Habitat

They have been observed in the Strait of Gibraltar, at depths of 25 to 50 meters. Found in shaded zones adhering to large blocks of rock and occasionally loose stones. (**Photos 441 and 442**).

Phot. 441

Distribution

In temperate and tropical waters of the eastern Atlantic. Found in the Strait of Gibraltar and the Bay of Algeciras.

Environmental sensitivity

Pseudoplumaria marocana has been included in this guide as an indicator of adverse environmental conditions based on the author's personal observations.

Phot. 442

11.42. *Sertularella spp.* Gray, 1848

Phot. 443

Phylum: Cnidaria
Class: Hydrozoa
Order: Leptothecata
Family: Sertulariidae
Genus: *Sertularella*
Common name: None

Description

Species in this genus of hydrozoans form colonies of up to 6 cm tall, with branches growing in a single plane and polyps arranged alternately. The polyps are contained within thecas (sheaths) (**photos 443 and 444**). Due to the large degree of variation between the species in this genus there are no specific characteristics to help clearly differentiate one from another.

Habitat

Sertularella spp. are found in shaded areas growing on exposed rocks (**photos 445 - 447**), banks of mussels or even on buoys. They also colonize other invertebrate colonies, e.g., gorgonians.

Distribution

There are numerous species in the Mediterranean, including some endemic species, e.g., *Sertularella crassicaulis*.

Phot. 444

Environmental sensitivity

Mediterranean species from the genus *Sertularella* can generally be considered as indicators of adverse environmental conditions; this is based on the author's personal observations that the species' abundance decreases until its disappearance according to geographical areas of gradient, from external zones, with turbulent and rejuvenated waters, to internal zones, with less hydrodynamism and greater anthropogenic pressures. *Sertularella cylindritheca* and *S. gayi* are particularly sensitive species. While *S. ellisii* and *S. mediterranea* exhibit less sensitivity. And at the opposite end of the scale, *S. polyzonias* is considered to be tolerant.

Phot. 445

Phot. 446

Phot. 447

BRYOZOANS

JCGG

11.43. *Adeonella calveti* (Canu y Bassler, 1930)

Phot. 449

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Adeonellidae
Genus: *Adeonella*
Common name: *Moose antler* (Spanish name)

Description

Forms densely-branched, erect, rigid and fragile colonies with orangey coloration that can reach 10 cm high. The branches are flat, measure 2 mm wide by 0.5 mm thick and have rounded tips (**photo 449**). Individual zooids are diamond-shaped.

The species is easily confused with *Smittina cervicornis*, which forms colonies of very similar shapes and colors, but *S. cervicornis* has less dense ramification and lighter colors. If the zooids can be discerned, then the two species are easily distinguished: *Adeonella calveti* has clearly rhomboid zooids, while those of *S. cervicornis* appear as elongated, almost rectangular, hexagons.

These two species are unrelated and so the similarity of their colonies is a very notable example of convergent evolution.

Habitat

It is present in walls, cavities and overhangs at depths of 5 to 50 m in well-conserved coralline habitats (**photo 450**), commonly associated to areas of gorgonians. Given the fragility of its branches, the species preferentially settles in sheltered environments.

Distribution

Considered endemic throughout the Mediterranean, but it is also found in coasts around the Gulf of Cadiz.

Environmental sensitivity

Adeonella calveti prefers clean and relatively calm waters, since the stiffness and fragility of its branches mean it is sensitive to elevated degrees of hydrodynamism. Divers should avoid touching or collecting examples as colonies break very easily. The species' sensitivity to pollution has also been recorded (Harmelin and Capo, 2002).

The visually very similar species, *Smittina cervicornis*, is more tolerant and can be found in zones with high degrees of sedimentation, as long as the hydrodynamism is not so strong as to break its branches.

Phot. 450

11.44. *Bicellariella ciliata* (Linnaeus, 1758)

Phot. 451

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Bugulidae
Genus: *Bicellariella*
Common name: None

Description

Colonies grow to 6 cm tall, have a glassy white color, and are branched and very flexible given the low degree of calcification. The zooids have long, soft, threadlike spines, giving colonies the appearance of cotton wool balls (**photos 451 and 452**).

Habitat

They are distributed from intertidal zones down to 140 m. In the Mediterranean, they have particularly been cited in shallow waters together with photophilic algae.

Examples can be found in rocky intertidal zones growing on the roofs of cavities which are exposed to the air for a short time during low tide, as long as it is sheltered from the sun and can conserve moisture.

Its preference for this type of substrate indicates that the species is sensitive to sedimentation but tolerates high levels of hydrodynamism.

Distribution

Very widely distributed throughout the Atlantic, that the Indian and parts of the Pacific Ocean, also common across the Mediterranean.

Environmental sensitivity

Tends to inhabit biodiverse environments in good condition, but, like the majority of bryozoans, its ecological requirements have not been studied in any detail and no specific threats are known other than those affecting its typical habitats (author's personal observations).

Phot. 452

11.45. *Caberea boryi* (Audouin, 1826)

Phot. 453

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Candidae
Genus: *Caberea*
Common name: None

Description

Colonies form in semicircular fans just 2 cm tall, with dichotomously divided branches measuring approximately 0.5 mm wide (**photos 453 and 454**). It is primarily an orangey color, although it can present greenish tones. Branches appear to be covered with hairs due to an abundance of organs called vibracula which consist of long, articulated, mobile chitinous hairs that the colony uses to clean away adhering particles.

Habitat

Lives on hard bottoms at depths ranging from the low-tide line to 100 m, although it is most abundant at 20 - 60 m. Prefers zones with low or moderate hydrodynamism. It is frequently observed in association with other organisms, such as gorgonians, hydrozoans, sponges, ascidians and other bryozoans, over which it often grows as an epibiont (Zabala, 1986; Hayward and Ryland, 1998). This preference for developing in association with other organisms means it is more abundant in highly-diverse environments.

Distribution

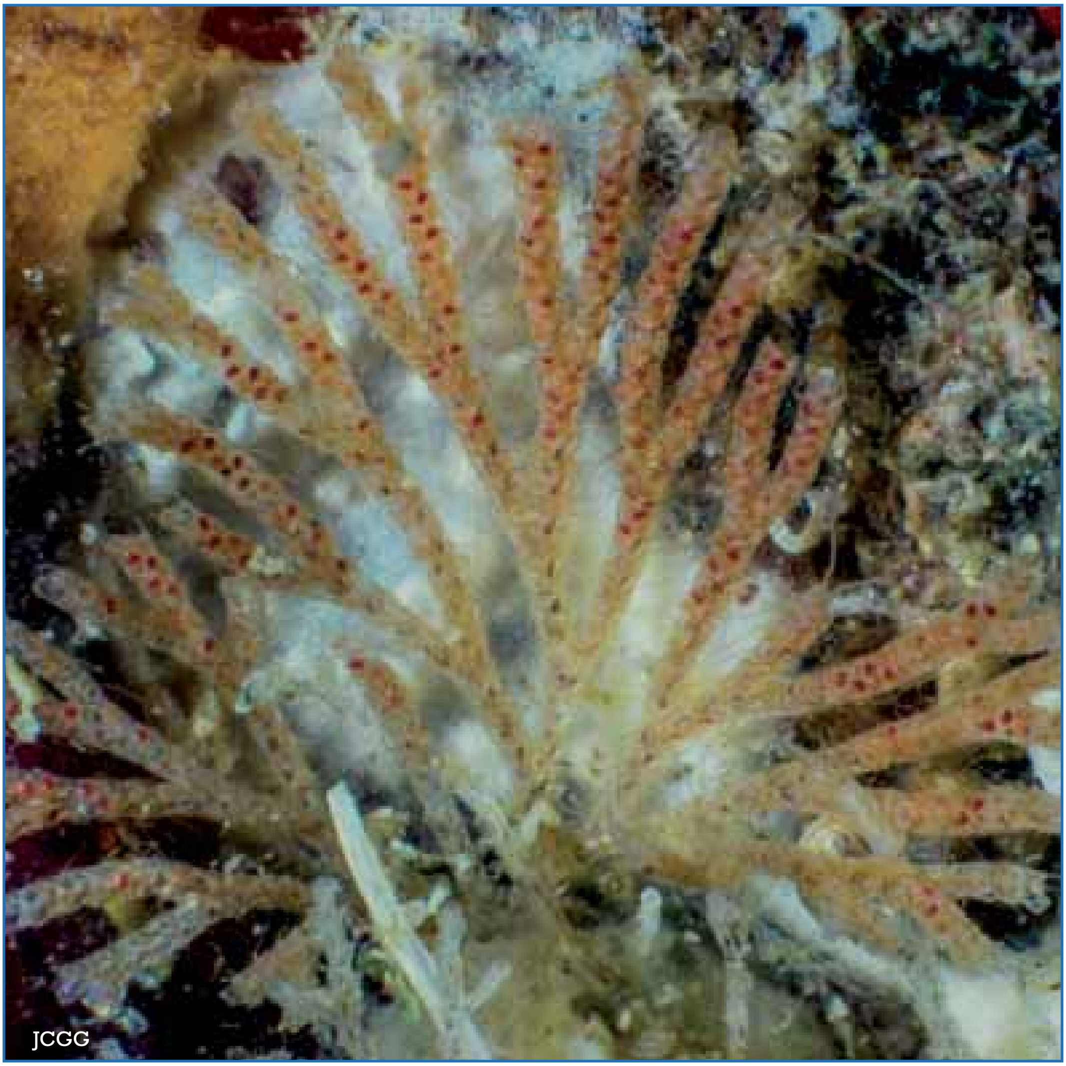
Broadly distributed in temperate and warm waters of the Atlantic, Mediterranean and Indo-Pacific.

Environmental sensitivity

There is no detailed knowledge of its requirements, but is not seen in deteriorated areas (author's personal observations).

Notes

The size of this species means it can be confused with certain species from the *Bugula* genus, the distinguishing feature being *C. boryi's* spiral shape.



Phot. 454

11.46. *Cellaria spp.* Ellis y Solander, 1786

Phot. 455

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Cellariidae
Genus: *Cellaria*
Common name: None

Description

Colonies have an ivory-white color and can easily grow to 5 or 6 cm (or more in the case of *Cellaria sinuosa*), they are erect, flexible and dichotomously branched (**photos 455 and 456**). The branches have long, well calcified, cylindrical internodes with dark, flexible, chitinous joints, which facilitate their identification. The internodes vary from 5 to 10 mm long, with a thickness of slightly less than 1 mm. When the colony is fertile, the ends of the internodes swell due to the large number of incubation chambers that develop in this area.

Zooids are rhomboid or elongated hexagons, but they are difficult to observe when diving as they are never more than 0.5 mm big. Colonies anchor to the substrate via chitinous rootlets.

Cellaria fistulosa and *C. salicornioides* are difficult to distinguish without specialized optical equipment, but *C. sinuosa*, which is less common and found at greater depths in Spanish coastal waters, can be differentiated from the other two as it is a more robust species, with internodes that tend to exceed 10 mm long and 1 mm thick.

Habitat

The three species are common on walls rich in fauna, mixed with other sessile organisms and often as epibionts of gorgonians and other erect invertebrates (Zabala, 1986).

They can also be found, at least in the case of *Cellaria fistulosa*, on soft substrates if the larvae settle on a hard object, such as the remains of a shell or a small stone (Zabala, 1986).

Cellaria fistulosa and *C. salicornioides* can be found in the first 100 m, being very common at depths of around 20 m, and so they may easily be observed while diving. *C. sinuosa*, however, prefers colder waters and is found at greater depths around Spanish coasts, generally deeper than 50 m (Zabala, 1986; Hayward and Ryland, 1998).

Distribution

The three species coincide around Iberian coasts and in the Mediterranean, but while *Cellaria fistulosa* and *C. sinuosa* are distributed towards the north of Europe, being common around the British Isles and in the North Sea, *C. salicornioides* is more typical of warmer waters, primarily distributed around the Iberian Peninsula and western Africa, although there are examples cited off the south coasts of Great Britain (Cook, 1967; Zabala, 1986; López de la Cuadra and García-Gómez, 1996; Hayward and Ryland 1998).

Environmental sensitivity

The environmental sensitivity of these species has not been studied in detail. *Cellaria sinuosa* and *C. salicornioides* apparently need good quality water and are not found in seriously deteriorated zones. *C. fistulosa* seems to be the most tolerant, given its abundant presence has been cited in areas of moderate sedimentation influenced by river outflows, and examples have been found in some internal areas of the Bay of Algeciras, but always in locations with a relatively low degree of sedimentation. The other two species appear to have stricter requirements. In any case, none of them are found in seriously deteriorated areas.

Phot. 456

Notes

Three species from the genus *Cellaria* have been cited on the coasts of Andalusia, *C. fistulosa, C. salicornioides* and *C. sinuosa*, although this last example is seldom encountered while diving due to its preference for colder waters (it is more typical in northern Europe) which are found at depths of over 50 m around Spanish coasts. Due to the difficulty in distinguishing the different species while diving they shall be dealt with collectively.

11.47. *Chartella spp.* Gray, 1848

Phot. 457

Phylum: Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Flustridae
Genus: *Chartella*
Common name: None

Description

Colonies of this genus have an appearance that botanists call "flustriform" (derived from *Flustra*, a similar genus not found in Andalusia), which consists of highly-branched, flexible, flat laminae with the appearance and consistency of paper (**photos 457 and 458**). The two species considered (*Chartella tenella* and *C. papyracea*) have an ivory color. The branches of *Chartella papyracea* are somewhat finer than those of *C. tenella* and have rectangular ends, while the tips of the latter species are more rounded. They can grow to over 10 cm and are composed of rectangular zooids approximately 0.5 mm long and 0.25 mm wide.

Although flustriform colonies exist all over the world, represented by various genera and a significant number of species, they are not very common in Andalusia. These two species are the only ones to be commonly cited in this form, although there are others that have been observed less frequently, such as *Hincksinoflustra octodon*. Therefore, any divers who observe a flustriform colony have more than likely found one of the two species mentioned here.

Habitat

They preferably inhabit sheltered, rocky zones: walls, cavities, overhangs and underneath stones down to depths of 100 m, sometimes even found in the intertidal zone growing in deep hollows where they may be exposed to air as long as they are sheltered from the sun and can conserve moisture. They have been cited as commonly growing on walls of gorgonians and other environments of high diversity.

Distribution

Both species converge almost uniquely around the coasts of Andalusia, given that *Chartella papyracea* is indigenous to the European Atlantic and *C. tenella* is considered to be endemic of the Mediterranean.

Environmental sensitivity

As with the majority of the bryozoans, environmental aspects of these species have not been investigated. However, they are found in highly-diverse and undisturbed environments which means they could be good indicators.

There are no specific threats known except for the general deterioration of the well-conserved environments which they inhabit.

Notes

Two species from this genus have been cited on the coasts of Andalusia: *Chartella tenella* and *C. papyracea*. Both present very similar shapes and colors, making them difficult to identify while diving.

Phot. 458

11.48. *Reteporella spp.* Busk, 1884

Phot. 459

Phylum Bryozoa
Class: Gymnolaemata
Order: Cheilostomatida
Family: Phidoloporidae
Genus: *Reteporella*
Common name: Venus' Lace or Neptune's Lace

Description

Species from the genus *Reteporella* have an unmistakable appearance. They are rigid, fragile colonies composed of finally perforated laminae (**photo 459**), with some species reaching over 10 cm tall. Although certain species in the genus grow in an arborescent form and not as laminae, they are less common and found at considerable depths, thus the species which can be observed while diving correspond to the general laminar form mentioned above.

Habitat

Found inhabiting well-conserved environments, habitually in coralline bottoms, walls of gorgonians and generally in sites of broad diversity (**photo 460**). The depth varies according to species. *Reteporella grimaldii*, which forms relatively large colonies in depths of up to 50 m, is one of the easiest to observe while diving. It is also found among meadows of *Posidonia*.

Distribution

The genus is distributed throughout the world, represented by many species, from the poles to the tropics. *Reteporella grimaldii* is found in the Atlantic and the Mediterranean.

Environmental sensitivity

Species belonging to the genus *Reteporella* require clean waters, with a low to moderate level of hydrodynamism. The fine perforations on its colonies importantly allow water to circulate and provide the zooids with food, hence a high level of sedimentation could block the pores and would be lethal for the colony. The species have also been recognized as pollution sensitive (Harmelin and Capo, 2002).

The colonies' fragility means they are sensitive to knocks and in habitual diving zones they can suffer damage (Guarnieri *et al.*, 2012). Furthermore, some divers collect them for ornamental purposes, a practice which must be eradicated.

Environmental protection bodies

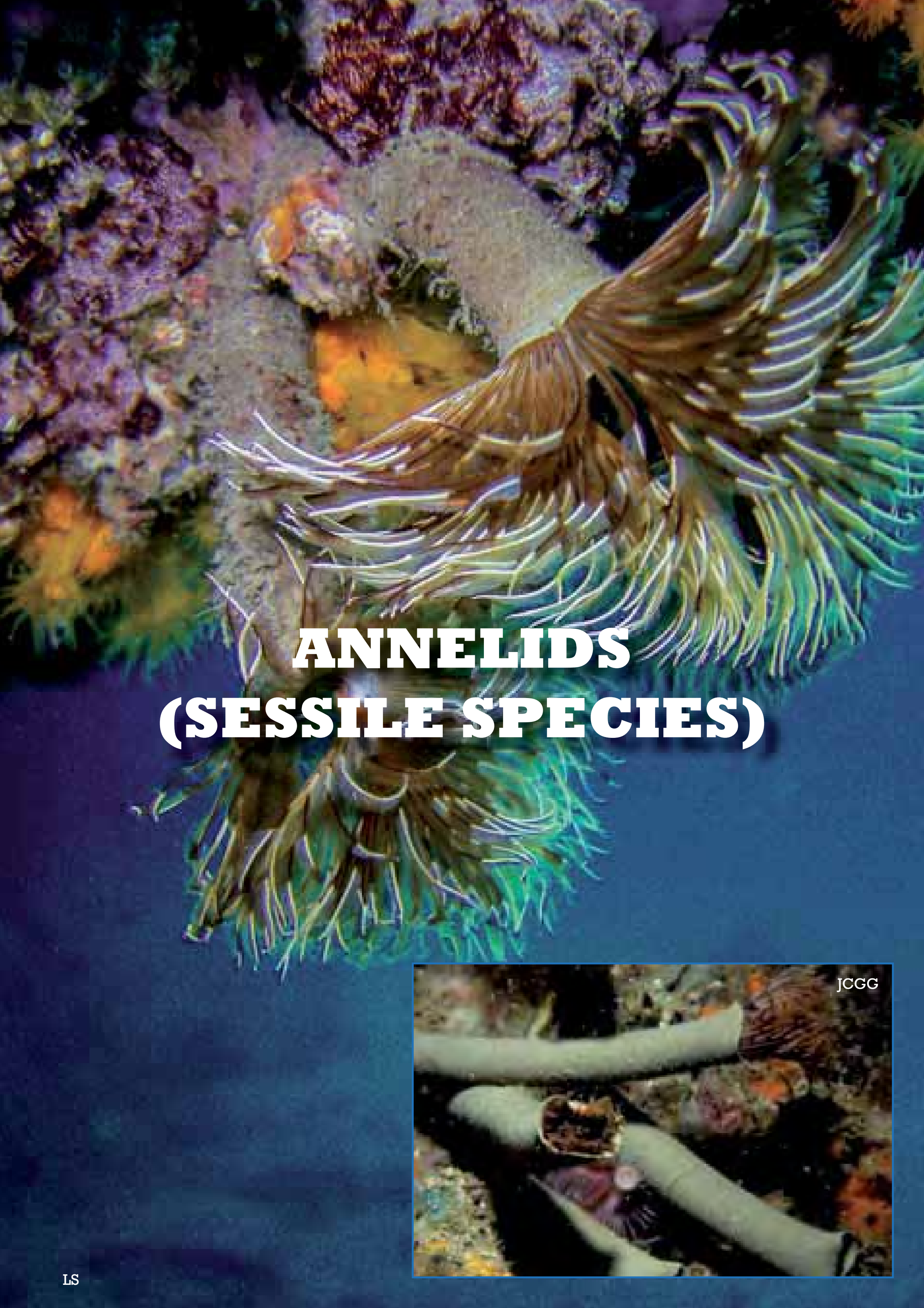
Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Lesser Risk".

Notes

It is very difficult to differentiate the different species of *Reteporella* without using advanced optical equipment, hence this guide presents them collectively. The most familiar to Spanish coasts is *R. grimaldii*, which was until recently known as *R. septentrionalis*. For a long time this genus was called *Sertella*.

Phot. 460

ANNELIDS (SESSILE SPECIES)



LS

JCGG

11.49. *Bispira volutacornis* (Montagu, 1804)

Phot. 463

Phylum: Annelida
Class: Polychaeta
Order: Sabellida
Family: Sabellidae
Genus: *Bispira*
Common name: Twin fan worm

Description

This worm has a cylindrical body, although slightly flattened along the ventral side, measuring 15 cm long and 1 cm wide. The body varies between grayish-green and purplish-brown. It has some yellow, brown or purplish-whitish filamentous extensions at the top that form a crown. The animal can withdraw this crown inside the tube where it dwells, which is formed from mucus secretions and fine sedimentary particles, and has a figure-of-eight shaped opening. (**Photo 463**).

Habitat

This species lives on well-lit or semi-shaded, rocky bottoms where there is a certain degree of hydrodynamism. Several individuals may appear together. Inhabits intertidal pools and depths down to 30 m.

Distribution

In the eastern Atlantic, from the south of Norway to the south of the Iberian Peninsula. Also throughout the Mediterranean.

Environmental sensitivity

This species has only been cited in areas with low levels of sedimentation and organic load (Carvalho *et al.*, 2006).

MOLLUSCS (SESSILE SPECIES)

JCGG

11.50. *Dendropoma petraeum* (Monterosato, 1884)

Phot. 465

Phylum: Mollusca
Class: Gastropoda
Order: Littorinimorpha
Family: Vermetidae
Genus: *Dendropoma*
Common name: None

Description

This gastropod has a somewhat irregular shell, shaped like a tube that has been rolled into a spiral. The tube can measure up to 0.5 cm in diameter. The species forms compact aggregates with calcareous algae, such as dense multi-perforated and very well cemented formations (**photo 465**). This species can be confused with another vermetidae, *Vermetus triquetrus*, but this latter species has a shell with a slightly triangular cross-section, a longitudinal dorsal crest and does not form compact aggregates.

Habitat

Inhabits well-lit, rocky bottoms and locations with strong or moderate hydrodynamism. It is intertidal and subtidal (it lives below the low-tide line, in the area where waves break, sometimes remaining exposed to the air), down to depths of 5 meters. Only found in clean waters. The species forms dense aggregates together with encrusting calcareous algae *Neogoniolithon brassica-florida*, formerly known as *Spongites notarisii* (**photo 466**), and *Mesophyllum alternans,* formerly known as *M. lichenoides* (**photos 467 - 469**). These aggregates yield some calcareous conglomerates in various forms (frequently in the shape of crests or cornices measuring 20 - 30 cm thick) which in some cases are considered to be micro-reefs. The aggregates can also establish themselves on patelliform, or dish-shaped, shells (limpets and similar forms) (**photo 470**).

Distribution

In the western Mediterranean, including the Strait of Gibraltar, which appears to be the western limit of its distribution.

Phot. 466

Phot. 467

Phot. 468

Phot. 469

Environmental sensitivity

A species of narrow ecological valence that is very sensitive to pollution (García-Gómez, 2007; Ibrahim, 2009) and sedimentation. It is threatened by coastal deterioration (Fernández-Torquemada *et al.*, 2005; Schembri *et al.*, 2005), the footsteps of bathers and people passing over seashore rocks, and above all by oil slicks and surface contamination (Moreno, 2008). *Dendropoma petraeum* has a high ecological value (Sfriso and Facca, 2011) since the biostructures which it forms help to protect rocks from erosion. Formations of this species are in themselves habitats that facilitate the coexistence of other species of associated invertebrates.

As we already highlighted for *Astroides calycularis*, the fact that *D. petraeum* is an excellent indicator of clean waters, while also being protected, converts it into a species of choice for any environmental surveillance initiative seeking to protect the coastal seabeds it inhabits, whether at a scientific, technical or voluntary level.

Notes

A species of high ecological value because of the biostructures it forms which help to protect rocks from erosion. The crest formations also help to generate new habitats by retaining seawater and creating pools. Finally, it is worth highlighting that these formations are in themselves a habitat, providing a home to numerous invertebrate species.

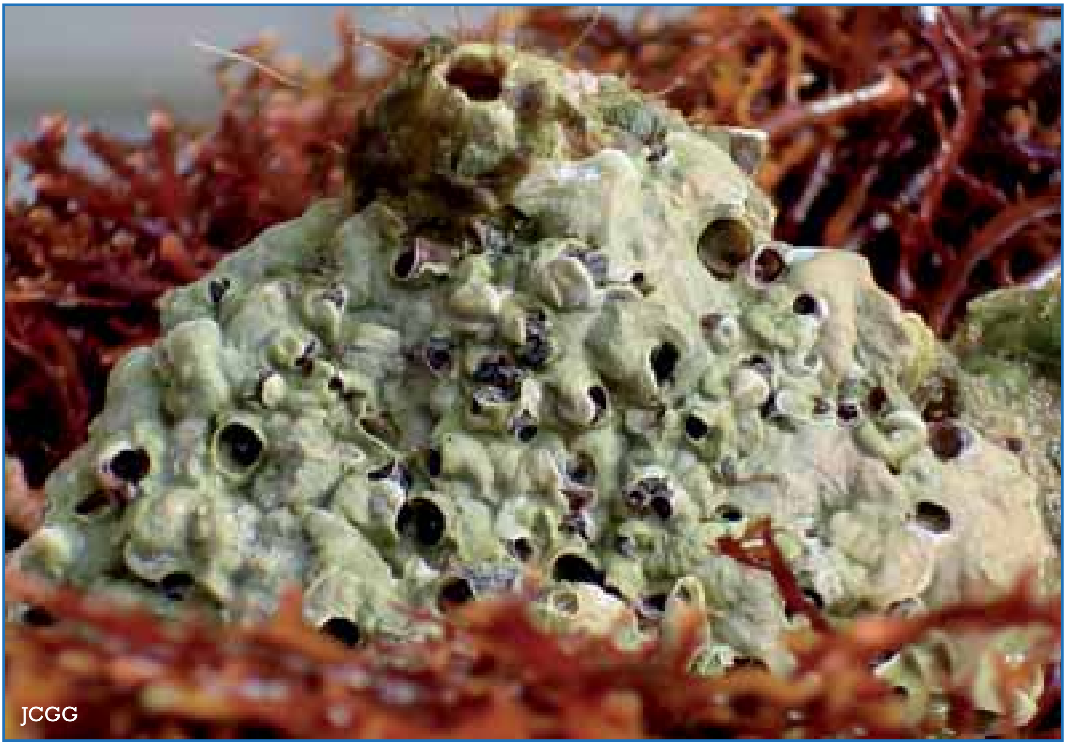
Environmental protection bodies

Included in the Barcelona Convention (Annex II: List of endangered or threatened species) and in the Berne Convention (Annex II: strictly protected fauna species).

Included in the Spanish Catalogue of Threatened Species, under the category "Vulnerable".

Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".



Phot. 470

11.51. *Pinna nobilis* Linnaeus, 1758

Phot. 471

Phylum: Mollusca

Class: Bivalvia

Order: Pterioida

Family: Pinnidae

Genus: *Pinna*

Common name: Noble pen shell, Fan mussel, Sea-wings or Wing-shell

Description

This bivalve has a triangular shell, shaped like the keel of a boat (**photo 471**), one side is very acute while the opposite side is round and fragile. The valves have a brown coloration on the external surface while the inside is pearlescent, yellowish-orangey and iridescent. The surface is covered by fine radial ribs, with wavy growth lines, and can be coated by epibionts, such as gorgonians and algae or sponges. Examples can reach almost 100 cm tall and 30 cm wide, making it not only the largest bivalve in the Mediterranean but also the largest shelled mollusk in this sea.

Habitat

The species lives in sandy, muddy or detritic bottoms, also among patches of marine phanerogams. It anchors to the substrate by means of some vertical threads, usually around one third of the shell is buried although in some areas where the water is very turbulent this portion can be greater. It has been noted that young individuals are more abundant in shallow waters, whereas adults appear in deeper zones. Found from depths of 2 - 60 m.

Distribution

A species endemic to the Mediterranean Sea, although there are some isolated populations in the Bay of Biscay, and there are also citations in the Atlantic coasts of Morocco and Portugal.

Environmental sensitivity

Many of its populations have suffered a major decline in the number of individuals, mainly due to the progressive destruction of its habitats (Rabaoui *et al*, 2008) and its sensitivity to marine pollution (García-Gómez, 2007; Katsanevakis and Thessalou-Legaki, 2009; Guallart and Templado, 2012; Sureda *et al.*, 2013). Furthermore, divers collect specimens for decorative purposes and it suffers the direct threat from anchors and trawler nets which tend to fish illegally in areas inhabited by this species (Addis *et al.*, 2009). Even though the species prefers clean waters and undisturbed bottoms (García-Gómez, 2007), its low frequency means it cannot be used in surveillance programs concerned with environmental water quality. Nevertheless, given its size and sedentary nature, *Pinna nobilis* is easily monitored by divers who frequently dive in areas where it is present.

Environmental protection bodies

Included in the Barcelona Convention (Annex II: List of endangered or threatened species) and in the Berne Convention (Annex II: strictly protected fauna species).

Included in the EU Council Directive 92/43/EEC (Annex V: Animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures).

Included in the Spanish Catalogue of Threatened Species, under the category “Vulnerable”.

Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category “Vulnerable”.

11.52. *Pinna rudis* Linnaeus, 1758

Phot. 472

Phylum: Mollusca
Class: Bivalvia
Order: Pterioida
Family: Pinnidae
Genus: *Pinna*
Common name: Rough penshell

Description

This bivalve has a thin, fragile triangular shell in the form of a boat's keel. It can grow to 40 cm tall. The surface has between 5 and 8 radial ribs, these are quite marked with several tubular scales which are longer at the edges. It is pinky-brown and generally presents encrustations of bryozoans and calcareous algae, as well as other forms of Epibiosis. (**Photos 472 - 474**).

Habitat

The species settles on muddy and sandy bottoms, but it is also found on rocky bottoms exposed to sunlight where it usually positioned among the rough surfaces of the rocks. Its range covers from the low-tide line, in the first few meters of water, down to depths of approximately 50 m.

Distribution

Throughout the Mediterranean including the Alboran Sea and the Strait of Gibraltar. It is also present in the Atlantic (it is transatlantic, found in temperate zones on both sides of the ocean), including the Caribbean (in the western Atlantic, it is only found in this sea), the Azores, the Canary Islands and the Atlantic coasts of the southern Iberian Peninsula.

Environmental sensitivity

As with *Pinna nobilis*, this species catches the attention of divers who tend to capture examples for ornamental reasons and collections (Moreno and Barrajón, 2008). It is also threatened by dragged anchors and trawler nets. It prefers clean waters (Ben Mustapha *et al.*, 2002) but is less selective than *Pinna nobilis*, it also has a greater capacity to survive attacks from predators (Dietl and Alexander, 2005). Examples are found in unclean bottoms, but nevertheless pollution free (García-Gómez, 2007). Although *Pinna rudis* is not particularly useful for coastal environmental monitoring programs given its low abundance, the species can easily be monitored by divers who frequently dive in areas where it has settled.

Environmental protection bodies

Included in the Barcelona Convention (Annex II: List of endangered or threatened species) and in the Berne Convention (Annex II: strictly protected fauna species).

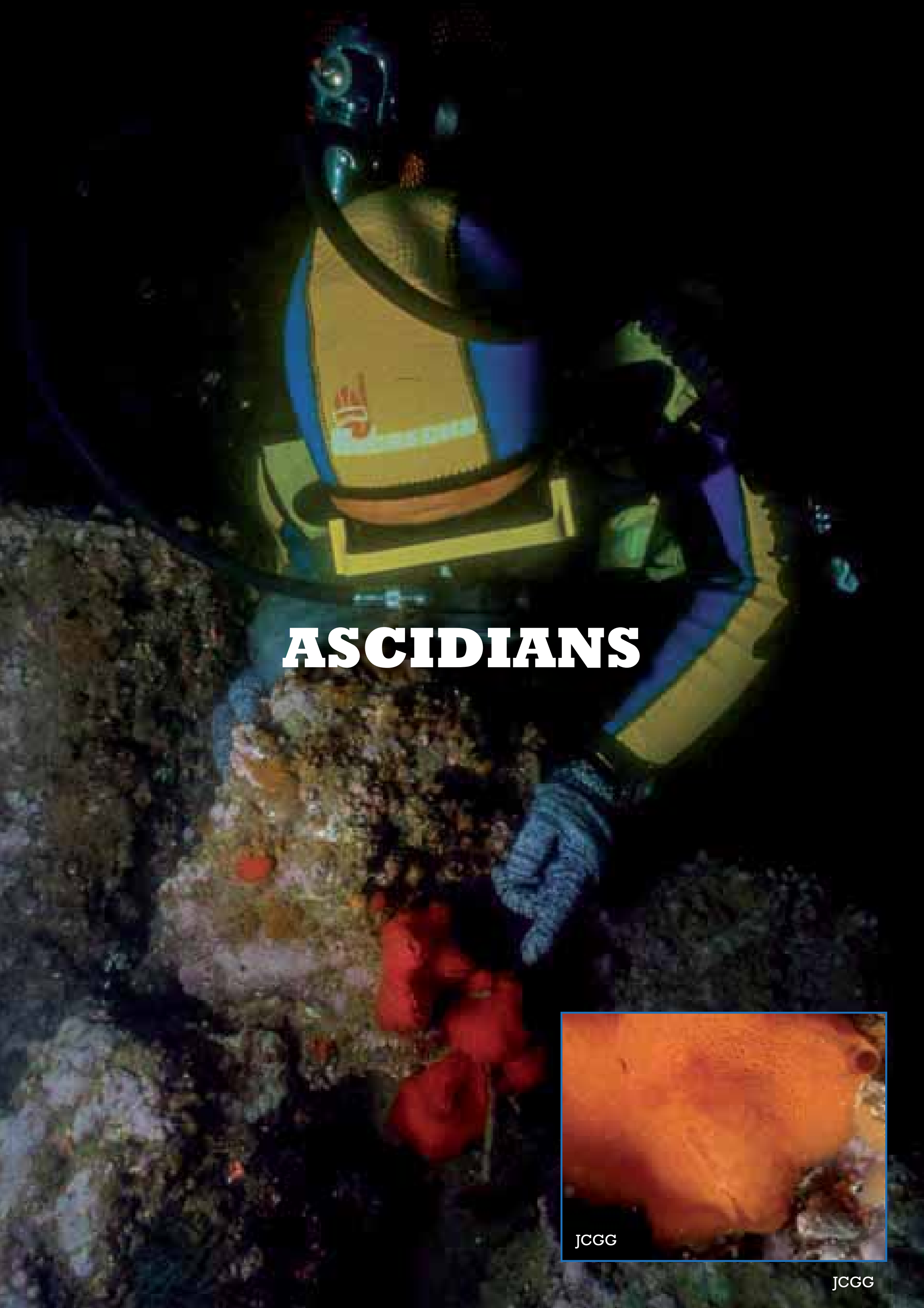
Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al.*, 2008), under the category "Vulnerable".

Phot. 473

Phot. 474

ASCIDIANS



JCGG

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11.53. *Halocynthia papillosa* (Linnaeus, 1767)

Phot. 477

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Pyuridae
Genus: *Halocynthia*
Common name: Red sea-squirt

Description

A solitary ascidian with a bottle-shaped body that grows to between 12 and 20 cm long. It is usually a bright red color and has a leathery texture (**photo 477**), although it can sometimes be a yellowish-bone color (**photo 478**). It has a very distinctive velvety surface.

Habitat

A sublittoral species that is usually found attached to rocky substrates in zones of reduced light, such as vertical walls, crevices, caves and overhangs, as well as coralline and pre-coralline habitats. It can also be found in communities of algae, meadows of *Posidonia* and coastal detritic environments. It is exceptionally rare in shallow waters (less than 10 meters), but is relatively common between 20 and 40 meters.

Distribution

Distributed throughout the Mediterranean, from Israel to the Strait of Gibraltar. Also present around the eastern Atlantic including Portugal and the Canary Islands.

Phot. 478

Environmental sensitivity

Halocynthia papillosa is very sensitive to environmental disturbances (Naranjo *et al.*, 1996). Its numbers tend to decrease drastically when the degree of environmental stress increases (a regressive species). It is exceptionally sensitive to pollution derived from organic material and persistent turbidity (Carballo and Naranjo, 2002), hence it is a very good indicator of clean and rejuvenated waters (García-Gómez, 2007). *H. papillosa* has also demonstrated a high degree of sensitivity to the presence of recreational divers in its vicinity, mainly due to the resuspension of sediment caused by their flippers (Luna-Pérez *et al.*, 2010, 2011). However, it is apparently tolerant to abnormal increases in water temperature (Pérez *et al.*, 2000).

It is easily identified while diving (**photo 479**), making it a good candidate for checking the ecological progress of appropriate enclaves; the aim being to monitor for any unusual losses or disappearances that could be linked to a progressive deterioration of the littoral marine environment. It is quite rare for the species to carry epibionts, so when instances are observed, and especially if there are several examples, the situation could be related to a disturbance (García-Gómez, 2007) (**photo 480**).

Environmental protection bodies

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".

Phot. 479

Phot. 480

11.54. *Stolonica socialis* Hartmeyer, 1903

Phot. 481

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Stolidobranchia
Family: Styelidae
Genus: *Stolonica*
Common name: Orange sea grapes

Description

The colonies of this Ascidiacea comprise oblong or barrel-shaped zooids, these measure around 25 mm wide, are arranged in tight clusters and united by their stolons, which also form the base. The surface of the body is thin and colonies are orangey. (**Photos 481 and 482**).

Habitat

Settles on rocky seabeds, attached to vertical surfaces and overhangs in areas with a moderate to high hydrodynamism and low degree of sedimentation. It can also be observed in connection with sandy or biodetritic substrates that neighbor rocky areas, where it is found anchored to biogenic concretions. Examples are occasionally observed as epibionts of other sessile organisms, particularly gorgonians (**photos 483 - 485**). The species inhabits a range of 10 to 40 meters, but more frequently it is found in the interval of 20 to 30 m.

Distribution

In the eastern Atlantic, from the British Isles to Morocco, including the Strait of Gibraltar.

Phot. 482

Phot. 483

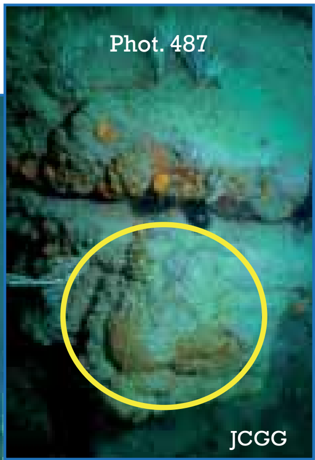
Phot. 484

Phot. 485

Environmental sensitivity

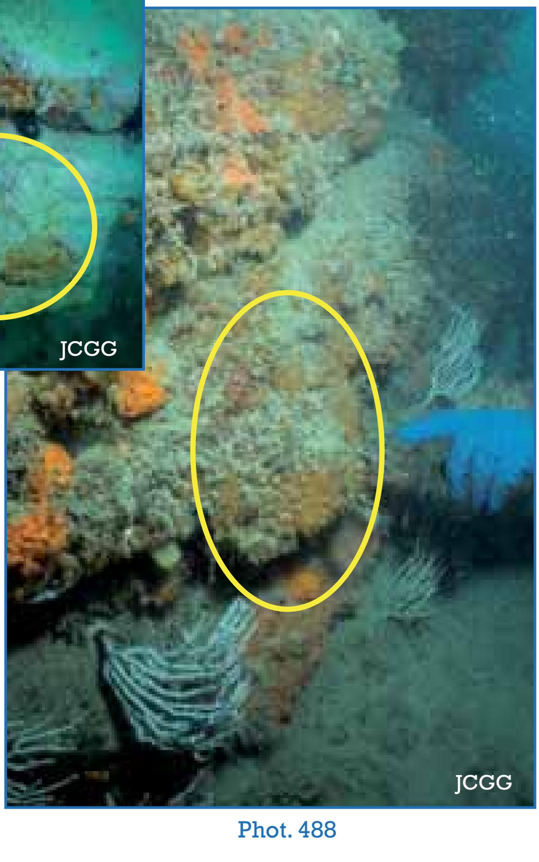
It is a sensitive species, characteristic of clean and rejuvenated waters (Naranjo *et al.*, 1996; Zubía *et al.*, 2003). It will not tolerate certain levels of organic load or high rates of sedimentation and it prefers natural substrates to artificial ones, even if they are located in a good environmental setting (Hiscock *et al.*, 2010). This species, therefore, is never located in disturbed bottoms subjected to either the direct or indirect influence of wastewater discharges (Carballo and Naranjo, 2002). *Stolonica socialis* has also proven susceptible to excessive sedimentation derived from the overflow of coastal dredging operations, especially if the colonies are settled on horizontal surfaces (García-Gómez, 2007) (see the series of images in **photos 489 - 492**). When these impacts occur to a high degree, even colonies anchored to vertical surfaces are seriously affected (**photos 486 - 488**).

The eye-catching coloration of *Stolonica socialis*, the size of its colonies and unmistakable appearance (once the observer has familiarized his/herself with the species) make it an ideal choice for performing underwater surveillance operations in the sublittoral environment.



Phot. 487

Phot. 486



Phot. 488

Phot. 489

Phot. 490

Phot. 491

Phot. 492

11.55. *Clavelina dellavallei* (Zirpolo, 1825)

Phot. 493

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Clavelinidae
Genus: *Clavelina*
Common name: Bluestriped light bulb tunicate

Description

A colonial ascidian with independent zooids (although they are joined by basal stolons) that can grow to 5 cm long. The zooids are transparent and so their internal structures are visible, so the species derives its overall color from some yellowish and bluish pigmentation (**photos 493 - 495).** The peduncle (stem) has a chitinous texture while the rest is gelatinous.

Habitat

Associated to communities of algae in either well-lit or shaded environments, and also anchored to vertical rocky surfaces and overhangs, generally prefers zones of moderate to high hydrodynamism. Also found growing over gorgonians and in coastal coralline and detritic bottoms. Although on rare occasions it can be found at depths of less than 5 m, the species normal habitat begins at 10 m and has even been cited at depths of 90 m.

Distribution

Throughout the Mediterranean, from Greece and Tunisia to as far as Spain including the Alboran Sea and the Strait of Gibraltar.

Environmental sensitivity

Clavelina dellavallei is sensitive to environmental disturbances, particularly wastewater discharges and civil engineering works, thus it prefers natural ecosystems in a good ecological state (Carballo and Naranjo, 2002). It is, therefore, a good indicator of clean and rejuvenated waters (Naranjo *et al.*, 1996; López-González *et al.*, 1999; García-Gómez, 2007). It is especially sensitive to persistent turbidity and a high sedimentation rate. Researchers have also classified the species as very vulnerable to diving activities (Lloret *et al.*, 2006; García-Charton *et al.*, 2008).

It is easily recognized while diving, hence it should be the focus of special attention in coastal seabed environmental surveillance programs, particularly any which may be implemented by recreational divers.

Phot. 494

Phot. 495

11.56. *Polysyncraton lacazei* (Giard, 1872)

Phot. 496

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Didemnidae
Genus: *Polysyncraton*
Common name: None

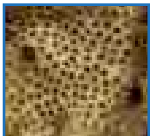
Description

A colonial ascidian species, almost always colored orangey-red. It forms laminar or slightly massive colonies with lobes of varying sizes and can cover large areas of rock which can easily be confused with red or orange sponge species (**photos 496 - 501**). *Polysyncraton lacazei* can be distinguished from these sponges by close observation of the colonies, since the ascidian reveals a high density of lighter-colored points that are absent from the similarly colored coating sponges, which only present oscules (water exhaust holes).

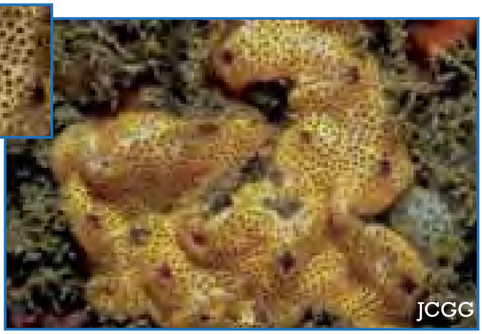
Habitat

Found in sheltered zones, such as vertical walls, overhangs, cave entrances or under stones. Also inhabits semi-exposed enclaves, coastal coralline and detritic habitats. It sometimes appears in association with algal communities in both well-lit and dark zones. Examples have been observed in meadows of *Posidonia* and *Caulerpa prolifera*. Its range covers from the low-tide line down to depths of 30 - 40 m.

Distribution



Phot. 497



Phot. 498

In the eastern Atlantic, from Scandinavia to South Africa. Also throughout the western Atlantic and the Indo-Pacific. Found in the east and west Mediterranean including the Alboran Sea and the Strait of Gibraltar.

Environmental sensitivity

Polysyncraton lacazei is a sensitive species, typically found in well-conserved, biologically rich and well-structured seabeds (Turón, 1985; Chabbi *et al.*, 2010). While it essentially requires clean and rejuvenated waters (García-Gómez, 2007; Chebbi, 2010), they can tolerate certain degrees of disturbance although their presence in such cases is quite exceptional (Naranjo *et al.*, 1996). Given the bright colors and the fact that colonies can cover large areas of substrate, once divers have familiarized themselves with the species, it can prove a useful indicator when monitoring frequent diving routes where it is constantly present. Consequently, the total disappearance of the species from enclaves where it was previously abundant indicates that something important could be happening; this should be confirmed through parallel observations focused on other sensitive indicator species.

Phot. 499

Phot. 500

Phot. 501

11.57. *Aplidium conicum* (Olivi, 1792)

Phot. 502

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Polyclinidae
Genus: *Aplidium*
Common name: None

Description

A colonial ascidian, of massive morphology, generally in the shape of a pear, a disk or it may be irregular (**photo 502**). Its size normally varies between 5 and 10 cm in diameter, although colonies measuring over 25 cm across the largest diameter can be encountered. It has a fleshy-cartilaginous consistency and sand does not tend to stick to its surface. The color varies from whitish or pale pink to orangey-yellow, with some areas a bright orange color (**photos 503 - 510)**.

Habitat

Typically found associated to communities of photophilic algae in turbulent or semi-turbulent waters, growing over natural rocks - mainly on vertical walls and overhangs (**photo 503**). It is also found living among sciaphilous algae communities, plus coastal coralline and detritic habitats. Examples have been observed in meadows of *Posidonia* and *Caulerpa prolifera*. It is found at depths of a few meters, in shaded environments, down to 40 meters.

Distribution

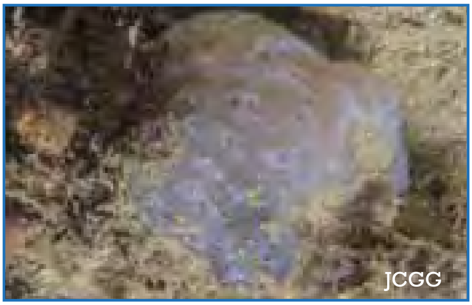
In the Mediterranean it extends from the Cape of Trafalgar in the Strait of Gibraltar to the coasts of Italy and Tunisia, including corresponding Spanish coasts, the Balearics and Ceuta.

Phot. 503

Phot. 504

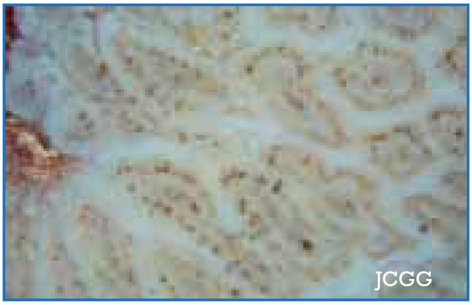
Phot. 505

Phot. 506



Phot. 507

Phot. 508



Phot. 509

Environmental sensitivity

Aplidium conicum is an excellent indicator of clean and rejuvenated waters (García-Gómez, 2007; Chabbi *et al.*, 2010; El Lakhrach *et al.*, 2012) as it is very sensitive to any deterioration in water quality or significant environmental disturbances (Naranjo *et al.*, 1996; Carballo and Naranjo, 2002). An example of the environmental information (renewed waters) provided by this species is shown in **figure 32.** The yellow dots indicate the presence of the species in 1995 in the Bay of Algeciras. One of them, inside the port area, illustrates its unexpected existence. However, the image obtained by the Landsat satellite (courtesy of CMAYOT of the Junta de Andalucía) shows how a current (dashed yellow arrow) bathes the interior of the basin, which seems to explain the unusual presence (García-Gómez *et al*. 1997).

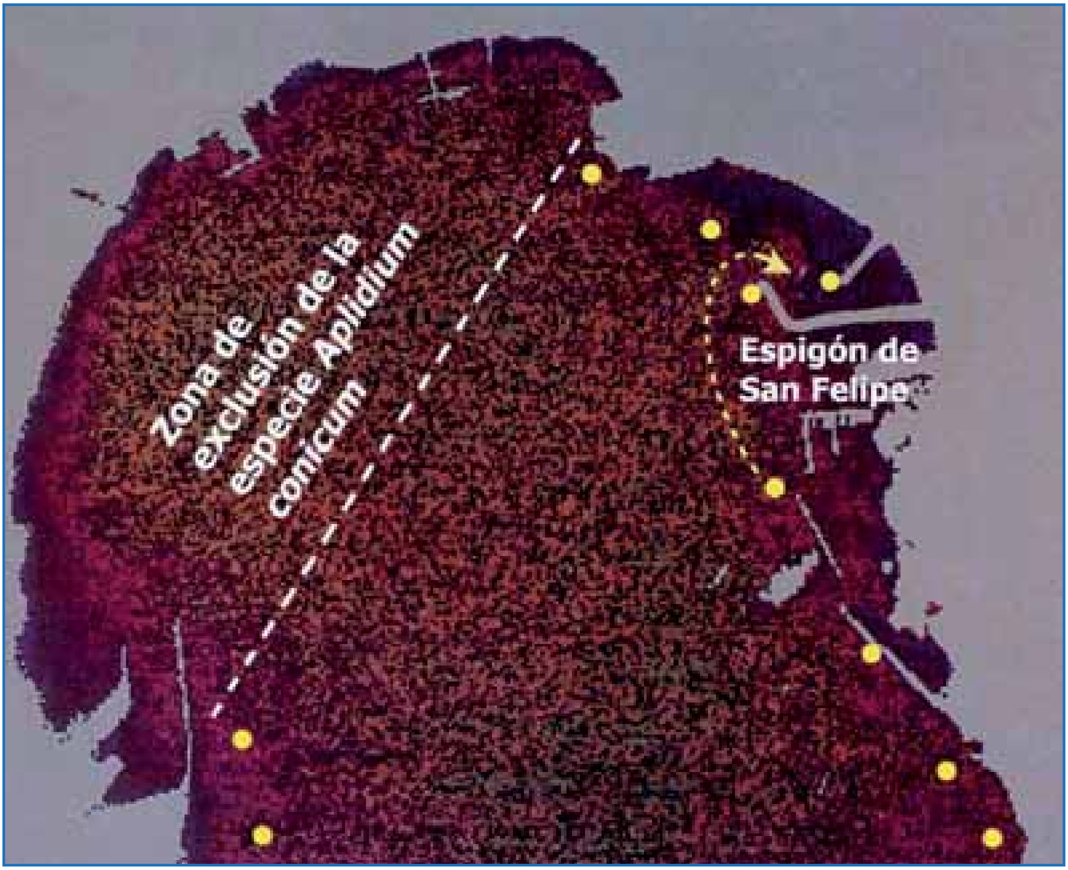


Fig. 32

Phot. 510

It is particularly sensitive to organic loads, high sedimentation rates and elevated levels of turbidity. The species has also shown a negative correlation with water current intensities (Ordines *et al.*, 2011). **Photos 511 and 512** indicate the species' extreme sensitivity to excessive sedimentation derived from human activities along the littoral. **Photo 513** illustrates a colony almost completely inundated by fine sediment. **Photo 514** is the same colony and its immediate surroundings after manual cleaning. The pale color is a clear warning sign (compare with **photo 513**) of the colonies' "pre-mortem" situation.

The size and bright color of the species make it ideal for use as an indicator in coastal seabed environmental monitoring programs.

Phot. 511

Phot. 512

Phot. 513

Phot. 514

11.58. *Aplidium punctum* (Giard, 1873)

Phot. 515

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Polyclinidae
Genus: *Aplidium*
Common name: None

Description

This ascidian is characterized by its long-stemmed, club-shaped colonies (**photos 515, 516 and 518**). Some long peduncles (stems) emerge from a common base and give rise to the balloon-like ends of the clubs, which have a diameter of 1 to 3 cm. The orange colonies have a fleshy-gelatinous consistency. Examples are normally free from encrusting sand.

Habitat

Found attached to rocky surfaces in the infralittoral zone, preferentially vertical surfaces with attenuated light (**photo 517).** It also prefers locations with moderate to intense hydrodynamism. While occasionally it is observed in shallow waters, the species usually inhabits depths of 10 to 30 m. Reproduction is from March to May.

Distribution

Examples are found in the Strait of Gibraltar and Alboran Sea. Sightings in the eastern Atlantic extend from the British Isles to Portugal.

Phot. 516

Environmental sensitivity

Aplidium punctum is sensitive to environmental disturbances, its populations tend to disappear when they occur (Naranjo *et al.*, 1996; Derrien-Courtel *et al.*, 2008; Van Rein *et al.*, 2011). This species, therefore, is a very good indicator of clean and rejuvenated waters (Carballo and Naranjo, 2002; García-Gómez, 2007). It is particularly sensitive to high organic loads, extreme turbidity and elevated sedimentation rates. If the sedimentation is caused by human activities or in areas close to dredging operations that produce overflow, then the fine sediment produced by these activities buries and ultimately kills the colonies after just a relatively short period of exposure to the disturbance (**photo 519** demonstrates the poor state of a colony after a few days of exposure to a water column with sedimentary turbidity). As it is highly visible and easily recognized while diving, this species is recommended for use as an indicator in coastal seabed environmental monitoring programs.

Phot. 517

Phot. 518

Phot. 519

11.59. *Pseudodistoma obscurum* Pérès, 1959

Phot. 520

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Pseudodistomidae
Genus: *Pseudodistoma*
Common name: None

Description

A colonial sea squirt that has two different forms. On one hand, it forms large globular, pyramidal and conical colonies that can grow to over 5 cm tall; fleshy, bright or pale yellow (**photos 520 and 523**), and normally without any encrustations of sand (this morphotype was previously assigned to the species *Pseudodistoma crucigaster,* which is currently considered to be a synonym of *P. obscurum*). On the other hand, there are colonies with a similar morphology (although sometimes they are flattened or discoid) but of much smaller dimensions as they do not tend to surpass 5 cm tall and 10 cm in diameter; they are also fleshy, but with a more solid consistency than the larger morphotype, and do tend to be encrusted with sand. The small form is grayish, sometimes almost black (hence the species name *obscurum*) (**photos 521 and 524**). Occasionally both varieties can be found growing almost together (**photo 522**). There are also morphotypes with more neutral or intensely darkened yellow tones.

Habitat

The species is associated with communities of photophilic algae in zones of moderate to high hydrodynamism; it is also found in very shaded areas with calm waters and in coralline habitats. It has also been observed in

Phot. 521

Posidonia meadows and on coastal detritic substrates. Normally observed over a depth range of 5 to 35 meters.

Distribution

Found in the western Mediterranean, the Alboran Sea and the Strait of Gibraltar.

Environmental sensitivity

Pseudodistoma obscurum is sensitive to environmental disturbances of a human origin (Naranjo *et al.*, 1996; García-Gómez, 2007; Chebbi, 2010). It requires clean waters (López-González *et al.*, 1997; Carballo y Naranjo, 2002) and moderate to high hydrodynamism for survival (Zubía *et al.*, 2003), hence it is a good indicator of these environmental conditions. It is particularly sensitive to high organic loads, extreme turbidity and elevated sedimentation rates.

Phot. 522

Phot. 523

Phot. 524

11.60. *Polycitor adriaticus* (Drasche, 1883)

Phot. 525

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Polycitoridae
Genus: *Polycitor*
Common name: None

Description

This species forms massive colonies of differing shapes, about 10 cm in diameter and 5 cm tall (**photo 525**, ringed by circles). The colonies, with a fleshy-gelatinous consistency and smooth surface, have a very short peduncle (stem) which cannot be seen, or is only occasionally visible, while diving. Examples are colored whitish, although somewhat translucent, and have dark brown, figure-of-eight shaped patches corresponding to the zooids (**photos 527 and 528**).

Habitat

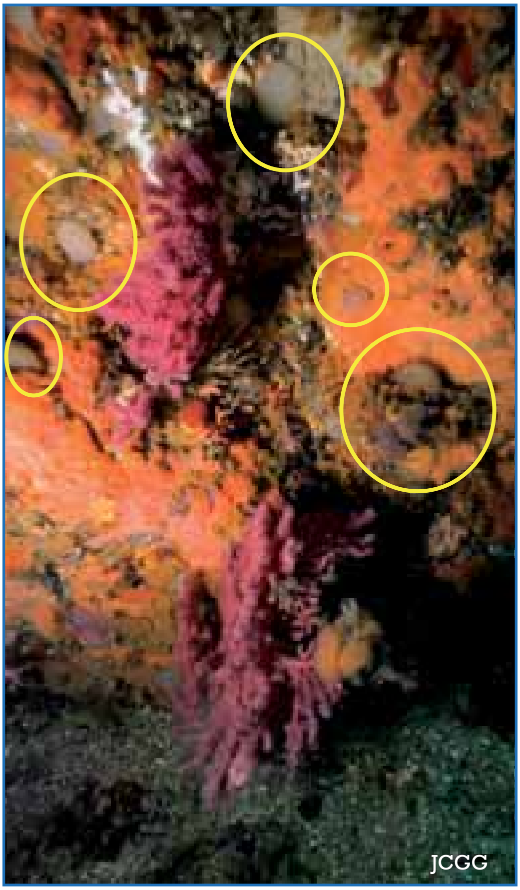
Typically found on vertical walls and overhangs (**photo 526)**, in association with algal communities in zones exposed to currents or of moderate hydrodynamism. Generally settles on well-shaded or semi-shaded bottoms. Also found growing among *Posidonia* meadows, detritic seabeds and, exceptionally, it has been identified in sandy/muddy bottoms. Examples have been observed on concrete walls where there is a high degree of hydrodynamism, such as areas surrounding ports. Bathymetrically, it is located between 2 and 40 m, although it is more frequently found in a range of 10 to 30 m.

Distribution

In the Mediterranean, the Alboran Sea and the Strait of Gibraltar.

Environmental sensitivity

Polycitor adriaticus is sensitive to environmental disturbances (Carballo and Naranjo, 2002; García-Gómez, 2007) and, therefore, is also regressive, in other words its populations decrease when there is an increase in environmental stress. It is exceptionally sensitive to pollution derived from organic material, extreme turbidity and high rates of sedimentation, thus it is a very good indicator of clean and rejuvenated waters (Naranjo *et al.*, 1996; Chabbi *et al.*, 2010; El Lakhrach *et al.*, 2012). The species has also demonstrated its sensitivity to abnormal water temperature increases (Verdura *et al.*, 2013).



Phot. 526

Phot. 527

Phot. 528

11.61. *Polycitor crystallinus* (Renier, 1804)

Phot. 529

Phylum: Chordata
Subphylum: Tunicata
Class: Ascidiacea
Order: Aplousobranchia
Family: Polycitoridae
Genus: *Polycitor*
Common name: None

Description

A colonial ascidian which anchors directly to the substrate without employing an intermediary peduncle (stem). Colonies are massive, taking a globular shape and measuring between 6 and 7 cm in diameter. They are whitish and generally present several intense white circles surrounding the zooids' siphons (**photos 529 - 531**). The whitish color is even brighter in more developed colonies and some specimens can even present an orangey-yellow tone. Examples have a fleshy, gelatinous texture and smooth surface. There is often sand at the base of colonies (the part which anchors to the substrate), but the rest of the surface is always free of encrustations.

Habitat

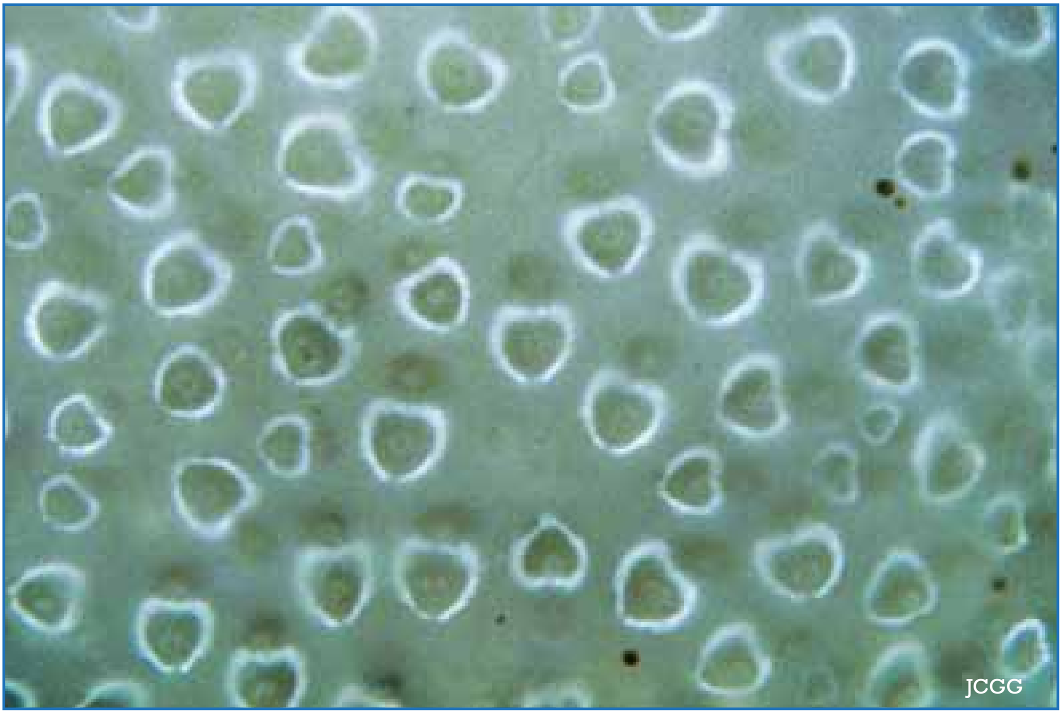
Inhabits rocky bottoms, preferably in shaded zones of moderate hydrodynamism, growing over vertical walls and overhangs in coralline habitats. Examples have also been cited in *Posidonia* and *Caulerpa* meadows, in rhizomes of *Laminaria* algae, as well as coastal detritic and muddy bottoms. It can be observed as an epibiont of gorgonians (*Eunicella*). Its range covers from 4 m all the way down to the bathyal zone.

Distribution

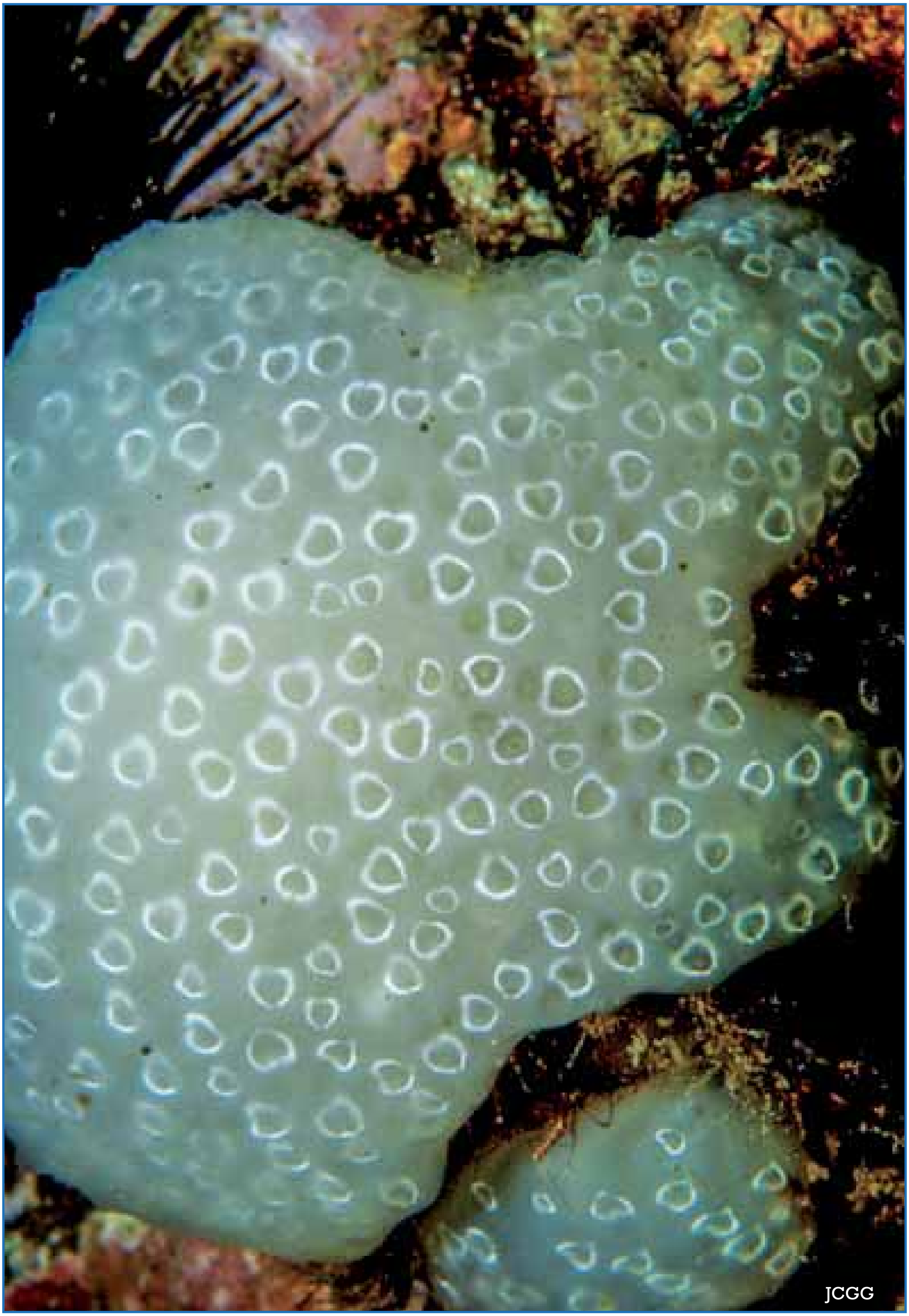
Throughout the Mediterranean and the Strait of Gibraltar. Also found in the eastern Atlantic (Senegalese and Gambian coastal waters).

Environmental sensitivity

Polycitor crystallinus is indicative of unpolluted, clean waters and, therefore, is sensitive to environmental disturbances (Naranjo *et al*, 1996; García-Gómez, 2007). Species numbers tend to reduce or disappear when there is an increase in environmental stress derived from any type of significant anthropogenic impact.



Phot. 530



Phot. 531

12 COMPLEMENTARY SENSITIVE BENTHIC SPECIES

JCGG

MOLLUSCS

JCGG

12.1. *Patella ferruginea* Gmelin, 1791

Phot. 534

Phylum: Mollusca
Class: Gastropoda
Family: Patellidae
Genus: *Patella*
Common name: Ribbed Mediterranean limpet

Description

Patella ferruginea is the largest limpet in Europe, varying in length from 40 to 80 mm, although it can reach lengths of up to 100 mm. It has a very distinctive shell which is characterized by some very broad, deep and irregular radial ribs (**photos 534 and 535)**. The outer edge of the shell of young examples is very irregular, while that of adults tend to be smoother and more regular. The shell is rusty-brown, with darker concentric bands observed on smaller examples, while internally it is a shiny, opaque white color. The shell varies in height, ranging from the tallest and most conical examples, generally characteristic of less turbulent waters, to smaller and flatter specimens, typically in zones of greater hydrodynamism. *P. ferruginea* presents a large, muscular foot, which is cream-colored with orangey tones. The back of the foot and the head are a dark grayish color.

Habitat

This species cannot be defined as strictly sessile because it is actually vagile during high tide, actively moving around the vicinity of its footprint or "home scar" to which it returns and remains attached to during low tide. Nor is it an FBI (Fixed Biological Indicator) species according to the definition given by Rovere *et al.* (2015), and can only be considered as such during low tide.

Inhabits rocky, intertidal zones, primarily located in the upper mid-littoral level (**photos 536 and 537)**. There are indications that it is related to belts of *Chthamalus stellatus*.

Distribution

A species endemic in the western Mediterranean whose clear regression has been noted, in both European and African waters, since the beginning of the 20th century. Presently it is practically extinct from continental European coasts, with just small subpopulations remaining around Corsica, Sardinia and Pantellaria. In African waters, it is limited to the coasts of Morocco, the Habibas Islands of Algeria, and the island of Zembra and Cape Bon in Tunisia. Off the Spanish coasts, there are examples around Andalusia and Murcia, while the largest populations exist near Ceuta, Melilla and the Chafarinas Islands.

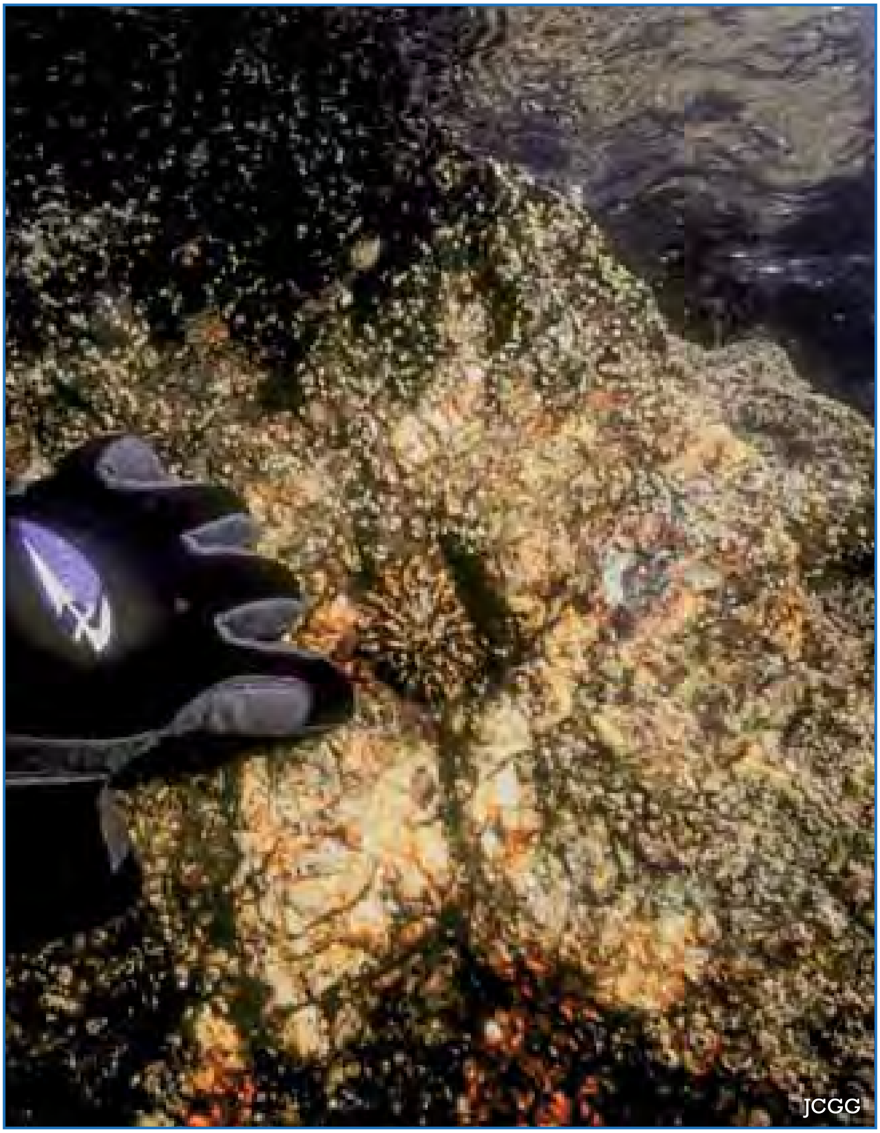
Phot. 535

Environmental sensitivity

Patella ferruginea is a species traditionally associated with clean and well-oxygenated waters. It is sensitive to pollution, turbidity and decreases in oxygen levels (Espinosa, 2005). Previous studies have suggested using the species as an indicator of good environmental conditions (Espinosa *et al.*, 2007).

Notes

It is an emblematic species within recent proposals for Artificial Marine Micro-reserves (García-Gómez *et al.*, 2011, 2014) since, despite its sensitivity to disturbances, it has established important populations in artificial environments that have certain, favorable environmental conditions; while only approximately 2,500 examples exist throughout the whole of the littoral surrounding the Iberian Peninsula (Moreno and Arroyo, 2008; Andalusian Environmental and Water Agency communication), over 14,000 have been discovered in the port of Ceuta alone, the Spanish enclave in mainland Africa (Rivera–Ingraham *et al.*, 2011).



Phot. 536

Environmental protection bodies

Included in the Barcelona Convention (Annex II: List of endangered or threatened species) and in the Berne Convention (Annex II: strictly protected fauna species).

Included in the EU Council Directive 92/43/EEC (Annex IV: Animal and plant species of community interest in need of strict protection).

Included in the Spanish Catalogue of Threatened Species, under the category "In Extinction Risk".

Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Critically Endangered".

Phot. 537

12.2. *Lithophaga lithophaga* (Linnaeus, 1758)

Phot. 538

Phylum: Mollusca
Class: Bivalvia
Order: Mytiloida
Family: Mytilidae
Genus: *Lithophaga*
Common name: Date mussel

Description

This *Bivalvia* species has elongated, matching valves, with an almost cylindrical form and a reddish-brown color (**photos 538 and 539).** There are very fine, concentric, radial bands on its outer surface. The inside is light blue and examples can reach a size of 10 cm.

Habitat

The species is endolithic (grows inside rock) and inhabits rocky substrates in the infralittoral zone, rooting itself inside limestone rocks which it dissolves and perforates by secreting an acidic substance (**photo 540).** It is capable of eroding a cavity of up to 20 cm long. Generally found from surface waters down to depths of 30 m.

Distribution

Found in the eastern Atlantic, from Morocco to Portugal, including the Canary Islands and Madeira, and throughout the Mediterranean littoral.

Environmental sensitivity

The species requires clean and rejuvenated waters. It is rare in seabeds subjected to high levels of sedimentation and organic load (author's personal observations).

Notes

The main threat to *Lithophaga lithophaga* arises from its considerable gastronomic interest, as it is highly regarded in many Mediterranean countries. And, due to its rock drilling nature, the methods used to fish or collect this species imply irreversible destruction of its habitat (Pantoja-Trigueros *et al.*, 2000; Moreno *et al.*, 2008c). Therefore it is protected across Europe (Moreno *et al.*, 2008c; Tunesi *et al.*, 2008).

Environmental protection bodies

Included in the Barcelona Convention (Annex II: List of endangered or threatened species)) and in the Berne Convention (Annex II: strictly protected fauna species).

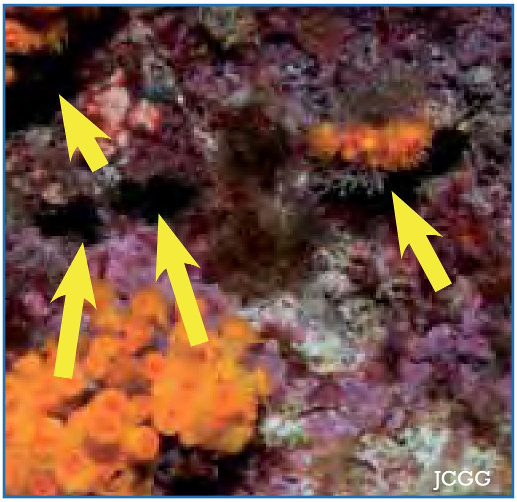
Included in the EU Council Directive 92/43/EEC (Annex V: Animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures).

Included in the Spanish Catalogue of Threatened Species, under the category "Vulnerable".

Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al.*, 2008), under the category "Vulnerable".

Phot. 539



Phot. 540

12.3. *Charonia lampas lampas* (Linnaeus, 1758)

Phot. 541

Phylum: Mollusca
Class: Gastropoda
Order: Littorinimorpha
Family: Ranellidae
Genus: *Charonia*
Common name: Pink lady or knobbed triton

Description

This gastropod is the largest in the Mediterranean. Has a thick, solid and robust shell measuring up to 40 cm long and 15 cm in diameter. The shell is conical, has nine whorls and a pointed spire. Whorls are covered with knobs and ridges, these may be eroded on older individuals. The shell opening is broad and oval, with several small, brown teeth along one side. The exterior of the shell is whitish/grayish-yellow, with quite thin, irregular, brownish-red radial stripes; while the body is orangey or reddish. (**Photos 541, 542 and 545).**

Habitat

Found in rocky bottoms, and detritic seabeds that are close to rocky areas (**photos 543 and 544).** It feeds on sea urchins and starfish, to such a degree that it plays a part in controlling the populations of these types of organisms. The species normally inhabits shallow waters down to depths of more than 100 meters.

Distribution

Although *Charonia lampas* is present in all of the world's temperate seas, the subspecies *Charonia lampas lampas* is found in the western Mediterranean including the Alboran Sea and the Strait of Gibraltar and in the eastern Atlantic, from the Canary Islands to the Bay of Biscay.

Environmental sensitivity

Even though the species prefers clean waters and undisturbed bottoms (Bazairi *et al.*, 2013), its low frequency means it cannot be used in surveillance programs, except those with very large resources (CAPMA, 2012). However, since it is a protected species of large dimensions, it should be included in this guide so that it may be identified, respected and protected because it is often collected by divers for decorative purposes or as food. This message is not only aimed at divers, but also to fishermen would accidentally catch examples of this species in their nets (trammels, trawlers) (Malaquias *et al.*, 2006) and which should be returned to the sea as soon as they are recognized at the surface.

Environmental protection bodies

Included in the Barcelona Convention (Annex II: List of endangered or threatened species) and in the Berne Convention (Annex II: strictly protected fauna species).

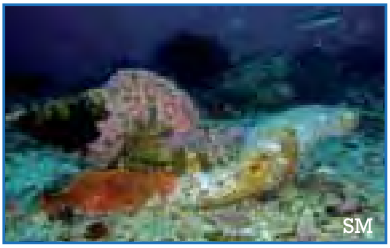
Included in the Spanish Catalogue of Threatened Species, under the category "Vulnerable".

Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al.*, 2008), under the category "Vulnerable".

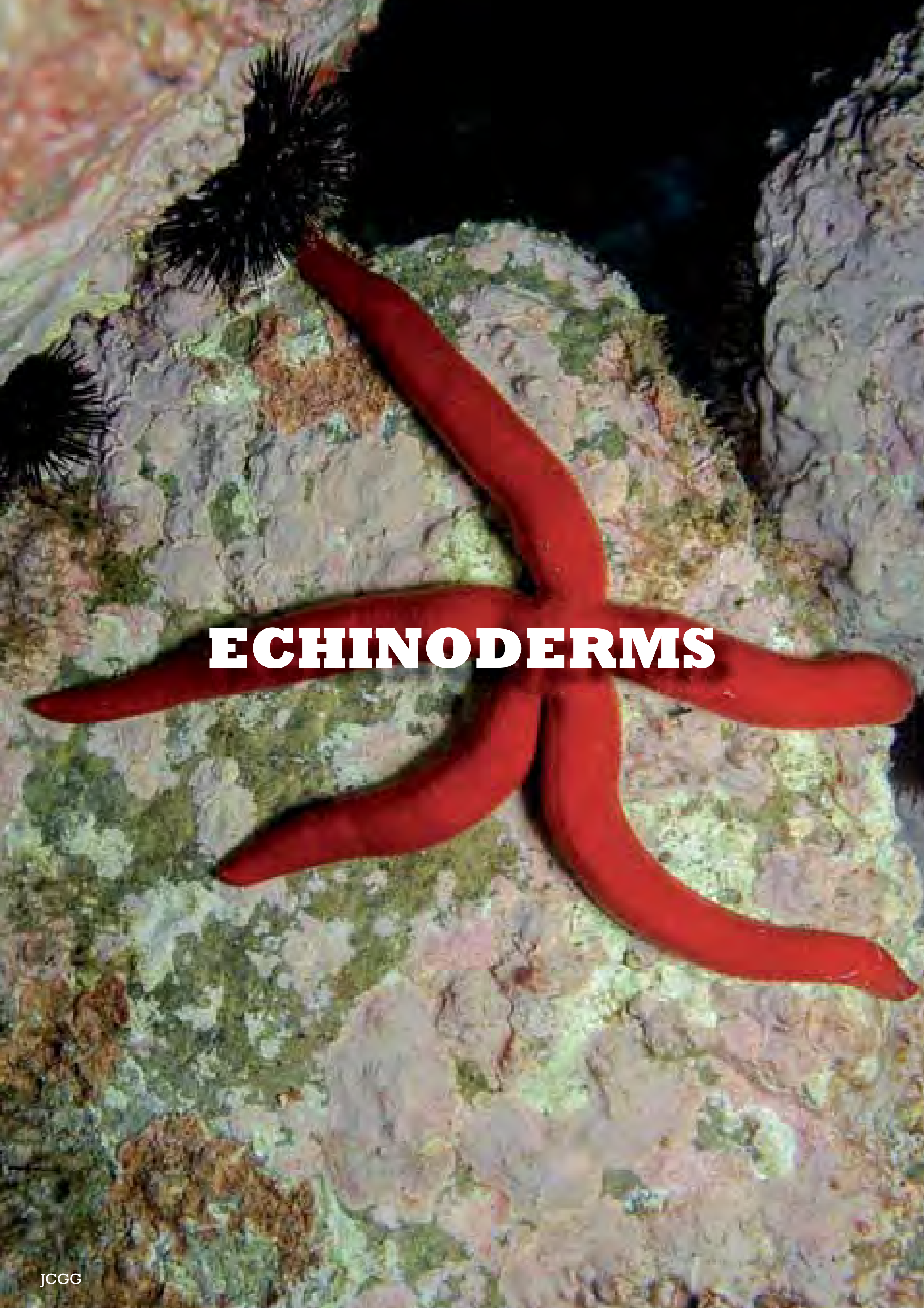
Phot. 542

Phot. 543



Phot. 544

Phot. 545


ECHINODERMS
JCGG

12.4. *Antedon mediterranea* (Lamarck, 1816)

Phot. 547

Phylum: Echinodermata
Class: Crinoidea
Order: Comatulida
Family: Antedonidae
Genus: *Antedon*
Common name: Feather star

Description

This sea lily is reddish, yellow or brown and can present a homogeneous or irregular mixture of these tones (**photos 547, 549 - 551).** The body has a small, cup-shaped central cone and a rounded apex. Ten feathery arms derive from the central cone. On the dorsal section there are as many as 40 cirri that measure 1.5 cm long and end in a hook. It can grow to dimensions of 25 cm. A sedentary, gregarious species that reproduces in spring and summer.

Habitat

Typically found on rocky seabeds with abundant algae, in sandy or muddy bottoms, and also in meadows of *Posidonia*. It usually anchors to organisms living on these types of sea floor (**photo 548).** The species prefers shaded or semi-shaded zones (in fact it moves away from light), with reasonably turbulent waters. Found at depths ranging from 15 m, down to 200 - 300 m.

Distribution

In the Mediterranean, to as far as the Strait of Gibraltar.

Phot. 548

Environmental sensitivity

A species that is observed in areas presenting good ecological conditions, sometimes even in abundance (El Lakhrach *et al.*, 2012). *Antedon mediterranea* has displayed sensitivity to anthropogenic environmental disturbances (Candia-Carnevali *et al.*, 2001; Barbaglio *et al.*, 2006) and trawling (Mangano *et al.,* 2013). Nevertheless, it appears to be well tolerant of sedimentation processes, as it has been discovered living abundantly in areas with a high degree of mud and clay deposition (McKinneya and Jaklin, 2001).

Phot. 549

Phot. 550

Phot. 551

12.5. *Astrospartus mediterraneus* (Risso, 1826)

Phot. 552

Phylum: Echinodermata
Class: Ophiuroidea
Order: Euryalida
Family: Gorgonacephalidae
Genus: *Astrospartus*
Common name: None

Description

A large, grayish ophiuroid (or brittle star), that reaches diameters of up to 40 cm. It has a thick, pentagonal central disk with a diameter of about 8 cm. This bears five arms that branch several times dichotomously from the base, each branch is progressively thinner and they are entangled together (**photos 552 and 553)**. Both the disk and branches are covered with fine granules.

Habitat

Settles over rocky and sandy/muddy bottoms that are shaded or semi-shaded environments and where water movement is moderate but constant. Often found growing over other organisms such as gorgonians, always facing the current in order to catch food. It is found at depths of 25+ m.

Distribution

Distributed throughout the Mediterranean and Atlantic.

Environmental sensitivity

Frequently found in association with communities characteristic of zones of high ecological value (Junoy and Viéitez, 2008; Templado *et al.*, 2012). *Astropartus mediterraneus* has demonstrated vulnerability to water temperature increases (Escoubet *et al.*, 2001) and fishing activities

(Gonçalves *et al.*, 2008), among other disturbance factors. In zones with an environmental gradient, this species disappears upon approaching areas with more turbid waters, less hydrodynamism and more anthropization (personal observations).

Notes

It is a rare species.

Environmental protection bodies

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Lesser Risk".

Phot. 553

12.6. *Centrostephanus longispinus* (Philippi, 1845)

Phot. 554

Phylum: Echinodermata
Class: Echinoidea
Order: Diadematoida
Family: Diadematidae
Genus: *Centrostephanus*
Common name: Long-spined urchin or hatpin urchin

Description

As its name suggests, this urchin is characterized by its long, fragile spines of up to 14 cm. The spines have alternating bands of whitish or yellowish rings contrasted by violet ones. It has a depressed violet-purple body measuring around 6 cm in diameter. It is an active species. (**Photos 554 - 556).**

Habitat

Examples are it is found on shaded or slightly-shaded, rocky bottoms, as well as in detritic, sandy or muddy seabeds. This species exhibits negative phototropism and so it flees from sunlight. During daytime dives, therefore, it is found in caves and crevices between rocks. It is found between 15 and 130 m, with denser populations occurring at depths of 60 - 130 m.

Distribution

In the Mediterranean, including the Strait of Gibraltar, and throughout the Atlantic.

Environmental sensitivity

Due to its very fragile nature, *Centrostephanus longispinus* is typically found in zones of high environmental quality (Micael *et al.*, 2012) and which are relatively uninfluenced by fishing and diving activities (Lloret *et al.*, 2006).

It is also classified as a species that prefers warm waters, thus its presence in areas where it was previously absent could be a sign of water temperature increases (Francour *et al.*, 1994; Pérez, 2008).

Notes

The species will only tolerate a narrow range of temperatures. It is quite rare.

Environmental protection bodies

Included in the Barcelona Convention (Annex II: List of endangered or threatened species) and in the Berne Convention (Annex II: strictly protected fauna species).

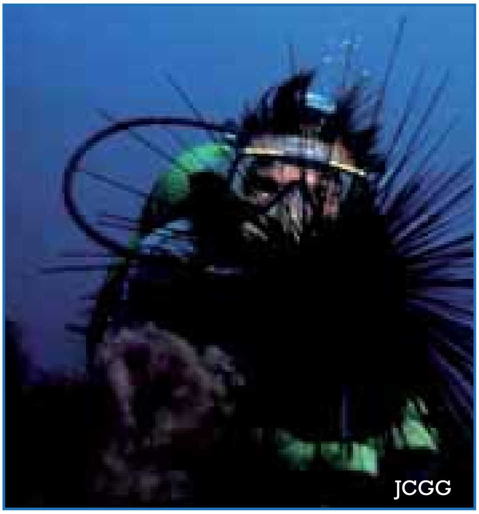
Included in the EU Council Directive 92/43/EEC (Annex V: Animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures).

Included in the Spanish Catalogue of Threatened Species, under the category "Special Interest".

Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category "Vulnerable".

Phot. 555



Phot. 556

12.7. *Gracilechinus acutus* (Lamarck, 1816)

Phot. 557

Phylum: Echinodermata
Class: Echinoidea
Order: Camarodonta
Family: Echinidae
Genus: *Gracilechinus*
Common name: *Honduran sea urchin* (Spanish name)

Description

The body of this spherical sea urchin can measure up to 17 cm in diameter, sub conical and the surface of the mouth is flattened. Examples can be yellow, pinkish or orangey and present clear radial bands. The reddish spines with whitish bands are relatively short and delicate on this species. (**Photos 557 and 558).**

Habitat

Lives among shaded or semi-shaded, rocky bottoms, as well as in detritic habitats and meadows of *Posidonia*. Reproduction is mainly in spring and summer, although it can reproduce throughout the majority of the year. Inhabits depths ranging from 20 to 250 meters.

Distribution

Throughout the Mediterranean including the Strait of Gibraltar and along European coast of the Atlantic.

Environmental sensitivity

Gracilechinus acutus has been used as an indicator of relatively unpolluted waters (Wielgolaski, 1975). It is also a suitable indicator for evaluating the impact of trawlers (González-Irusta *et al.*, 2012) and disturbances related to hydrocarbon pollution (Hughes *et al.*, 2010). Nevertheless, various studies (Catarino *et al.*, 2008; Moureaux *et al.*, 2011) indicate it is capable of tolerating environments with high levels of heavy metal pollution, where it manages to survive but suffers various impacts.

In the Strait of Gibraltar it has been observed in clean waters and well-structured bottoms, never in anthropized interior zones (personal observations).

Notes

The species was formerly cited as *Echinus acutus.*

Phot. 558

12.8. *Echinus melo* Lamarck, 1816

Phot. 559

Phylum: Echinodermata
Class: Echinoidea
Order: Camarodonta
Family: Echinidae
Genus: *Echinus*
Common name: Melon sea urchin

Description

This urchin has a spherical body with a diameter up to 14 cm. It is olive green with some clear stripes. There is a small number of long spines, colored olive green and with white tips, and several shorter, yellowish-green spines. (**Photos 559 and 560).**

Habitat

The species lives in hard, sandy and coralline habitats. Inhabits a range from 30 to 1,000 m.

Distribution

In the Mediterranean, including the Strait of Gibraltar, and the eastern Atlantic, from the Azores to the coasts of Portugal.

Environmental sensitivity

Echinus melo is commonly present in areas of high environmental quality (Micael *et al.*, 2012), including well-conserved coralline habitats (Lo Iacono *et al.*, 2012; Templado *et al.*, 2012), while it usually disappears from areas disturbed by chemical and biological pollution (Altug *et al.*, 2011). The species is also known to be particularly sensitive to impacts derived from trawlers (Hall-Spencer *et al.*, 1999).

Phot. 560

12.9. *Ophidiaster ophidianus* (Lamarck, 1816)

Phot. 561

Phylum: Echinodermata
Class: Asteroidea
Order: Valvatida
Family: Ophidiasteridae
Genus: *Ophidiaster*
Common name: Purple sea star

Description

This species of starfish is an orangey-red or purple color, sometimes with a strong shade of violet. It is robust and has a diameter of up to 45 cm. The central disk is small and completely surrounded by some long, thick, cylindrical arms which are rounded at the ends. (**Photos 561 - 563).**

Habitat

Found living in well-lit or semi-shaded, rocky bottoms with moderately turbulent water. The species prefers high water temperatures. It inhabits depths of 5 to 40 m.

Distribution

Throughout the Mediterranean, including the Strait of Gibraltar. In the eastern Atlantic, from the Azores to the Gulf of Guinea.

Environmental sensitivity

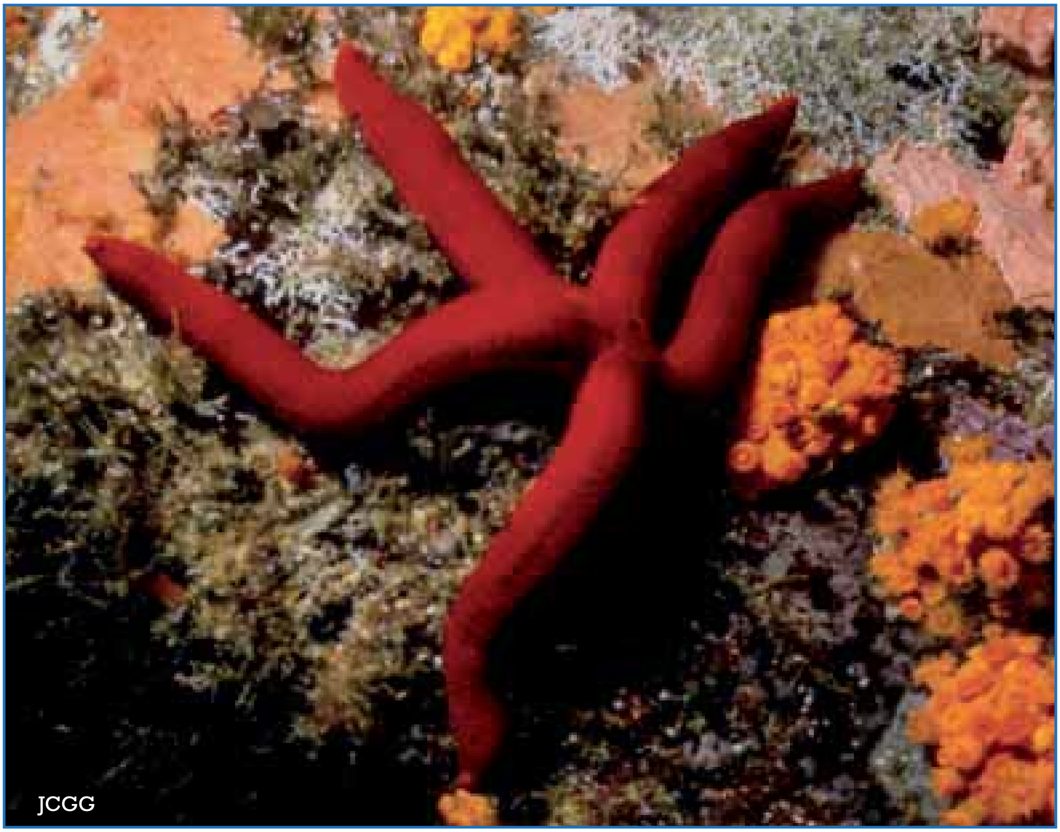
Ophidiaster ophidianus is included on the list of species protected by the Barcelona Convention (Boudouresque, 2002) and is frequently found in zones of high environmental quality (Tunesi *et al.*, 2008; Micael *et al.*, 2012). It is classified as a species that prefers warm waters, thus its presence in areas where it was previously absent could be a sign of water temperature increases (Francour *et al.*, 1994; Pérez, 2008).

Environmental protection bodies

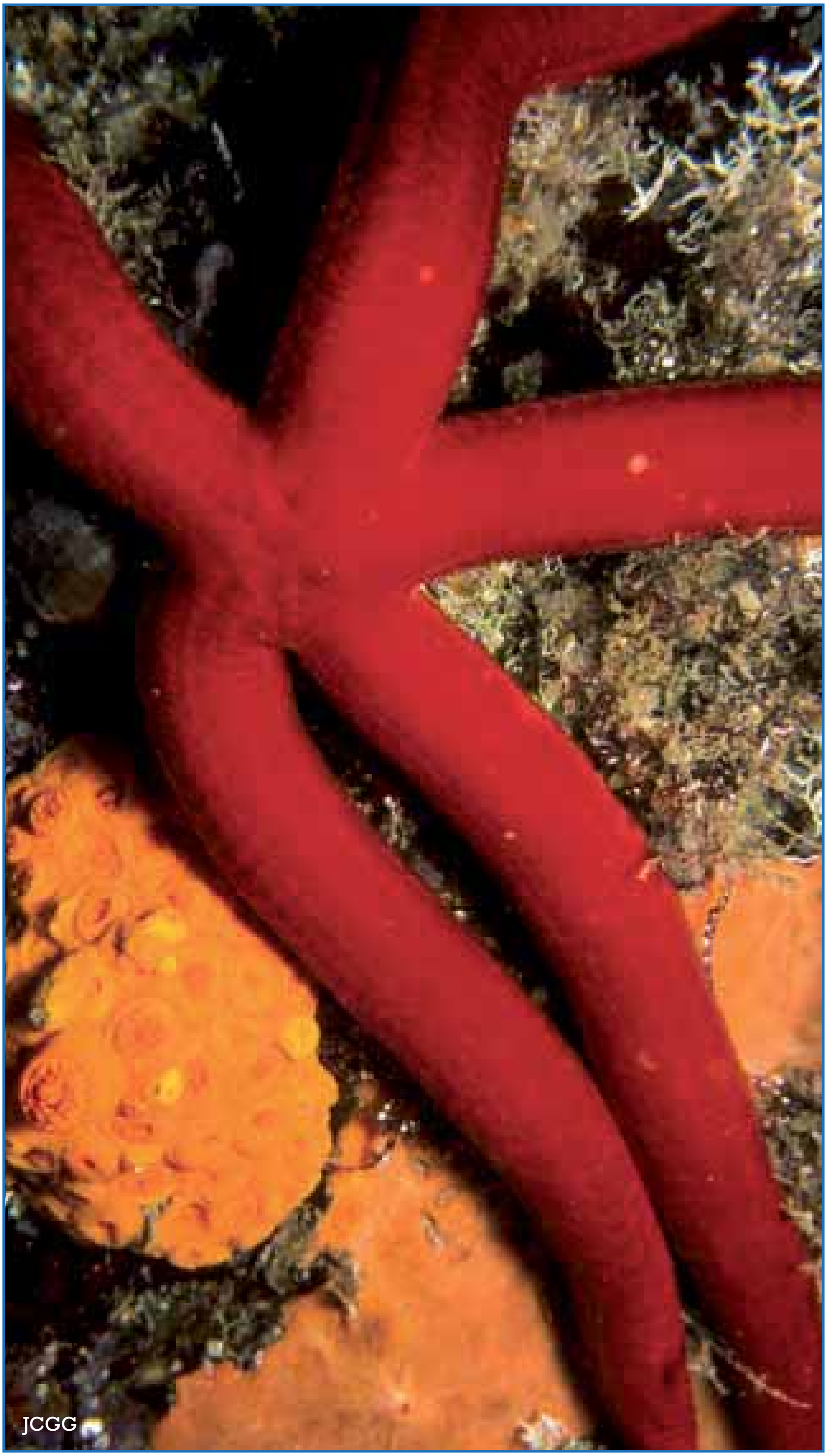
Included in the Barcelona Convention (Annex II: List of endangered or threatened species) and in the Berne Convention (Annex II: strictly protected fauna species).

Included in the Spanish List of Specially Protected Wildlife (LESRPE, Spanish Royal Decree 139-2011).

Included in the Red Data Book of the Invertebrates of Andalusia (Barea-Azcón *et al*., 2008), under the category “Vulnerable”.



Phot. 562



Phot. 563


FISHES
JCGG

12.10. *Apogon imberbis* (Linnaeus, 1758)

Phot. 565

Phylum: Chordata

Subphylum: Vertebrata

Class: Actinopterygii

Order: Perciformes

Family: Apogonidae

Genus: *Apogon*

Common name: King of the mullets or Cardinal fish

Description

A bright red species with a short, oval body and pinkish fins, examples grow to 15 cm long (**photo 565**). There are 2 or 3 black spots, sometimes merged together, along the base of the caudal (or tail) fin. The pectoral fins are long and rounded, reaching at least as far as the beginning of the anal fin. The first dorsal fin is triangular, while the second one is higher and broader than the first. It has large eyes, both the dorsal and ventral sections of the head are brown. The large mouth has a prominent lower jaw filled with small, fine teeth.

Habitat

Apogon imberbis is a migratory species and can be observed in solitary or forming part of a group. It normally lives on rocky substrates, in crevices or caves (**photo 566**). It is a very sciaphilic species (in other words, it prefers strictly shaded habitats). Therefore, it can only be observed by divers during the day if they look to the very backs and bottoms of crevices and cavities. Examples can be found in very shallow waters, including just 1 - 2 m in very shaded areas, down to depths of 200 m.

Distribution

Throughout the Mediterranean and nearby Atlantic, including the Strait of Gibraltar.

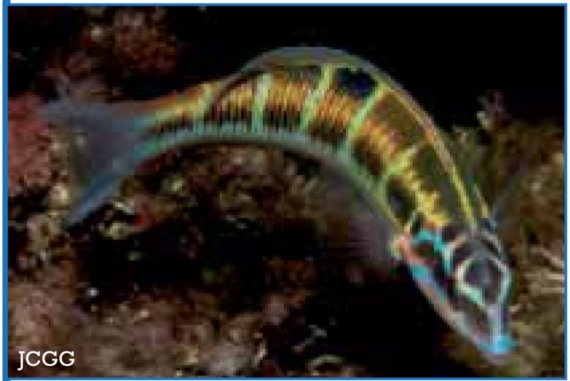
Environmental sensitivity

While it has occasionally been cited in muddy substrates, this species typical prefers rocky enclaves with very low light levels and “roofs”, it is sensitive to environmental disturbances and prefers clean, unpolluted and rejuvenated waters (Guidetti *et al.*, 2002, 2004; García-Gómez, 2007). However, if the said disturbances are not excessively significant, then it is possible the species numbers will not suffer (Guidetti *et al.*, 2003; Azzurro *et al.*, 2010).

Although *Apogon imberbis* does not leave its dark refuge during the daytime, observers should try to monitor it along their habitual diving route in the months when it is always present (groups of at least a few individuals) in specific caves or crevices which are easily located during routine dives (Bussotti *et al.*, 2003).

Phot. 566

12.11. *Thalassoma pavo* (Linnaeus, 1758)



Phot. 567

Phylum: Chordata
Subphylum: Vertebrata
Class: Actinopterygii
Order: Perciformes
Family: Labridae
Genus: *Thalassoma*
Common name: Ornate wrasse or Peacock wrasse

Description

This fish is characterized by its elongated, fusiform and laterally compressed body. It has a medium-sized, convex head with thin, retracted lips revealing conical teeth arranged in a single file along each jaw. The eyes are small. Both dorsal and anal fins are long, with the dorsal fins being the longer of the two, the posterior end is acute. Pectoral fins are long and oblique, while the ventral fins are quite short. Males reach lengths of up to 25 cm and are green with fine, pinkish, transverse lines; the head is reddish with blue arabesque patterns and the lips are white. There are transverse stripes of various colors running along the flanks. They have a blue strip on the flanks, in the pectoral fin area, there are also some longitudinal stripes of various colors on the dorsal and anal fins. Females measure up to 15 cm long, they are also green with 5 or 6 transverse blue stripes and have blue arabesque patterns on the head. Examples present a black patch on the dorsal region and longitudinal stripes on the unpaired fins. There are lots of different color variations which were previously considered to be different species. Despite these coloration differences, this species' appearance is easily differentiated from all the other species of wrasse, so it should not prove difficult to identify while diving. (**Photo 567**).

Phot. 568

Habitat

It is a very active, gregarious species which lives among rocky seabeds and meadows of phanerogams (**photo 568**, inside the circles; **photo 569**), habitually found in caves, openings, vertical walls, blocks of rock and stone covered by algae. Examples have also been observed inhabiting the rock/ sand and sand/phanerogam interface, including over muddy and coarse sands, gravel and detritic seabeds, as well as inside sponges and empty polychaete worm tubes. It is found at depths of between 1 and 50 m.

Distribution

Throughout the Mediterranean, including the Strait of Gibraltar. Along the eastern Atlantic, from Portugal to the Congo.

Environmental sensitivity

As with the majority of Mediterranean wrasse, it is a sensitive species that lives in clean, unpolluted and rejuvenated waters (García-Gómez, 2007). *Thalassoma pavo* is usually sensitive to water pollution (Azzurro *et al.*, 2010), but cases have also been cited in which the species' presence did not appear to be affected by different types of disturbance (Guidetti *et al.*, 2002, 2003, 2004; Araújo *et al.*, 2005).

Phot. 569

Although it is very elusive, it approaches divers without hesitation when they carefully lift up a stone to observe its infralapidicola coatings or selectively extract samples from the substrate. This makes the species easy to locate while on habitual diving routes, especially when diving at shallow depths (0 - 15 m) and in relatively undisturbed bottoms.

12.12. *Anthias anthias* (Linnaeus, 1758)

Phot. 570

Phylum: Chordata
Subphylum: Vertebrata
Class: Actinopterygii
Order: Perciformes
Family: Serranidae
Genus: *Anthias*
Common name: Swallowtail seaperch or marine goldfish

Description

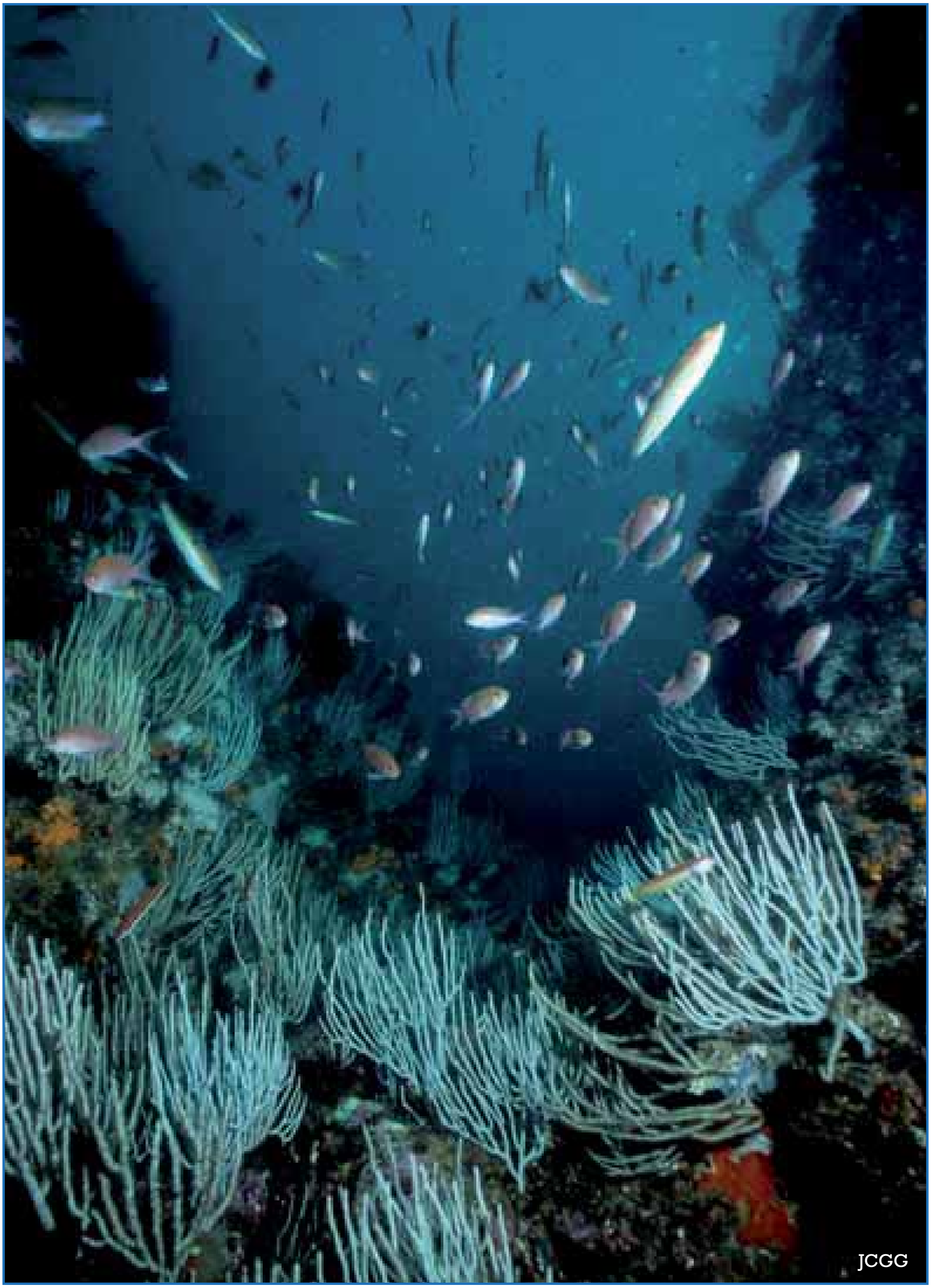
This species has a high, oval and laterally compressed body, it can reach 25 cm long but it is usually much smaller. It has a high head with a short face, a broad, oblique and protractible mouth and several small teeth. The lower jaw is more prominent than the upper and it has large eyes. The main body is red, while the abdomen has a lighter color. The flanks and nose exhibit three longitudinal, yellow stripes. Fins are violet around the edges. Its dorsal fin runs along practically the full length of its back; the pectoral fins are large, wide and round; ventral fins are very long and the caudal fin is very low-cut (**photo 570**).

Habitat

It tends to live in small groups. It is found near rocky bottoms, especially close to vertical walls (**photo 571**) and the entrances of holes and crevices (**photos 572 and 573**). However, dense shoals of this species are also observed over rocky blocks and horizontal rocky enclaves (i.e., close to rocky promontories) (**photos 574 and 575**). Generally found at depths of 20 meters or more, but it can also be encountered at lesser depths in shaded, rocky zones.

Distribution

Throughout the Mediterranean and Atlantic, including the Alboran Sea and the Strait of Gibraltar where it is very abundant.



Phot. 571

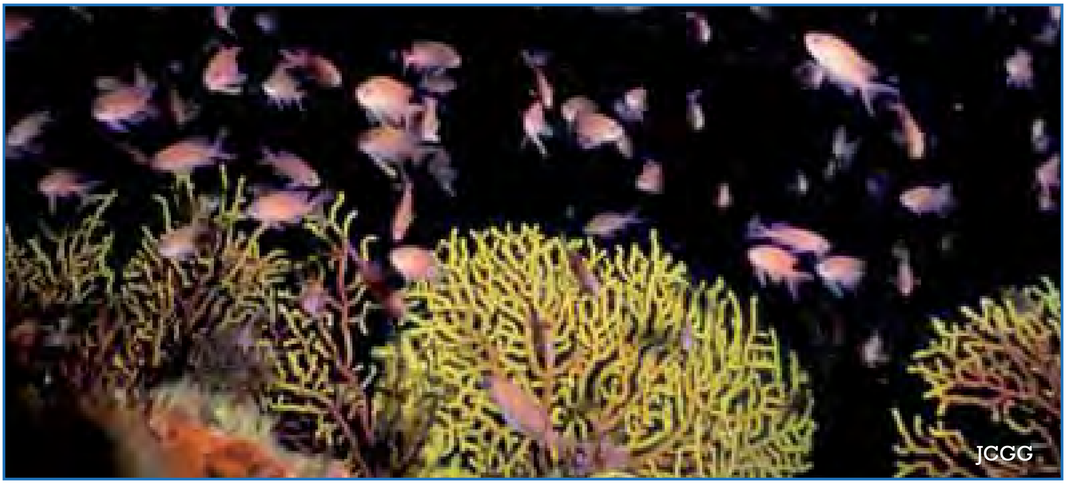
Phot. 572

Phot. 573

Environmental sensitivity

A sensitive species that requires clean, unpolluted and rejuvenated waters (García-Gómez, 2007), and as such it is usually more abundant in areas that receive protection than those which do not (Cecchi *et al.*, 2007; Consoli *et al.*, 2013). *Anthias anthias* delights divers, not only because of its abundance and color, but also because it lives very close to rocky surfaces which allows divers to get very close and feel pleasingly accompanied when passing over the rocky bottoms where this species dwells (Templado *et al.*, 2012). As such, when swimming along habitual diving routes at depths of 20 to 40 meters, these permanent companions will be missed if there is a severe disturbance impact which causes them to flee and disappear from areas where they were once ever-present.

Although still unconfirmed, the disappearance of this species (while it is habitually sedentary but since it possesses the capacity to actively flee from hypothetical deterioration of its environmental conditions) could be one of the first indications of the initial stages of an environmental disturbance. Contrastingly, benthic bioindicators permanently attached to the substrate cannot offer such a rapid response and indication of deterioration because, obviously, they cannot flee. For surveillance purposes, we recommend selecting an easily locatable site along a habitual diving route where divers can observe the continuous presence of large groups of the species.



Phot. 574

Phot. 575

12.13. *Phycis phycis* (Linnaeus, 1766)

Phot. 576

Phylum: Chordata
Subphylum: Vertebrata
Class: Actinopterygii
Order: Gadiformes
Family: Phycidae
Genus: *Phycis*
Common name: Forkbeard

Description

This species has an elongated, fusiform body with a slight degree of lateral compression. It can reach up to 1 m long and is colored brown-olive green with violet highlights, but this coloration becomes lighter along the sides until it blends into a white underside. It has a small head but a very large mouth with ends that nearly reach the eyes, the upper jaw is more prominent than the lower and it has small teeth. The species' eyes are relatively large. There are two dorsal fins of a similar height; the first is short and the second quite long. Both the pectoral and caudal fins are rounded. The ventral fins, located in front of the pectoral fins, are filamentous, forked and large; in fact they finish at the beginning of the anal fin. **(Photos 576 - 578).**

Habitat

A solitary species that inhabits rocky bottoms, above all crevices and caves **(photo 579).** Found from 20 down to 600 m.

Distribution

Throughout the Mediterranean including the Strait of Gibraltar and in the eastern Atlantic, from Ireland to the Cape Verde Islands.

Phot. 577

Environmental sensitivity

Phycis phycis is one of the species most exemplary of Spanish coralline habitats (Templado *et al.*, 2012), which always requires good environmental conditions. The fact that *P. phycis* is more abundant in areas where environmental protection measures are implemented compared to those lacking such protection is further evidence of its sensitivity to environmental disturbances (Cecchi *et al.*, 2007). Finally, the species has demonstrated low levels of accumulation of different toxic and contaminating elements (Carvalho *et al.*, 2005).

Phot. 578

Phot. 579

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APPENDIX

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CIES-SUB
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IT3 CLOUD

Datacentre service company responsible for creating the webs for accessing underwater images and the software for interpreting and analyzing the images.

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