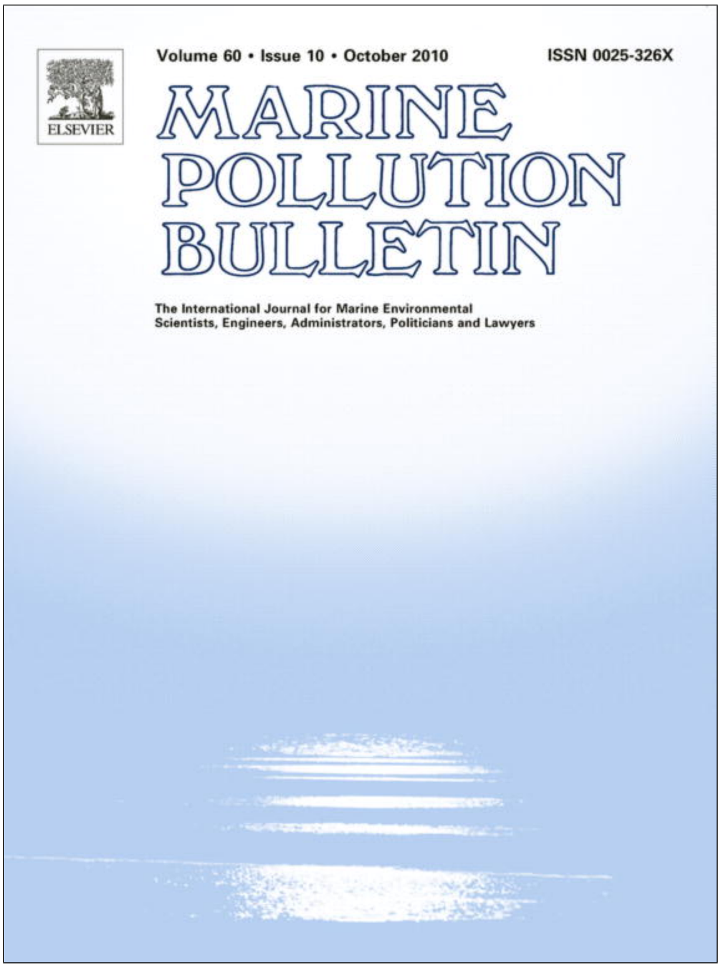
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Review

Human health benefits supplied by Mediterranean marine biodiversity

Josep Lloret *

University of Girona, Faculty of Sciences, Department of Environmental Sciences, 17071 Girona, Catalonia, Spain

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ABSTRACT

This paper summarizes the overall benefits supplied by Mediterranean marine biodiversity to human health and highlights the anthropogenic and environmental causes that are threatening these benefits. First, the Mediterranean Sea is a valuable source of seafood, which is an important component of the so-called "Mediterranean diet". This type of diet has several health benefits, including cardio and cancer protective effects, which are attributed to the high intake of seafood-derived n-3 (omega-3) fatty acids. Second, the Mediterranean marine organisms, particularly the benthic ones, have furnished a large variety of bioactive metabolites, some of which are being developed into new drugs to threat major human diseases such as cancer. Third, the Mediterranean coastal areas provide environments for practising maritime leisure activities that provide physical and psychological benefits to users. Despite all this, fishing, tourism, contamination and sea warming are deteriorating this rich marine ecosystem, which needs to be protected to assure human welfare.

1. Introduction

Marine ecosystems provide a wide range of goods and services which are essential for the human population. These include seafood, fuel, biological products for medicinal purposes, nutrient and waste management, climate regulation, development of tourism activities and nonmaterial benefits such psychological and emotional benefits (Chivian and Bernstein, 2008; National Research Council, 1999).

Traditionally, the focus of research and concern has been on the impact of human activities such as fisheries, aquaculture and tourism on these goods and services (King, 2007; Orams, 1999). However, the inter-relationships between human health and the marine biodiversity have been poorly studied (Chivian and Bernstein, 2008; National Research Council, 1999), and most of the attention has been given to the detrimental health impacts of emerging health risks such as pollution, toxic algal blooms and pathogens (Fleming et al., 2006; Bowen and Halborson, 1996). Only in recent years there has been increasing recognition of the beneficial direct impacts of marine ecosystems and biodiversity on human health (see e.g. Melillo and Osvaldo, 2008; Newman et al., 2008; Pandey, 2009; World Health Organization, 2005). But, compared with terrestrial ecosystems, the links between marine ecosystems and human health have been far less studied and the historical baseline of information is brief.

In all this, the Mediterranean Sea makes no exception, despite its great marine biodiversity. The Mediterranean basin has been ranked among the 25 "biodiversity hotspots" on earth, on the basis of its high species richness and endemism and the exceptional loss of habitat suffered by its biota (Myers et al., 2000). A rough estimate of more than 8500 species of macroscopic marine organisms live in the Mediterranean Sea, corresponding to somewhat between 4% and 18% of the world marine species, despite the Mediterranean Sea is only 0.82% in surface area and 0.32% in volume as compared to the world ocean (Bianchi and Morri, 2000). About 84% of these species are animals, of which 77% invertebrates and 7% vertebrates, whilst the 16% left are algae and sea grasses (Bianchi and Morri, 2000).

However, the inter-relationships between human health and the marine biodiversity remains far less understood than in other world-oceans, and most of studies have focused on health risks posed to humans by pathogens, algal blooms and contamination (Elhamri et al., 2007; Garcés et al., 2007; Martí-Cid et al., 2007; Masó and Garcés, 2006; Storelli, 2009; Storelli and Marcotrigiano, 2000). This paper summarizes for the first time the overall benefits supplied by Mediterranean marine biodiversity to human health and highlights the anthropogenic and environmental causes that are threatening these benefits.

2. Healthy Mediterranean seafood

2.1. The "Mediterranean diet" and the omega-3 fatty acids intake

In Mediterranean countries, the traditional diet (so-called "Mediterranean diet") has been consistently shown to be associated with favourable health outcomes and a better quality of life (reviewed by Sofi, 2009; Sofi et al., 2008). Several epidemiological

* Tel.: +34 972418269; fax: +34 972418150.
E-mail address: josep.lloret@udg.edu

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and observational studies suggest that this type of diet traditionally followed by Mediterranean people may protect against chronic diseases and mortality, with Mediterranean nations presenting lower rates of cardiovascular disease and cancer in comparison to other nations (Benetou et al., 2008; Trichopoulou, 2001). Cardiovascular diseases and cancer are the two most important causes of disease in the world. According to the (World Health Organization, 2009a,b), cardiovascular diseases and cancer accounted for an estimated 17 million and 8 million deaths in 2004 and 2007 respectively, representing 29% and 13% of all global deaths in those years, respectively. Greater adherence to this diet has been also associated with longevity in the elderly (Trichopoulou, 2004), a reduction of depressive disorders (Sánchez-Villegas et al., 2009), and prevention of iron deficiency (Mesías et al., 2009).

The long chain omega-3 (or n-3) fatty acids (eicosapentanoic and docosahexanoic fatty acids) found in seafood, which is an important component of the "Mediterranean diet" (Simopoulos, 2001; Willett et al., 1995), have been identified as a main element responsible for this cancer and cardio protective effect in Mediterranean populations (Ortega, 2006; De Lorgeril and Salen, 2007; Chrysohoou et al., 2007; Bosetti et al., 2009). The relatively high intake of essential n-3 fatty acids by Mediterranean people contributes to a healthy diet in several ways. First, fish consumption has been shown to reduce coronary heart disease mortality because omega-3 fatty acids from fish oil help to improve cardiovascular health by decreasing risk factors such as triglyceride concentrations, blood pressure, platelet aggregation and heart arrhythmias (Fung et al., 2009; Chrysohoou et al., 2007; Mozaffarian and Rimm, 2006; Mozaffarian, 2009). Second, fish-derived omega-3 fatty acids consumption protects against the development of certain cancers, e.g. mammary (Stoll, 2002) and prostate cancers (Itsiopoulos et al., 2009).

In addition to the cardio and cancer protective effects of fish consumption, fish intake in the Mediterranean has been also associated with less severe depressive symptoms in adults (Bountziouka, 2009) and less development of asthma and respiratory allergies in children (Biltagi et al., 2009; Olsen et al., 2008). Omega-3 fatty acids also mediate the inflammatory process and influence the general health status of the skeletal system throughout the body (Watkins et al., 2001; Benito et al., 2005).

Biological and chemical investigations have shown that Mediterranean seafood species are a good dietary source of omega-3 fatty acids, particularly the pelagic fish species such as sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), mackerel (*Scomber scomber*) and bluefin tuna (*Thunnus thynnus*), and crustaceans such as lobster (*Palinurus elephas*) and crabs (*Liocarcinus* spp). The muscle (i.e. the edible part) of these pelagic fishes and crustaceans can contain up to 10 more times of total lipids and omega-3 fatty acids than that of demersal fish species such as angler (*Lophius* spp) or hake (*Merluccius merluccius*), or mollusks such as squid (*Loligo vulgaris*) and cuttlefish (*Sepia officinalis*) (Tornaritis et al., 1993; Soriguer et al., 1997; Imre and Saglik, 1998; Saglik and Imre, 2001; Mourente et al., 2001; Sirot et al., 2008). Pelagic species tend to concentrate the lipid reserves in their muscle whereas demersal species tend to concentrate lipids in their livers or mesenteries (Lloret et al., 2008a; Soriguer et al., 1997). Pelagic species contribute the most to the total Mediterranean landings, representing about 67% of the total landings (compared to 59% in the Pacific, 51% in the Atlantic, 45% in the Indian Oceans according to FAO, 1995). Thus, marine resources of the Mediterranean represent a particularly important stock of omega-3 fatty acids.

Despite fish-derived omega-3 fatty acids consumption seems to be an important determinant of the health of Mediterranean people, some authors have suggested that the role of the overall Mediterranean dietary pattern may be more important than the effect of single components (Sánchez-Villegas et al., 2009). Thus, there may be a fair degree of protection from the combination of the omega-3 fatty acids found in fish with other natural ingredients in olive oil, nuts, fruit and plant foods, which are also common in the Mediterranean diet (Sánchez-Villegas et al., 2009).

2.2. Other healthy constituents of Mediterranean seafood

Apart from the omega-3 fatty acids, seafood species are an important source of high-quality proteins, minerals and vitamin D (Médale et al., 2003). Seafood species are particularly rich in selenium and iron. Selenium is an essential dietary trace element that plays an important role in antioxidant defense systems and may protect against cardiovascular disease and the toxic effects of mercury (Mozaffarian, 2009). Iron is involved in energy metabolism as an oxygen carrier in hemoglobin and its deficiency is the most common single-nutrient deficiency disease in the world affecting most seriously women, children and adolescents of underdeveloped countries (Trowbridge and Martorell, 2002), including north African Mediterranean countries (Bagchi, 2004).

More recently, the field of available world marine food sources has been further increased by also including some algae, which are a potentially great source of natural compounds that could be used as functional ingredients (Plaza et al., 2009; Ortega, 2006). Marine macro and micro algae are important sources of proteins, amino acids, essential fatty acids such as the linoleic acid (or omega-6 fatty acid), vitamins, polysaccharides and other carbohydrates that have been used worldwide as food supplements (Borowitzka, 1995; Becker, 2007). However, Mediterranean algae species are not used directly as food; only some species belonging to the genus *Gracilaria* are used to obtain agar, an additive used by food industries for its jellifying properties (Joubert et al., 2009; Marinho-Soriano and Bourret, 2005).

2.3. Threats

Despite the importance of seafood for a healthy diet, overfishing in the Mediterranean is threatening some fish stocks (European Commission, 2004). In the Catalan Sea and the Adriatic Sea, for example, total landings of sardine and anchovy have steadily decreased over the last decades (Palomera et al., 2007), as well as landings of bluefin tuna and tuna-like species in the Mediterranean (ICCAT, 2009). The depletion of these fish stocks, particularly the pelagic oily fish populations, is reducing the potential supply of long chain omega-3 fats. The current recommendations of governmental health agencies to people in developed countries, to increase their intakes of fatty fish by at least 2–3-fold, are incongruent with the collapse of global fish stocks (Jenkins et al., 2009). This raises the necessity to better manage fisheries in the Mediterranean in order to avoid overexploitation and allow stock recovery, and, at the same time, to seek about alternative sources of omega-3 fatty acids such as marine algae, microorganisms and plants (Surette, 2008).

Furthermore, microbial and chemical contamination is threatening throughout the world the seafood quality and quality (Fleming et al., 2006). In the Mediterranean, pathogens such as parasites (see e.g. Manfredi et al., 2000; Rello et al., 2009); pollutants such as heavy metals, dioxins and polychlorinated biphenyls (PCBs; see e.g. Storelli, 2009; Storelli and Marcotrigiano, 2000; Elhamri et al., 2007; Martí-Cid et al., 2007); and toxins from harmful microalgae blooms (see e.g. Masó and Garcés, 2006; Garcés et al., 2007), are affecting the safety of the seafood supply. The health benefits and risks associated to seafood consumption are leading to controversy. Thus for example, concerns regarding potential cancer risks of the PCBs/dioxins and mercury, which are present in some fish species (particularly in large pelagic fish, which are also the richest in omega-3 fatty acids), have tempered the perception of fish as a healthy food (Mozaffarian, 2009; Mozaffarian and Rimm, 2006).

Apart from the impact of fishing and pollution, climate change is emerging as a key factor that could have considerable implications for the exploited natural resources word-wide. Climate change is leading to a warming of the Mediterranean (Bethoux and Gentili, 1996) and changes in the productivity of small pelagic fishes (Sabatés et al., 2006).

3. Medicines from Mediterranean marine species

Approximately one-third of today's best selling drugs are either natural products or have been developed based on lead structures provided by nature (Menna, 2009) and almost 60% of drugs approved for cancer treatment are of natural origin (Amador et al., 2003). However, up to now almost all medicinally used natural products or derivatives thereof were obtained from terrestrial organisms rather than from those inhabiting the sea (Menna, 2009). The study of marine organisms for their bioactive potential has increased in recent years. Many marine species, from sharks to algae, produce bioactive compounds with important potential applications as medical drugs (Amador et al., 2003; Calvert, 2005; Fusetani, 2000; Blunt et al., 2008). Overall, about 15,000 pharmacologically active compounds have been isolated from marine species, many of them being structurally unique and absent in terrestrial organisms (Newman and Cragg, 2004). Out of these, in 2008 there were 45 derived natural products tested to be used as medical drugs in preclinical and clinical trials, even though only two of them have been developed into registered drugs (Wijffels, 2008).

In the Mediterranean Sea, the majority of bioactive (antibacterial, antifungal, antiviral, cytotoxic or antifouling) molecules have been isolated from benthic species: algae, marine phanerogams and, particularly, animals such as sponges, bryozoans, echinoderms, polychaetes, ascidians, molluscs and cnidarians (Uriz et al., 1991; Becerro et al., 1997). These chemical compounds serve as a form of defence against predators, competitors and invading microorganisms and parasites (Blunt et al., 2008; De Rosa, 2002; Uriz et al., 1991, 1992; Wahl and Banaigs, 1991; Becerro et al., 1997; Pronzato, 1999).

3.1. Ascidians and sponges

Among benthic animals, soft-bodied, sessile animals such as sponges and ascidians have concentrated most of the interest in pharmaceutical studies. The toxic chemicals are crucial for invertebrates lacking morphological defence structures such as shells or spines (Blunt et al., 2008; De Rosa, 2002). Indeed, ascidians and sponges are the most prolific marine producers of novel compounds in terms of new metabolites reported annually (Taylor et al., 2007; Menna, 2009). Furthermore, more ascidian and sponge-derived compounds are in clinical and preclinical trials (e.g., as anticancer or anti-inflammatory agents) than compounds from any other marine taxa (Taylor et al., 2007; Menna, 2009). Taking into account that there are about 130 species of ascidians and 629 species of sponges in the Mediterranean, of which nearly half of them are endemic to this sea (Voultsiadou, 2009), there is still a huge potential for discoveries in these two groups.

Ascidians represent the most highly evolved group of animals commonly investigated because they have a great ability to produce an array of cytotoxic molecules (Menna, 2009). In a NW Mediterranean survey, ascidians were among the three most bioactive taxa (Uriz et al., 1991). Among the first six marine derived compounds that have reached clinical trials as antitumour agents, three were derived from ascidians, as evidence of the high potential of these organisms as a new source of antitumour compounds (Menna, 2009). Yondelis, which has been derived from a Caribbean ascidian, is one of the few marine compounds being developed into a registered and commercialized drug in the European Union with indications in soft tissue sarcomas and ovarian cancer (Menna, 2009; http://www.pharmamar.com/yondelis.aspx). Although a large of marine compounds are described as potential drugs, very few have reached the stage of commercial production like Yondelis has been able to. Aplidine, a chemical compound derived from the Mediterranean ascidian *Aplidium albicans*, has been shown to be a powerful anticancer agent (Taddei et al., 2006; Le Tourneau et al., 2007) and is currently in clinical trials for a variety of cancers (Menna, 2009; http://www.pharmamar.com/aplidin.aspx). Another Mediterranean ascidian showing antitumoral activity is *Tridemnum inarmatum* (Ioannou et al., 2009). Recently, sulphated compounds having cytotoxic or antimicrobial activity have been isolated from Mediterranean ascidians of the families Ascidiidae and Polyclinidae (Aiello et al., 1997; Menna, 2009).

A wide variety of novel secondary bioactive metabolites have been isolated from various species of marine sponges world-wide, including powerful antiviral, antimalarial, antitumour and anti-inflammatory, as well as antimicrobial (antibiotic) compounds (Faulkner, 2002). Mediterranean sponges have been screened for their bioactivity in several areas. In the Tunisian coast, seven sponge species have been shown to possess a specific antibiotic activity, with *Agelas oroides* and *Axinella damicornis* being the most bioactive ones (Touati et al., 2007). In the Western Mediterranean, sponges presented the highest percentage of bioactive species of all groups of benthic animals studied: among 59 sponge species studied, 90% any kind of biological activity, whether it was cytotoxic, antibacterial, antiviral or antifungal (Uriz et al., 1991, 1992). In the Adriatic coast, 21 sponges analyzed had cytotoxic activity and two species presented antimicrobial activity (Sepcic et al., 1997). In the French Mediterranean coast, 28 sponges revealed that most of them presented antibacterial and antifungal activities, particularly the species *Aplysina cavernicola* (Amade et al., 1987). This study also demonstrated that a higher percentage of Mediterranean sponges than Polynesian ones (from which several active compounds have been also isolated) produced antimicrobial extracts (Amade et al., 1987). In Italy, the Mediterranean sponge *Rhaphisia lacazei* showed antiproliferative activity against human broncopulmonary cancer cells (Casapullo et al., 2000). Among all sponge species studied, it seems that *Reniera sarai* is the one presenting the broader and stronger spectrum of biological activities including antimicrobial and antitumoral ones (Sepcic et al., 1997; Chelossi et al., 2006; Turk et al., 2007).

3.2. Other animal benthic species

Other Mediterranean animal benthic species such as opisthobranchs, cnidarians, echinoderms and bryozoans are being studied for their pharmaceutical interest, even though the number of investigations is much lower compared to ascidians and sponges. Recent discoveries, however, offer new insights into the pharmaceutical interests of these groups.

Opisthobranchs, a group of soft-bodied molluscs, are currently receiving an increasing attention world-wide (Cimino and Gavagnin, 2006). A number of chemicals derived from these animals exhibit bactericidal, antifouling or antitumoral activities (Fahey and Carroll, 2007; Faulkner, 2002; Shubina et al., 2007; Cimino and Gavagnin, 2006). Recent studies reveal that a number of the 243 existent Mediterranean opisthobranchs (Le Renard, 2009) present chemical compounds that are biologically active (Cimino et al., 2004, 1999; Fontana, 2006).

Cnidarians have also proven to be a source of biologically active chemical molecules (Blunt et al., 2008). Among them, gorgonians have been the subject of numerous chemical investigations (Blunt et al., 2008; Koh et al., 2002). Recently, the antitumoral activity of a chemical compound derived from the Mediterranean gorgonian *Eunicella cavolini*, which is one of the most abundant gorgonian species in the Mediterranean Sea, has been demonstrated (Ioannou et al., 2008, 2009). Furthermore, new steroids exhibiting pharmacological activities have been isolated from the deep-water Mediterranean coral *Dendrophyllia cornigera* (Kontiza et al., 2006).

Bryozoans and echinoderms are two groups of benthic animals that produce bioactive compounds too (Mutter and Wills, 2000; Yokota, 2005). Novel metabolites showing antitumoral activity have been isolated from the Mediterranean bryozoan *Myriapora truncata* (Cheng et al., 2007), while the antifungal activity of the Mediterranean sea cucumber, *Holothuria polii* has been recently demonstrated (Ismail et al., 2008).

3.3. Algae and marine phanerogams

There are numerous reports of macroalgae derived chemical compounds that have a broad range of biological activities, such as antibiotic, antiviral, antifouling, anti-inflammatory, cytotoxic and antimitotic, some of which have been used in pharmaceutical industries (Chen and Jiang, 2001; Borowitzka, 1995). In the Mediterranean, the extracts from several macroalgae species such as *Jania rubens*, *Cystoseira mediterranea*, *Posidonia oceanica* and, particularly, *Falkenbergia rufolanosa*, have been shown to have antibacterial and/or antifungal activities (Calvo et al., 1986; Bernard and Pesando, 1989; Uriz et al., 1991; Ballesteros et al., 1992; Salvador et al., 2007), whereas other algae species such as *Asparagopsis taxiformis* and *A. armata* showed remarkable antiprotozoal activity against *Leishmania* (Genovese et al., 2009). Furthermore, some proteins such as the Phycoerythrin, which in the Mediterranean has been extracted and purified from the red algae *Corallina ellongata*, have gained importance in immunodiagnostic, therapy and cosmetics (Rossano et al., 2003). New lipids exhibiting an array of pharmacological activities have been also isolated from *Cymodocea nodosa* (Kontiza et al., 2006), a marine phanerogam species which is distributed along the Mediterranean coasts, the North Atlantic coast of Africa and the Canary Islands. Mediterranean phytoplankton may also constitute a potential source of new sterols (Rontani and Marchand, 2000), which could be used as starting materials for the synthesis of hormone steroids (Borowitzka and Borowitzka, 1988).

3.4. Marine microorganisms

Marine-based microorganisms are also a potential source of new medicines. However, the successes to date are based upon a very limited investigation of these microorganisms in few areas of the world oceans, including the Mediterranean (Pushparaj et al., 1999), suggesting a high potential for continued discovery of new drugs from these microbes (National Research Council, 2002). Accumulated evidence also suggests that microorganisms living in the body of sponges could well be the true source of at least some of these metabolites found in Mediterranean sponges (Thiel and Imhoff, 2003) and in other species from other oceans (Taylor et al., 2007; Anand et al., 2006). Marine sponges often contain diverse and abundant microbial communities, including bacteria, microalgae, and fungi. In some cases, these microbial associates comprise as much as 40% of the sponge volume and can contribute significantly to host metabolism via e.g. photosynthesis or nitrogen fixation (Taylor et al., 2007).

3.5. Threats

Despite the human health benefits provided by the organisms reviewed before, benthic species are impaired by a wide variety of human activities and environmental change. Bottom trawling causes widespread disturbance of sediments in shelf seas and can have a negative impact on benthic fauna both in soft and hard bottoms (see e.g. Hiddink et al., 2006). In the Mediterranean, several studies have shown the impact of trawling on benthic animals such as molluscs, sponges and ascidians living in soft bottoms of the continental shelf (Demestre et al., 2000; Pranovi et al., 2001; De Biasi, 2004; De Juan et al., 2007). Thus, bottom trawling adversely affects the potential discovery of new medicines from benthic animals.

On the other hand, microbial and chemical contamination is threatening several sponge populations of the world oceans (Webster, 2007; Taylor et al., 2007). Sponge disease epidemics can have serious long-term effects on sponge populations, especially in long-lived, slow-growing species (Webster, 2007). Reports of sponge disease have increased dramatically in recent years with sponge populations decimated throughout the world oceans and seas, particularly the Mediterranean (Pronzato, 1999). In some cases, the synergetic action of harvesting and disease has taken a number of sponge populations to the brink of extinction (Pronzato, 1999).

Furthermore, there are numerous impacts of recreational uses on coastal benthic species of the Mediterranean. These range from the impact of recreational boating on seagrass meadows, the effects of scuba-diving on hard-sessile benthic invertebrates and the human trampling's effects on rocky shallow areas (Lloret and Riera, 2008). Sea-grasses such as *Posidonia oceanica* and macro algae such as *Cystoseira mediterranea* are suffering from mechanical damage caused by anchors of pleasure boats (see e.g. Lloret et al., 2008b; Francour et al., 1999). Diving, despite is generally considered a non-destructive activity, is also impacting on the coastal environment because of the increment of scuba divers over the last decades in certain areas. Thus, some popular Mediterranean diving sites have become over frequented and in these sites, the coralligenous community suffers from unintentional contact from divers, particularly hard sessile invertebrates such as gorgonians and bryozoans (Sala et al., 1996; Badalamenti et al., 2000). Human trampling is also having a negative impact on biological diversity of rocky shores in the Mediterranean, particularly on macroalgae (Milazzo et al., 2002a,b).

In addition, cold-temperate, sessile animals such as the gorgonians *Paramuricea clavata* and *Eunicella singularis* are negatively affected by sea warming (Perez et al., 2000; Garrabou et al., 2001). The mass mortalities of these animals were related to the growth of opportunistic pathogens that benefit from sea warming (Cerrano et al., 2000).

4. Marine recreation and human health

Currently, the Mediterranean has become the world's leading tourist area, accounting for approximately 35% of all international tourist arrivals and revenues (Farsari et al., 2007). Different leisure activities such as recreational fisheries, scuba diving, whale watching and snorkelling have been built upon the exploitation or contemplation of different marine species, from cnidarians to mammals (see e.g. Lloret, 2010).

4.1. Physical and psychological benefits

The value of leisure in natural settings to humans is multiple and includes physical and psychological benefits (World Health Organization, 2003; Melillo and Osvaldo, 2008). Most of maritime leisure activities imply physical exercise, which is known to improve cardiovascular health (see e.g. Satoru et al., 2006; Carr et al., 2009; Bell et al., 2008) and help to prevent obesity and cancer (see e.g. Friedenreich and Orenstein, 2002; Bell et al., 2008). In particular, swimming, which is the most popular leisure activities conducted in Mediterranean coastal waters, can lower some of the coronary heart disease risk factors (Tanaka, 2009). There is also strong evidence suggesting that leisure activities conducted in the nature specifically can help to prevent or improve many mental health disorders, which are increasingly becoming a significant public health issue worldwide (Prince et al., 2007). Thus, recreational activities conducted in the nature can improve mental attention (see e.g. Pretty et al., 2005) and other psychological aspects of health such as mood (see e.g. Taylor et al., 2001), as well as reduce stress (Wells and Evans, 2003). In particular, swimming is known to prevent anxiety and depression (Wylie, 1994).

4.2. Threats

Pollutants such as heavy metals, dioxins and polychlorinated biphenyls (PCBs; see e.g. World Health Organization, 2003); and toxins from harmful microalgae blooms (HABs; see e.g. Masó and Garcés, 2006; Garcés et al., 2007), are affecting the recreational use of coastal marine waters in the Mediterranean. There is also strong evidence that the apparent increase of harmful algal and jellyfish blooms and pathogens in the Mediterranean coastal waters is in part due to sea warming (CIESM, 2001; Danovaro et al., 2009; Molinero et al., 2005). Maritime recreation itself (recreational fisheries, scuba diving, etc.) can adversely affect the marine environment (see e.g. Lloret, 2010).

5. Conclusions

This paper shows that the maintenance of a high Mediterranean biodiversity provides natural medicines, healthy seafood products and recreational opportunities that contribute to human well-being. The Mediterranean is a source of great biological diversity with an almost unexplored potential to provide significant therapeutic, as well as nutritional, benefits for humans. However, marine species from the Mediterranean are suffering from several anthropogenic and environmental impacts that are threatening these health benefits. The investigation and preservation of such diverse environment has significant health implications for current and future generations, not only for local people inhabiting in the Mediterranean border countries but also for the millions of tourists visiting each year this sea. Through the recognition of the interdependence of the health of both humans and the Mediterranean Sea made in this paper, it is hoped that more efforts will be made to restore and preserve the Mediterranean marine ecosystem. We need a sustainable exploitation of marine life and comprehensive conservatory measures for maintaining the rich Mediterranean marine biodiversity to assure human welfare. The creation of new coastal and offshore marine protected areas, where all kind of fishing and recreational activities are strictly regulated and where trawling is prohibited, may be best single management action that could effectively help preserving the health benefits provided by Mediterranean marine biodiversity. These areas will contribute to protect the marine benthos and the fishery resources, thus preserving the main health sources for humans (in the form of potential new medicines, healthy seafood and space for recreation).

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