NON-NATIVE SPECIES IN THE MEDITERRANEAN:

What, when, how and why?

© Patrice Francour

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Non-native species in the Mediterranean:

What, when, how and why?

The Mediterranean is becoming a tropical sea!

Invasive species are threatening the biodiversity of the marine ecosystems! There are a lot of newspaper articles about the presence of non-native species in the Mediterranean. But what is really happening?

The red soldierfish
Sargocentron rubrum

A resident of coral reefs. Now, he is part of the landscapes of the eastern Mediterranean

What are these non-native species? How can we distinguish the various kinds of species? How do these species manage to penetrate into the Mediterranean? What impact do these species have on the Mediterranean marine environment? How should we act to restrict the introduction of these species? What is the future of the Mediterranean in the face of these new arrivals?

When tropical fishes live side by side with local species! A common two-banded seabream, *Diplodus vulgaris*, share its habitat with the reticulated leatherjacket, *Stephanolepis diaspros* (centre)

SOMMAIRE

What are they?

Non-native species : species of fauna or flora which are found outside their known area of distribution. In the present case, they are species for which the Mediterranean Sea is not part of their original distribution area.

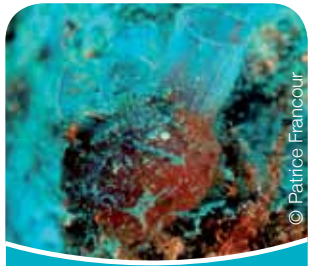
Caulerpa taxifolia

Caulerpa taxifolia, an invasive species that highlighted the importance of non-native species in the Mediterranean

Some 925 non-native species have been counted by now in the Mediterranean. They represent 13 phylum. Molluscs constitute the largest taxa (216 species), followed by fishes (127 species), plants (124 species) and crustaceans (106 species).

Non-native species arriving in the Mediterranean belong to every group: fishes, invertebrates, algae etc. The red throated ascidian (*Pyura momus*), the holothurian (*Synaptula reciprocans*) and the map angelfish (*Pomacanthus maculosus*), the latest species of fish to have got through the Suez Canal, are just a few examples among many others.

The holothurian
(*Synaptula reciprocans*)



The red throated ascidian
(*Pyura momus*)

The map angelfish
(*Pomacanthus maculosus*)

Where are they?

A very unequal distribution of non-native species between countries!

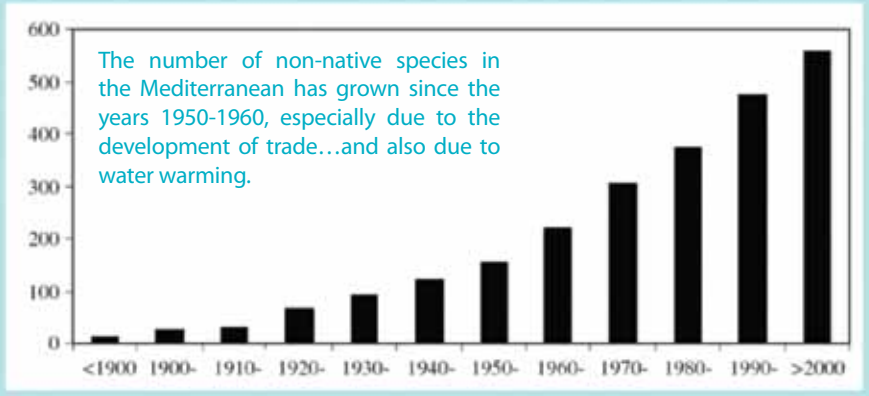
The countries with the most non-native species are located in the Eastern Mediterranean. The Suez Canal constitutes a major introduction route for species, whether 'naturally' or via maritime transport. However, the figures reported on the distribution map of non-native species between countries should be considered with great caution since they greatly depend on the scientific investigation effort.

A non-native species identified in two different countries may have different origins. Thus the presence of the orange-spotted grouper *Epinephelus coioides* in the Levantine waters is due to a migration of certain individuals from the Red Sea, whereas the specimen observed in the Adriatic Sea in 2000 probably arrived via a ship's ballast water.

The orange-spotted grouper
(*Epinephelus coioides*)

A speed racing?

The number of non-native species is growing quickly nowadays….



A steady increase over the years ...

…and their expansion in the Mediterranean is growing fast

Another sprinter from the Red Sea: the reticulated leatherjacket , *Stephanolepis diaspros*.

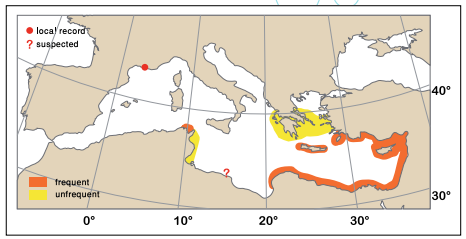
Did you know?

Certain species can spread very quickly. The bluespotted cornetfish (arrived in the Mediterranean from the Red Sea), observed on the Levantine coast in 2000, has only taken 7 years to reach the French coast.

The bluespotted cornetfish, (*Fistularia commersonii*).

Just an attempt, or a definitive settlement?

Among the species that enter the Mediterranean, some have only been seen once or twice: such is the case for the ornate spiny lobster *Panulirus ornatus*, seen once in 1989 on the Levantine coast. But others have multiplied quickly and have become well-established in our sea. They reproduce and their distribution area in the Mediterranean is regularly increasing. This is the case for the two species of rabbitfish present in the Mediterranean: *Siganus luridus* and *Siganus rivulatus*. Originally from the Red Sea, they can now form shoals made up of a very great number of individuals, as can be seen along the Levantine coast.



Distribution maps for the ornate spiny lobster *Panulirus ornatus* (left) and the rabbitfish *Siganus luridus* (right) (Source: ICSEM).

Shoal of *Siganus* sp.
In the eastern Mediterranean, the number of rabbitfish has grown recently: vast shoals are often seen when diving.

Are the invaders among us?

Not all the non-native species introduced into the Mediterranean are invasive species. An **invasive species** is a species that develops outside its original distribution and which is ecologically and/or economically harmful.

Caulerpa taxifolia: pretty but invasive. It does not kill but its speed of growth allows it to occupy every habitat and drive out the native species

Caulerpa taxifolia: this name used up a lot of ink in the early 1980s. This 'fluorescent green' alga, originally from Australia, quickly invaded the Mediterranean Seabeds. From a few square meters observed in 1984, the area it occupied quickly reached several hectares. Even if the alga has clearly dwindled nowadays, in some places it continues to rival the emblem plant of the Mediterranean, the Posidonia (Posidonia oceanica). In the seabeds where it has settled, the biodiversity has very clearly decreased.

Caulerpa taxifolia is not the only non-native species that has become invasive. Another Caulerpa from Australia, Caulerpa cylindracea (ex Caulerpa racemosa var. *cylindracea) is also gradually invading the Mediterranean. Its stolons creep over the seabed and cover the substratum like a blanket, stifling the living organisms*

Caulerpa cylindracea (green on the photo)

Portraits of some non-native species

Common name : Bluespotted Cornetfish
Latin name : *Fistularia commersonii*
Group : Fishes
Origin : Red Sea
Description : A fish with a very elongated body, 1to 1.6 m long. The back is greenish-brown and the belly silvery-white. The tail extends from a long white filament.
Ecology : Rocky and/or sandy beds, Posidonia meadows, down to an average depth of 50 m or even 100 m.
Distribution : Present throughout the Mediterranean.

The blue-spotted flute-mouth fish (*Fistularia commersonii*) puts on striped pyjamas when night falls

Latin name : *Caulerpa cylindracea*
Group : Chlorophyceae
Origin : Australia
Description : A dark green alga with a creeping stem that branches out in grape-like fronds of about 5 cm high, attached to the substratum by numerous short rhizoids.
Ecology : Rocky and/or sandy beds, Posidonia meadows, down to an average depth of 50 m or even 100 m.
Distribution : Present throughout the Mediterranean.

The creeping stolons of *Caulerpa cylindracea*.

Common name : Pacific cupped oyster
Latin name : *Crassostrea gigas*
Group : Molluscs
Origin : Japan
Description : A bivalve whose oval shell, of mauve or greenish colour, can be 30 cm long. The two valves are covered with very well marked concentric striations that are characteristic of the species.
Ecology : Lives fixed to a hard substrate from surface to down to a depth of 80 m along sheltered coasts, in brackish and marine coastal water.
Distribution : Basically present in the northern Mediterranean

A gastronomic delicacy from the Pacific.

Common name : Rabbitfish (Dusky spinefoot)
Latin name : *Siganus luridus*
Group : Fishes
Origin : Red Sea
Description : An ellipsoid fish with a small mouth that opens downwards and a straight edge tail. It is a uniform greyish-beige to very dark-brown colour, and can be 20-25 cm long.
Ecology : Frequents coastal rocky beds, often in small groups
Distribution : A species that proliferates in the eastern Mediterranean.

A pretty invasive rabbitfish

Common name : Sally Lightfoot crab
Latin name : *Percnon gibbesi*
Group : Decapod crustaceans
Origin : Atlantic
Description : The brown shell is disc-shaped and measures about 3 cm. Yellow rings are present on the leg joints, particularly around the joints.
Ecology : This crab is active during the day. It frequents the rocky environments and hard substrata in the littoral zone.
Distribution : Present throughout the Mediterranean.

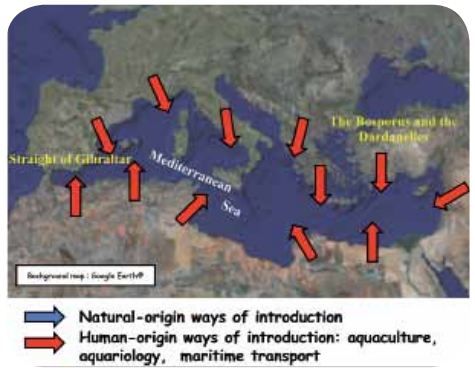
The yellow rings of the joints are very characteristic of this species.

Latin name : *Asparagopsis armata*
Group : Rhodophyceae
Origin : Indo-pacific
Description : An alga composed of pale pink pyramid- shaped tufts, 10 to 20 cm high. Its characteristic harpoons are used to anchor thalli to other algae. The thallus bears a great number of ramuli, which gives it the appearance of an asparagus.
Ecology : An alga that is often an epiphyte of other algae.
Distribution : Mainly on all the coasts of the north-eastern Mediterranean, especially in the colder areas.

In spring, the pink pompoms of this alga are visible over the entire seabed.

Introduction ways

Non-native species can be introduced into the Mediterranean in two different ways: naturally, carried by currents (e.g. larvae of fishes or invertebrates), or attached to a piece of driftwood (e.g. alga), or artificially by human intervention.



The Brazilian saupe, *Kyphosus sectator*, originally from the Atlantic, entered the Mediterranean through the Strait of Gibraltar before being caught on the French coast.

Pteragogus pelycus, a new beautifully-coloured wrasse, entered the Mediterranean via the Suez Canal.

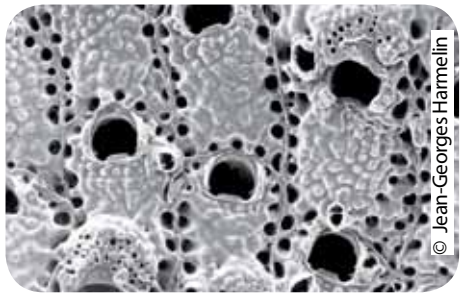
The Mediterranean communicates naturally with the Atlantic through the Strait of Gibraltar, and the Black Sea through the Bosporus and the Dardanelles. Moreover, In the late 19th century, men created a communication between the Mediterranean and the Red Sea by digging the famous Suez Canal. Since then, species can freely enter and leave the Mediterranean by using one of these straits or the Canal. But these roads are not the only ways of introducing non-native species in the Mediterranean. Through maritime transport, aquaculture and aquariology, man contributes intentionally or unintentionally to the spread of species in the Mediterranean.

Natural ways of introduction

The Strait of Gibraltar

The arrival of species in the Mediterranean via the Strait of Gibraltar has happened since it was re-opened 5.3 million years ago. The Mediterranean fauna that we see today is thus made up of species from different origins: particularly the North and South Atlantic, and endemic Mediterranean species. Nowadays, as a result of global warming, we are witnessing a speeding up of these new arrivals through the Strait of Gibraltar.

Gibraltar



This microscopic bryozoa, called *Parasmittina egyptiaca*, used the hull of a ship that was sailing through the Suez Canal to come and settle in the Mediterranean (photo taken using an electronic microscope)


Ferdinand de Lesseps

The Suez Canal: links the Mediterranean to the Red Sea

The Suez Canal

From 1869, when the Suez Canal was opened, a new way of introducing non-native species was born. This Canal enables the water of the Red Sea to communicate with that of the eastern Mediterranean. The canal, dug in order to shorten the trade routes between the Mediterranean and the Indian Ocean, removed the geographical barrier that existed between the two 'seas'. A large number of species that peopled the Red Sea, or even the Indian Ocean, were thus able to move into the Mediterranean through this Canal. These species are called Lessepsian species after Ferdinand de Lesseps, the French engineer who had the Canal dug.

The Bosporus and the Dardanelles

The Bosporus (a strait linking the Black Sea to the Sea of Marmara) and the Dardanelles (a strait linking the Sea of Marmara to the Mediterranean Sea) constitute ways of access for 'Pontic' species. The term comes from the name of the Pontic Greeks, descendants of the Greek-speaking peoples who lived around the Black Sea. However, the passing of species between the two seas mainly happens in a Mediterranean-Black Sea direction, because of the greater salinity of the Mediterranean Sea. It is easier for the Mediterranean marine species, used to saltier water, to develop in the slightly less salty water of the Black Sea than the reverse. This introduction route is thus negligible compared to the two other natural ways mentioned above.

Pontic species should pass through two straits before reaching the Mediterranean Sea.

The Russian grey mullet, *Liza haematocheilus* was first introduced into the Sea of Azov for fish farming. It then arrived in the Black Sea and has finally reached the Mediterranean Sea

Mnemiopsis leidyi, small but deadly!

Introduced into the Black Sea via ballast water, this little jellyfish rapidly proliferated in its new environment. Feeding on fish eggs and larvae, it has contributed to the crash of certain Black Sea fisheries. It has now reached the Mediterranean Sea.

Jellyfish: Mnemiopsis leidyi

Human-origin ways of introduction

Maritime transport

Maritime transport is the main vector helping the exotic marine species to spread around the world. Non-native species are carried in the ballast water or are attached to the boats' hulls (a phenomenon called fouling). It is the oldest way of introducing aquatic species.

The existence of 'invasion corridors' superimposed over the maritime trade routes was shown.

Mya arenaria

A transport not so recent!
The bivalve mollusc *Mya arenaria* has been present in Europe since the 16th century. But unlike what was thought previously, recent research has shown that it was probably introduced by the Viking ships when they crossed from North America.

The importance of this way of introducing species into the Mediterranean was increased by the opening of the Suez Canal and the increase in maritime traffic.

Did you know that?

Oil rigs can also be a source of species introduction. In the same way as when attached to the hull of a boat, species can be carried from one environment to another attached to the structure of the rig when it is moved

Ballast water

Balancing a ship requires the presence of ballast: immense compartments located in the hulls of ships. Originally, these were filled with rocks and sand. But the arrival of steel boats enabled liquid ballast like seawater to be used. It is easier and quicker to fill and empty ballast according to the ships' needs. But when the water is being pumped, organisms suspended in the water (larvae and eggs of organisms, viruses, bacteria, microscopic algae) can also be sucked out. The ballast water is then discharged in a different place from where it was pumped. The organisms present in the ballast water that have survived the transport are then poured out with the water in an environment that is foreign to their original living environment. Ballast water constitutes a major threat at ecological, economic and health level.

Not just ballast water

The arrival of marine organisms due to discharge of ballast water has to be qualified. A New Zealand study has shown the importance of some compartments located in the hulls of ships for the transporting of non-native species. These compartments, called coffers, are open to the sea via gratings (the water used as ballast is in fact pumped from these coffers). The study revealed the presence of many organisms belonging to different groups (fish larvae, molluscs, crustaceans, annelids etc.) attached to the walls of the coffers. Some of the non-native species that were supposed to have arrived via ballast water were probably in fact introduced in this way.

Areas near the big trading ports host a lot of introduced species.

The Indo-Pacific swimming crab, *Charybdis hellerii*, originally from the Pacific and present in the Mediterranean since 1920, was probably carried by a ship's ballast tanks.

Aquaculture

The non-native species introduced by aquaculture are of two kinds: species that were introduced intentionally to set up new aquaculture industries, and species introduced accidentally when, for example, they are attached to the species that are intentionally introduced. This was so, for example, for the Pacific cupped oyster *Crassostrea gigas*, originally from the north-western Pacific Ocean, introduced in the Mediterranean after a major mortality of the local species, the Portuguese oyster *C. angulata. C. gigas* enabled the introduction of another species of gastropod mollusc, the crepidule *Crepidula fornicata,* which has today become fairly invasive, as well as the alga *Undaria pinnatifida.*

Thau pond oyster

Oyster farming is a major vector of introduction because of the many exchanges that take place between oyster parks

The prolific *Crepidula fornicata*

Undaria pinnatifida

The brown alga, *Undaria pinnatifida*, arrived in the Mediterranean with the spat of the Japanese oyster Crassostrea gigas. Later, exchanges between aquaculture ponds facilitated its spread.

Aquariology

Caulerpas, green algae, are frequently used in aquariums because of their lovely colour. This was how *Caulerpa taxifolia* was introduced into the Mediterranean. Accidentally released into the sea during the cleaning of the aquariums, it quickly spread to many sites.

Fishes from aquariums can also arrive accidentally in the sea. Thrown out by people who do not want to look after them any more, they find themselves in the sea. According to their capacities of resistance, they can survive and even, in some cases, if several individuals of different sex are released, reproduce in the Mediterranean Sea. The honeycomb grouper *Epinephelus merra,* a species unknown in the Mediterranean, was thus caught near the French coast in September 2004. That is perhaps why a pyjama Chromodoris (*Chromodoris quadricolor*), a nudibranch mollusc, was observed in the Ligurian Sea in 1982.

Caulerpa taxifolia

Honeycomb grouper (*Epinephelus merra*)

Pyjama chromodoris
(*Chromodoris quadricolor*)

Impacts

Important impacts on biodiversity

The results for the fauna and flora are important, especially for the eastern Mediterranean, in which many non-native species have now settled. Yet the real impacts of these species on the existing ecosystems are often not very well known. Visible effects have however been noticed. For example, the arrival of a strict herbivore can profoundly modify the algal landscapes: in Turkey, the pullulation of rabbitfish has given rise to overgrazing of seabeds. The landscape becomes monotonous and the rocky bed totally lacking in algae.

«Non-native species can be at the origin of a new competition.»

If a non-native species exploits the same trophic resources as another species, the result is competition between the two species. In the long term, the native species may decline or disappear.

The saupe (*Sarpa salpa*)

In certain parts of the Mediterranean, the rabbitfish rivals the local herbivore, the saupe (*Sarpa salpa*).

Upheavals in the fisheries

Modifications in the fish stocks

Some exotic species have developed so well that it is now possible to exploit them commercially. Thus, in the eastern Mediterranean, in the Levantine basin, 3 exotic species (the rabbitfish « *Siganus rivulatus* », the lizardfish « *Saurida undosquamis* », and the Goldband goatfish « *Upeneus moluccencis* ») are now regularly offered on fishermen's slabs.

A few figures:

Some species are wildly successful. Thus, 43% of the halieutic resources in Turkey are of Lessepsian origin, and 72% of the fishes observed in Lebanon are rabbitfishes of the *Siganus rivulatus* species.

Certain economic loss

In Tunisia, the Lessepsian species *Metapenaes monoceros* replaced the local *Penaeus kerathurus* shrimp species. Shrimp fishing has not declined but the catch, 50% of which is now made up of the non-native species, is seven times less valuable commercially than catch formed of only the local species.

Disturbed sailing

In the Etang de Thau, the gulfweed *Sargassum muticum* can develop fronds that are over 4 metres high. These fronds form a continuous carpet on the surface of the pond. By twining around the boats' propellers, they can impede sailing to a great extent.

The gulfweed (*Sargassum muticum*)

Serious human and economic consequences

Non-native species can represent a danger for human health and have disastrous consequences for the local economy.

The jellyfish Rhopilema nomadica

Careful!

The jellyfish ***Rhopilema nomadica***, which entered the eastern Mediterranean in the 1970s via the Suez Canal, can give the unfortunate bather who meets it painful burns. When swarms of this jellyfish proliferate, the invaded beaches have to be closed. Likewise, the mollusc ***Conus textile***, also entered the Mediterranean via the Suez Canal, has a dangerous sting that can be deadly if the victim is a child.

LBallast water can also be a vector of new viruses, bacteria or toxic algae. By infesting the local fish species, these non-native pathogens can cause food poisoning to those who eat the infected molluscs or fish. The dinoflagellate alga *Alexandrium catenella* is responsible for a great many cases of poisoning and death in people who have eaten infected shellfish.

Considerable losses

The same introduced species also have very considerable economic effects.
The presence of the alga *Alexandrium catenella* in molluscs gives rise to a ban on the consumption of infected molluscs, and thus sizeable losses for the shellfish farmers concerned. When the jellyfish *Rhopilema nomadica* pullulates, this leads to the invaded beaches being closed. If the closure continues over a few days, the consequences for the tourist economy are then considerable.

the Cloth-of-gold cone (*Conus textile*)

What solutions?

Information and awareness

The appearance and rapid spread of the invasive species *Caulerpa taxifolia* gave rise to a vast awareness campaign carried out among the general public. Many brochures and signposting sheets were distributed to users of the sea, explaining what could be done to restrict the expansion of the alga: cleaning anchors or nets, not pulling it out by hand, etc.

Information leaflets have been published in various languages.

In France, a campaign is still under way: signposting the new sites that have been colonised by the algae *Caulerpa taxifolia* and *Caulerpa racemosa*.

Caulerpa On Line (http://www.caulerpa.org): an internet site that gives information
All the data concerning the colonisation of the seabed by *Caulerpa taxifolia* and *Caulerpa racemosa* is given on the COL (Caulerpa On Line) site. This site was developed by the Laboratoire Environnement Marin Littoral (now the ECOMERS laboratory) in the University of Nice-Sophia Antipolis, in France, as part of the 'Watchdog on the expansion of *C. taxifolia* and *C. racemosa* in the Mediterranean'. This interactive site is intended for the wider public and for decision-makers. It enables everyone to access any new observation, and has as its main purpose the collecting and publishing of the most recent information on areas colonised by invasive Caulerpas.

Regulations

Various legal tools exist to prevent the introduction of non-native species. Unfortunately, the laws are rarely enforced.

The Barcelona Convention

The Barcelona Convention, established in 1976, and amended and strengthened in 1995, and the protocols crafted as part of this Convention, aim to reduce pollution in the Mediterranean Sea area and to protect and improve the marine environment in this area with a view to contribution to its sustainable development. 21 states around the Mediterranean, as well as the European Community, have ratified this Convention. The '**Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean**' is one of the protocols springing from this Convention. It encourages the signatory countries to take all the necessary precautions to prevent the introduction of non-native species, and to wipe out invasive species, in the areas covered by the Protocol.

RAC/SPA

After the signing of the Barcelona Convention, the Regional Activity Centre for Specially Protected Areas (RAC/SPA) was set up in Tunis in 1985. Its main aim is to help enforce the Protocol on Specially Protected Areas and Biological Diversity in the Mediterranean, which came into force in 1999, by providing assistance to the Mediterranean countries (http://www.rac-spa.org).

The Action Plan on Invasive Species

In 2005, confronted with the growing number of invasive species in the Mediterranean, RAC/SPA crafted an Action Plan on Invasive Species. This Plan aimed at strengthening the capacities of the Mediterranean countries as regards the prevention and control of introductions of species into the Mediterranean Sea, and coordinating their efforts to this end.

Ballast water

In order to mitigate the impact of ballast water on the transfer of non-native species, chemical (use of chlorine, treatment with hydrogen peroxide or ozone, or deoxygenation) or physical (electric shock, increasing water temperature, ultraviolet, microfiltration) treatments were first of all envisaged. But these treatments had major consequences, whether environmental, or economic (due to the boat's being immobilized), or also for the health of the staff.
A less harmful measure is now being recommended by the **International Maritime Organisation** (IMO), a specialist United Nations body that shoulders responsibility for the international regulating of the security of maritime traffic and the prevention of marine pollution. It suggests a **guide for checking and managing ballast water** in order to mitigate the transfer of harmful and pathogenic organisms. The recommended measures are:
- exchanging ballast water out at sea
- regularly cleaning the ballast tanks to eliminate the sediment and mud that can accumulate there
- discharge on land where treatment facilities exist.

GloBallast

The GloBallast Programme is a programme set up in 2000 by the IMO in association with various partners, which aims at helping developing countries solve the problem of ballast water. As a result of the success of this programme, GloBallast, a partnership project, was born to help the most vulnerable developed countries overcome the threat of ballast water. For the Mediterranean region, work groups will be set up with the support of REMPEC (Regional Mediterranean Marine Pollution Emergency Centre; http://www.rempec.org) and of RAC/SPA.
The Project also contains an important national side devoted to enhancing capacities to promote the BWM Convention (Ballast Water Management, the International Convention on Checking and Managing Ships' Ballast Water and Sediment, adopted by the IMO in 2004) and helping the partner countries when implementing and enforcing it.
The Mediterranean countries are expected to adopt the "Draft Mediterranean Strategy on Ships' Ballast Water Management and Invasive Species" in early 2012. Its Action Plan will be implemented according to the timetable of the strategy between 2010 and 2015.

Knowledge

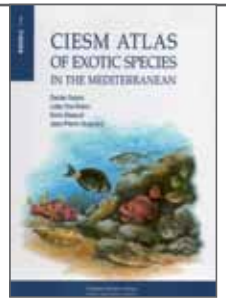
Databases that summarize current knowledge on non-native and invasive species have been crafted to help scientists and managers in their work.

The DAISIE Project (Delivering Alien Species Inventories for Europe)

This Project started in 2005 and enabled an inventory to be made of those non-native species of fauna and flora that are present in land, freshwater and marine environments all over the European continent, including the countries of the southern Mediterranean (Tunisia, Morocco, Algeria, Lebanon etc.). The Project was coordinated by the United Kingdom's Centre for Ecology and Hydrology (Natural Environment Research Council).18 research teams, each specialising in the study of one or several groups of organism, participated in this Project. One-off collaborations by other European countries completed the skills that had already been brought together. The Project ended in February 2008. A database accessible to everyone, and regularly updated, was created (http://www.european-alien.org). This database listed all the non-native species by region. For each species, a box presents the characteristics of the species, the place where it arrived in Europe, and its current distribution. The 100 most invasive species have been put together. For each of these a more detailed sheet is offered

An example of the first page of the sheet for *Marsupenaeus japonicus*, one of the 100 species considered as the most invasive (Source: http://www.european-alien.org).

CIESM's atlas of exotic species



The atlas is also available as books. Below is the volume on fishes.

In 2005, the International Commission for the Scientific Exploration of the Mediterranean (CIESM) brought out an atlas listing the various non-native species considered as established in the Mediterranean or as foreign (one-off sightings). This atlas is divided into 4 volumes:
- Fishes
- Decapod crustaceans
- Molluscs
- Macrophytes

In each volume, the species are arranged in families. For each species, a sheet describes the organism, the date and place where it was first observed in the Mediterranean, and its current distribution. This atlas is regularly updated and is accessible for everyone on the CIESM site (http://www.ciesm.org).

Marine Protected Areas:

A response to the increasing arrival of non-native species?

Marine Protected Areas are known to be areas of great biodiversity. These protected environments shelter a great number of species of alga, invertebrate or fish. Studies have shown that such areas were also rich in super-predators like the dusky grouper *Epinephelus marginatus*, the dentex *Dentex dentex*, and the barracuda *Sphyraena viridensis*. These species have a regulating role over species of a lower level (e.g. herbivores). This regulating role could also apply to non-native species arriving in these areas. The expansion of non-native species would thus be checked by the super-predators. The Protected Areas also shelter a greater number of parasites due to the greater availability of hosts. The parasites would also have a regulating role by living as parasites on the non-native species. Protected Marine Areas could thus be considered as areas where the impact of non-native species would be more limited. By creating more such Protected Areas in the Mediterranean, the expansion of non-native species could be restricted and prevented, and the biodiversity resilience strengthened.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Eradication campaigns

To prevent the expansion of non-native marine species and to protect important natural areas, some Marine Protected Areas have set up eradication campaigns. Thus, the Port-Cros National Park in France has started regular campaigns to look for and wipe out *Caulerpa taxifolia* plants. Every year these campaigns bring together scientists and amateur divers who are aware of the problem. A scrupulous inspection of the seabed is carried out and any shoot of *C. taxifolia* is meticulously eliminated. According to the size of the invaded area, this elimination is done either by pulling out the shoots by hand (for small areas) or by using copper covers (for bigger areas).


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Patience and meticulous care are needed to prospect for and then wipe out the Caulerpa.

Information and awareness

Information and awareness are essential elements of the actions of the Marine Protected Areas. These areas are thus tools giving early warning of any new arrival.

A beneficial effect that must be qualified: are these areas in fact more fragile than the unprotected areas?

The Protected Areas are indeed much appreciated by holidaymakers. Many amateur sailors come and anchor in the protected waters of the marine reserves. Some invasive species have in fact been spread via these boats. A tiny piece of *Caulerpa taxifolia* attached to an anchor can quickly reconstitute an individual and thus enable a new colony to become established there. Information and awareness are essential to protect the marine reserves and prevent the propagation of invasive species.

What future for the Mediterranean?

What future does the Mediterranean have, confronted by this mass arrival of new species? The term ‘tropicalization’ is often used to describe the future of this sea. But what is really going on? Professor Patrice Francour at the University of Nice-Sophia Antipolis takes stock of the situation:

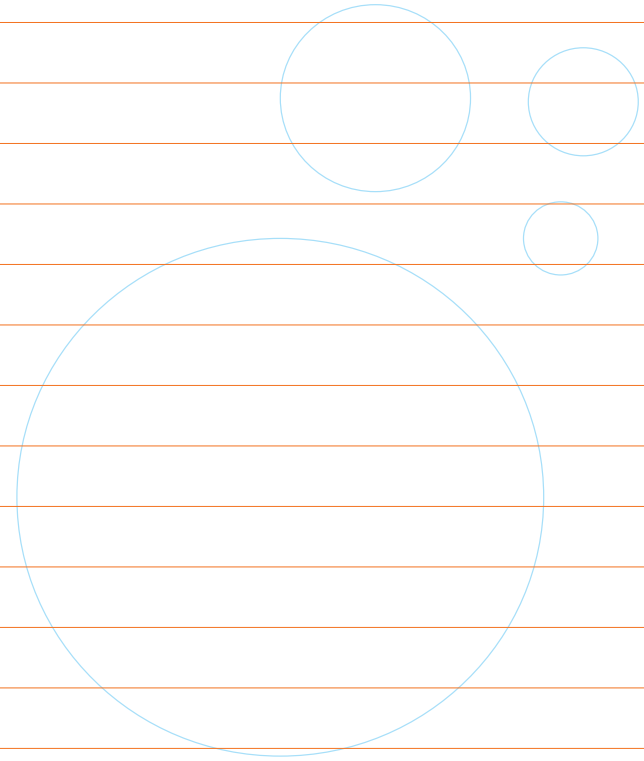
«If the phenomenon of the warming of the Mediterranean waters continues, we can expect that Lessepsian species will continue to arrive in the eastern basin. In the western Mediterranean, the arrival of species that are usually restricted to the eastern basin will be also increasingly important. Additionally there will be increasingly frequent passage of species from the tropical Atlantic via Straight of Gibraltar. The maritime traffic, which is constantly growing, will also continue to be a vector for the introduction of non-native species and a possible means of introduction for invasive species. Also, the impacts engendered by the introduction of these new species will be all the greater since the original populations will be disturbed or weakened. The impact will be less in the Marine Protected Areas.”

Shall we see, in a few years, the Malabar grouper (*Epinephelus malabarensis*) keeping company with our own dusky grouper (*Epinephelus marginatus*)?

Tomorrow’s Mediterranean?

And tomorrow? Shall we look around us and see gorgeous shimmering-coloured fishes furtively slipping between the corals and tropical algae?

Notes



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