Loss of functional diversity of fish due to intense fishing causing ecosystem-wide effects in Mediterranean sublittoral rocky reefs

By Paolo Guidetti

MARINE ECOSYSTEMS MAY undergo dramatic changes (for example, shifts between alternative community states, changes in ecosystem functioning and food-web disruption) because of the wide array of anthropogenic impacts they are usually subjected to (Pauly *et al*, 1998; Jackson *et al*, 2001).

© S Bava

The sea bream *Diplodus sargus sargus*, predator of adult and juvenile sea urchins in Mediterranean sublittoral rocky reefs.

This is especially true in regions like the Mediterranean basin where human populations tend to concentrate in coastal areas and where extractive activities (especially fishing) are historical and intense. Assessing direct and indirect impacts of fishing on natural communities (and the spatial and temporal scales at which they act) is one of the major challenges marine ecologists have to tackle worldwide in order to refine appropriate policies for an ecosystem-based management of fishery (Pikitch *et al*, 2004).

As in many other temperate regions, there is increasing evidence that sublittoral rocky reefs in many sectors of the Mediterranean Sea are shifting from macroalgal beds to barrens or areas without vegetation, usually caused by excessive grazing. This transition has often been attributed to changes in the rate herbivores (especially sea urchins) feed upon erect macroalgae as an indirect consequence of human activities (Sala *et al*, 1998; Guidetti *et al*, 2003). In coastal waters, erect macroalgae (together with seagrasses) exert paramount ecological roles: they are among the most important primary producers, contribute to the availability of detritus (which can also be exported into deep seas) and provide sizeable structure where many fish and invertebrate species (both as juveniles and adults) find shelter and food. Biodiversity in macroalgal beds, in addition, is far higher than in coralline barrens, as observed in other temperate regions (Graham 2004).

Sea urchins overgraze erect macroalgae especially when at high density, a condition that depends on several factors such as recruitment and the occurrence of mass mortalities, but there is increasing evidence that predators can be capable of controlling sea urchin population density (Sala & Zabala 1996; Guidetti 2004a; Hereu *et al*, 2004). The most effective sea urchin predators in the Mediterranean Sea are a few species of fish, mainly represented by sea breams (preying upon juvenile and adult urchins; e.g. *Diplodus sargus sargus*, pictured), and, secondarily, by wrasses (that feed only upon juvenile urchins; e.g. *Coris julis*) (Sala 1997; Guidetti 2004b). Density and size of sea breams, in particular, can be drastically reduced by fishing (to their functional extinction), which may be reflected as lower predation impact on sea urchins (Guidetti 2004a). When released from predator control, sea urchins increase in abundance and overgraze erect macroalgae, thus causing the transition to barrens. Fishing, by strongly and selectively impacting sea breams (Harmelin *et al*, 1995; Guidetti & Sala, unpublished data), may thus decrease the functional diversity of the fish predator assemblage in subtidal rocky reefs. This, consequently, may have cascading effects on the entire community and ecosystem functioning, as macroalgal beds and coralline barrens are structurally and functionally very different.

Scientific evidence of the trophic cascade involving fish, sea urchins and macroalgae triggered by fishing is restricted to a few areas of the Mediterranean basin. Trophic interactions, however, may change depending on the species (or trophic groups) involved, and may be context-dependent (O'Connor & Crowe, 2005). Both assemblage diversity and environmental contexts, from this perspective, may change in space (e.g. with latitude) and time (e.g. seasonally or on a multi-annual basis).

Further experiments, correlative and/or historical analyses, therefore, are more than welcome with the aims (1) to depict scenarios that may help understand possible thresholds in the density of strongly interactive species (e.g. keystone predators) that may push ecosystems to the brink, and (2) to plan appropriate management of fisheries based on the perception that ecosystem functioning and community structure may depend on the intensity of exploitation of high-level fish predators. The MarBEF RMP "Causes and consequences of changing marine biodiversity: a fish and fisheries perspective," led by Brian MacKenzie and Pascal Lorance, will provide an opportunity to deepen existing knowledge in some of these key areas and also to compare and contrast different results and experiences from areas outside of the Mediterranean, thus helping to refine management decisions, for example the management of coastal fisheries.

Paolo Guidetti
CoNISMa
University of Lecce, Italy
Email: paolo.guidetti@unile.it

References

Graham, MH, 2004. Effects of local deforestation on the diversity and structure of Southern California giant kelp forest food-webs. *Ecosystems* **7**: 341-357

Guidetti, P, Fraschetti, S, Terlizzi, A, Boero, F, 2003. Distribution patterns of sea urchins and barrens in shallow Mediterranean rocky reefs impacted by the illegal fishery of the rock-boring mollusc *Lithophaga lithophaga*. *Mar. Biol.* **143**: 1135-1143

Guidetti, P, 2004a. *'Top-down' control in Mediterranean rocky reef communities.* PhD dissertation, University of Lecce, Italy.

Guidetti, P, 2004b. Consumers of sea urchins, *Paracentrotus lividus* and *Arbacia lixula*, in shallow Mediterranean rocky reefs. *Helgoland Mar. Res.* **58**: 110-116

Harmelin, JG, Bachet, F, & Garcia, F, 1995. Mediterranean marine reserves: fish indices as tests of protection efficiency. *P.S.Z.N.: Mar. Ecol.* **16**: 233–250

Hereu, B, Zabala, M, Linares, C, Sala, E, 2004. Temporal and spatial variability in settlement of the sea urchin *Paracentrotus lividus* in the NW Mediterranean. *Mar. Biol.* **144**: 1011-1018

Jackson, JBC, Kirby, MX, Berger, WH, Bjorndal, KA, Botsford, LW *et al*, 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science* **293**: 629-638

O'Connor, NE, Crowe, TP, 2005. Biodiversity loss and ecosystem functioning: distinguishing between number and identity of species. *Ecology* **86**: 1783-1796

Pauly, D, Christensen, V, Dalsgaard, J, Froese, R, Torres Jr, F, 1998. Fishing down marine food webs. *Science* **279**: 860-863

Pikitch, EK, Santora, C, Babcock, EA, Bonfil, R, Conover, DO *et al*, 2004. Ecosystem-based fishery management. *Science* **305**: 346-347

Sala, E, Zabala, M, 1996. Fish predation and the structure of the sea urchin *Paracentrotus lividus* populations in the NW Mediterranean. *Mar. Ecol-Prog. Ser.* **140**: 71-81

Sala, E, 1997. Fish predators and scavengers of the sea urchin *Paracentrotus lividus* in protected areas of the north-west Mediterranean Sea. *Mar. Biol.* **129**: 531-539

Sala, E, Boudouresque, CF, Harmelin-Vivien, ML, 1998. Fishing, trophic cascades, and the structure of algal assemblages: evaluation of an old but untested paradigm. *Oikos* **82**: 425-439

Biodiversity Conservation

Europe's role in conserving biodiversity through a sustainable marine aquarium trade

By Paul Holthus

EUROPE IS THE second major importer of coral reef organisms for home aquariums. Marine ornamentals come primarily from developing countries with high marine biodiversity. International certification now enables importing countries to transform their ecological footprint in the aquarium trade from one that potentially supports destructive fisheries to one that conserves biodiversity, reduces poverty and creates sustainable livelihoods – thereby implementing the Convention on Biological Diversity. Several European marine ornamentals importers are MAC-certified, with many retailers soon to follow.

Collectors' gear, Bohol, The Philippines.

Despite the importance of coral reefs in sustaining human life and livelihoods and as one of the world's most diverse marine systems, the majority of the world's reefs are threatened by human activity. A responsible marine ornamentals trade has great potential to provide an incentive to coastal communities to protect their coral reefs from these threats and to thus ensure that they can continue to support biodiversity and economic benefits.

Approximately 45 countries, mostly in the developing world, supply marine ornamentals, with the Philippines and Indonesia as the largest exporters, with an estimated 7,000 marine aquarium collectors in the Philippines alone. Aquarium animals are the highest value products possible to harvest sustainably from coral reefs. Aquarium fish sell for about EUR 90.00/kg compared to food fish at EUR 1.00/kg. On average, live coral is worth EUR 1.30/kg, while crushed coral for lime sells for EUR 0.01/kg. An environmentally responsible high-value aquarium fishery can alleviate the poverty that drives people to use destructive fishing practices, such as blasting with dynamite to gather food.

Marine Aquarium Council (MAC) certification

Many aquarium-fish collectors and industry members use practices that prove it is possible to harvest marine ornamentals in a responsible, environmentally-sound manner. However, in some areas collection methods are used that destroy coral reefs. For example, some collectors use sodium cyanide to stun fish for easy capture, at the same time harming target and non-target species, including the reef-building corals themselves. Some collectors, exporters, importers and retailers also use poor post-harvest handling and transport practices resulting in unnecessary mortality of harvested animals.

The Marine Aquarium Council (MAC) is an international not-for-profit organisation that brings together the marine aquarium industry and hobbyists, public aquariums and conservation groups as well as government agencies and international organisations to support reef conservation and a sustainable marine aquarium trade. MAC certification was launched in late 2001, following years of input and review through an international, multi-stakeholder process to develop standards of best practice for quality and environmental sustainability. The certification provides third-party verification and labelling to identify responsible operators and their products that comply with MAC standards, allowing consumers to choose and support responsible operators and sustainable products.

MAC certification is designed to transform the existing marine ornamentals trade and does not promote the trade where it does not exist. For example, only non-destructive methods are allowed, and catch levels must remain within the limits of sustainability as proved by independent scientific assessment and monitoring. MAC certification also requires a reef management plan developed through multi-stakeholder involvement at the community level, including establishing a marine protected area, such as a 'no-take sanctuary' for reef fish.

Reef, fish and fisheries monitoring/management

It is critical to have a sound scientific understanding of the status of marine aquarium organisms and their coral reefs so that an informed decision can be made about sustainable-use levels and reef management. MAC requested the Global Coral Reef Monitoring Network (GCRMN) to develop methods to assess the status and condition of reefs and fish stocks in collection areas and evaluate the effectiveness of management by monitoring coral reefs and populations of exploited organisms and 'control areas' to determine if marine ornamentals collection has ecologically significant effects on overall reef ecosystem health or target species' populations.

Reef Check (a GCRMN member) developed the Marine Aquarium Trade Coral Reef

Monitoring Protocol (MAQTRAC) method to assess coral-reef health and fish populations and then monitor these over time to measure and improve management. An independent survey of reefs using MAQTRAC, and regular follow-up monitoring, is required to obtain and maintain MAC certification. The frequency of monitoring is 1-2 times per year. Also, in the absence of sufficient fisheries data for aquarium fishing in most developing countries, all MAC-certified collectors are required to keep logbooks to document their catch to monitor catch-per-unit-effort (CPUE) within the framework of the management plan. Having rural, village-based fishermen keep a logbook is a significant step forward in managing these multi-species fisheries and a step that has not been widely attempted.

The information on the abundance of target species, fishing effort, reef health and management effectiveness is shared with the collectors, community and stakeholders. This results in management recommendations on harvest volume and species levels to prevent over-fishing, the location and size of no-take zones, harvest rotation patterns and other sustainability measures that form the collection area management plan (CAMP) required by MAC certification.

Certification in action

MAC certification has been well-received by the marine aquarium industry, public and private aquarists and conservation organisations. MAC certification was launched in late 2001, and within several months over 70 companies made public "statements of commitment" to seek to achieve certification. By the end of 2004, the number of companies that had publicly committed to becoming certified had increased to over 120 in 20 countries. MAC certification has been achieved in the Philippines and Fiji by several collection areas, collectors' associations and exporters, and by several importers and retailers in the US, Canada, the Netherlands, France, the UK and Singapore.

MAC-certified marine ornamentals are now moving from 'reef to retail' at a pilot scale, engaging market forces in realising the win-win of linking conservation and sustainable use with responsible industry practices. However, the number of MAC-certified organisms available is still less than 1% of the trade. Much of MAC's efforts are focused on fieldwork in Indonesia and other developing countries that export marine ornamentals, to assist them in capacity-building for community-based reef management plans, training of collectors and other efforts to ensure their aquarium trade is sustainable and can be certified. The need now is to build on the successful start-up efforts and ramp up to a critical mass of certified supply and participants in order to fully realise the benefits

Collecting with net at Marcilla in the Philippines.

of MAC certification. To do this, MAC has focused on local efforts, working with marine ornamentals collectors and their communities in important source countries such as the Philippines, Indonesia and Fiji. MAC is also 'acting locally' with the rest of the industry by working with those exporters, importers and retailers that are making active efforts to become certified.

Conservation in Europe through sustainable trade

MAC-certified marine ornamentals are now moving through certified chains of custody, 'from reef to retail,' enabling consumers to identify and reward responsible businesses through their purchase of MAC-certified marine aquarium organisms, i.e., those that were collected, handled and transported in a sustainable manner. Europe is a key player in this transformation. For example, the Netherlands is a major importer of ornamental reef fish and corals for home aquariums, with several large wholesalers, approx-imately 40 retailers and 12,000 to 17,000 marine aquarium hobbyists. Studies supported by WWF, the global conservation organisation, have shown that Dutch marine aquarium hobbyists have an exceptionally high rate of willingness to do something to support certification (e.g., buying 'eco-fish') and are willing to pay an extra 10 per cent to 25 per cent for certified fish.

Europe could be a world leader in transforming the ecological footprint of the marine aquarium trade from a negative one to a positive one that helps conserve marine biodiversity, reduce poverty and achieve sustainable development in hundreds of coastal villages in high biodiversity developing countries such as Indonesia.

MAC certification label

Paul Holthus
Executive Director
Marine Aquarium Council
Email: www.aquariumcouncil.org

Collectors prepare for work, Marcilla, The Philippines.

Aquatic Invasions

Phantom aliens in Mediterranean waters

By Ferdinando Boero, Cristina Di Camillo Cinzia Gravili

ALIEN SPECIES ARE detected for two main reasons: they suddenly become very abundant and obvious, or there is somebody able to detect their presence.

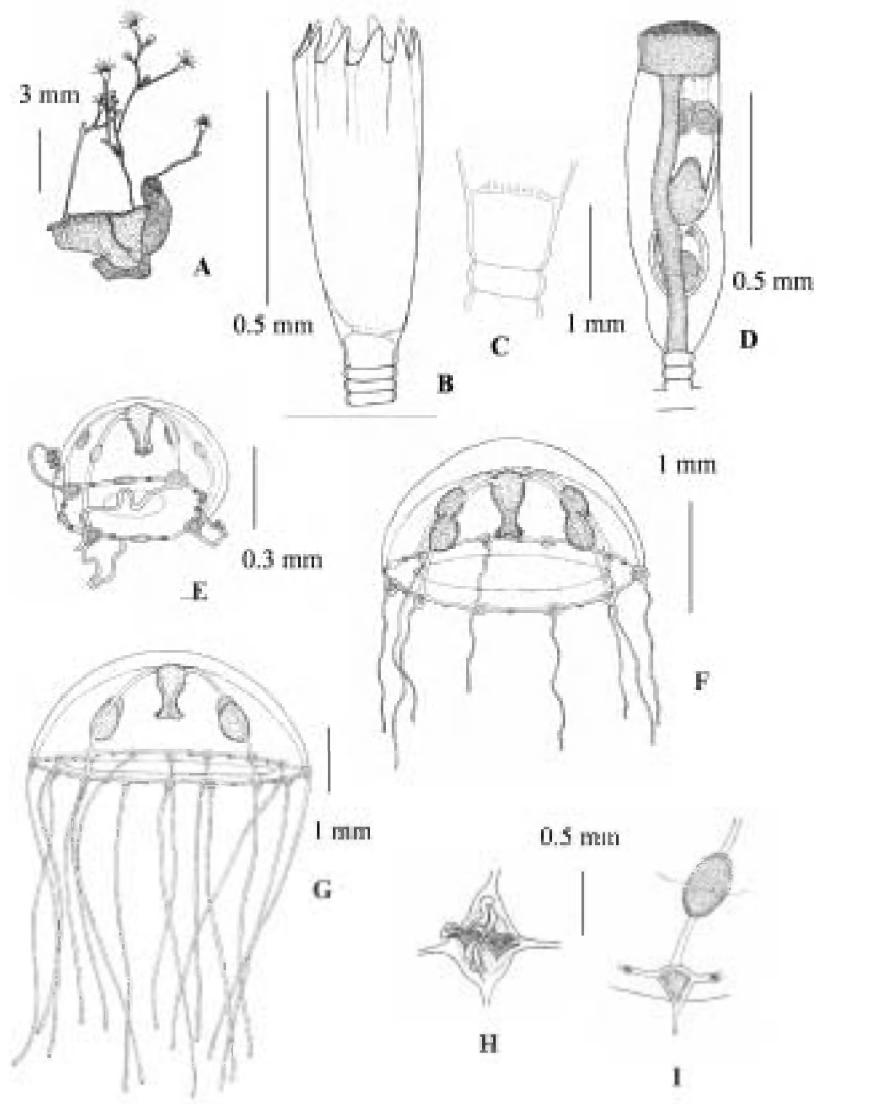
Sometimes, very abundant and obvious species are not recognised as aliens, simply because the scientific community fails to realise what they are or the history of their presence. Here, we present two cases of possible invasions of the Mediterranean by species of great (presumed) ecological importance. One has been overlooked (as an alien) for half a century, whereas the other was first recorded (and immediately recognised as an alien) less than ten years ago but was not of much concern as its potential impact is not that obvious. Both records regard hydrozoans of the genus *Clytia*, family *Campanulariidae*. Species of this genus are represented by a benthic polyp stage and a planktonic medusa stage.

The story of *Clytia linearis*

At present, *Clytia linearis* is one of the most common Mediterranean hydroid species in rocky shallow waters (Bouillon *et al*, 2004). The first record of this species from "near" the Mediterranean is that of Billard, in 1938, from the Suez Canal! Billard called it *Clytia gravieri*, considering it new to science, but then this nominal species was recognised as being identical to *Clytia linearis*, described by Thornely from the Indo-Pacific in 1899. *Clytia linearis* is different from all other *Clytia* species from the Mediterranean because, instead of being stolonal, it is branched. Stolonal species have a single polyp on each stem, whereas branched species have more than one polyp on each stem, a character too obvious to permit mis-identification!

The Mediterranean is one of the most studied seas in the world: it is highly improbable that *C. linearis* had been present but passed unnoticed. *Clytia linearis* is possibly the first successful Lessepsian migrant. And, if so, it is possibly the most successful of them all. Picard (1951) found it for the second time in the Mediterranean and, since then, the species has been recorded invariably as abundant at almost every investigated Mediterranean location, from shallow waters to shaded rocky bottoms.

The species is so successful that it is now going north. Altuna Prados (1995) recorded it along the Atlantic coast of Spain and remarked that his was the northernmost record of the species from the Atlantic coast of Europe, stressing that it was very abundant at his study site, whereas it had been left uncited by all authors who previously studied hydroids in the area. At present, *Clytia linearis* is a circumtropical species that is expanding its distribution along the Atlantic coast of the Iberian peninsula. It is probable that it has arrived at other areas, such as the Atlantic coast of France and the British Isles. Unfortunately, these countries have no more hydroid specialists (the last French hydroid specialist works at La Réunion) and it is very probable that its presence is passing unnoticed (even if the species is abundant). The species is unreported from the Atlantic coast of Northern Africa (but this proves nothing, since the fauna of that region is poorly known). The Spanish Atlantic record, then, might represent the expansion of a species from the Mediterranean to the Atlantic! *Clytia linearis* probably colonised the Mediterranean from the Suez Canal (the first "Mediterranean" record, being from the Suez Canal, is very suggestive of this pattern of colonisation), and, then, from Gibraltar, expanded its distribution to the Atlantic coast of Spain. Gibraltar, thus, is not only a way for Atlantic species to come into the Mediterranean, it is also a way for Mediterranean species to go into the Atlantic!



Clytia linearis. A: colony. B: hydrotheca. C: diaphragm. D: gonotheca with two medusa buds. E: newly-released medusa. F: eight-tentacles stage, with mature gonad. G: 15-tentacles stage with mature gonad. H: detail of cruciform manubrium. I: detail of tentacular bulb with statocysts and radial canal with gonads.