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The True Alien Nightmare

The look on the face of the first Cuban or Florida peninsula fisherman to find a lion fish (*Pterois volitans*) in his nets must have been worth seeing, back in the mid-1990s. This fish had never been spotted here before, so it was a focus of attention, especially for subaqua tourists in the Western Pacific. While it is a beautiful fish its venom can be deadly, yet it is even more harmful to the ecosystem, to other fish and crustaceans, due to its voracity. Its introduction seems to come directly from marine aquarology, possibly inadvertently, and is damaging. Rapid migration has already established this invader in the tropical waters of Venezuela and further south, 25 years after the first official record in 1992. I saw it myself in the waters of the Riviera Maya in 2013–2015. The flesh could be bought at fish stalls—and its consumption was encouraged. It is one of the many cases of an alien species that has managed to be introduced in a very particular type of pollution, that of biological invasion or contamination.

Here we need to introduce a term that is widely used in ecology as is highly relevant to the topic that we are now going to deal with: an allochthonous species. This refers to a species that, by various means (for example, the disappearance of a mountain range, the joining of a strait such as that of Gibraltar or human trafficking from one place to another between distant points) penetrates an ecosystem that is not its own, in which it is 'foreign'. The natives will be those who have long since adapted to the environmental conditions of the area. Species that are introduced into a new ecosystem may react in different ways, either simply disappearing because they cannot adapt to the environment, becoming aggressive because they do not have predators

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or competitors in the new space, or displacing other species that have similar requirements in terms of space, food, and so on,

A harmless species at its source may become invasive elsewhere. If it tolerates the environment, has the ability to multiply faster, can compete for food efficiently and has no predators, competitors, parasites or diseases to limit it, it can displace the native species. Of course, not all species that are introduced are successful; quite the contrary in the case of algae. Most remain as rarities, relics confined to small sites that are sometimes difficult to locate by a non-expert eye. But in some instances this has not been the case, and certain species have become real pests. Sessile organisms, such as algae, ascidians or corals, usually start at a few highly specific and scattered points; nearby, we will definitely find their place of entry, such as a port, a drain or an aquaculture facility, that had helped the species to introduce itself. Then, if successful, it reproduces quickly and its density increases. From then on, if conditions favour, it can begin to spread to other places, where it may or may not have a stable development.

When the presence of an alien organism becomes an invasion, it's no joke. In many places, it has been found that 80–90% of extinctions of local fauna and flora are due to the introduction and subsequent success of non-native species (especially on land, where the topic has been advanced by the scientific groups that study it).

It may be the case that the native species may encounter a tenant who takes up space and food or nutrient resources. In this case, the aggression is not straightforward, but having someone more efficient than you at eating or colonizing the rock or sand that you live in may mean that you have to give in more and more to your competitors until you are reduced to nothing. For example, Marc Rius of the Department of Animal Biology at the University of Barcelona found that invasive marine invertebrates, a species of ascidia, were capable of displacing their indigenous competitors from the earliest stage of their lives, as larvae. 'In the early stages of life, we found that the alien ascidian was able to accumulate space faster and inhibit the settlement of local species', writes Rius. But if these effects are serious or very serious, the potential change to the habitat is even more so. Invasive species can sometimes alter the habitat, the place where other species live, impoverishing it or making it sterile for the life cycles of plants and animals that had depended on its structures, holes, recesses, shelters or exchanges of nutrients, which change due to the arrival of the new tenant. This is especially true for algae species and other sessile bioengineering organisms; that is, those capable of creating living three-dimensional structures on which other species base their existence. Therefore, invasive species can and do have effects on the food chain and ecosystem structure by attacking the complex web of ecosystems at several points at once.

Other effects, perhaps less understood in the marine sphere, are those concerning the introduction of disease (such as smallpox and other epidemics among the natives of Mesoamerica in the sixteenth and seventeenth centuries), or the hybridization of species (the arrival of species that cross with native ones, diluting the so-called genetic acerbic). All these and other effects have made biological invasions one of the greatest problems for the economy, health and biodiversity of marine (and terrestrial) ecosystems.

Just consider something shocking: while we have been reducing pollution by oil, mercury, artificial substances or organic waste, at the same time we have been increasing pollution through invasive species of all kinds. An example of this is the ctenophore that was discussed in previous chapters and that is beginning to form dense banks on our Mediterranean coasts (*Mnemiopsis leidyi*). This gelatinous animal represents an estimated loss of more than €150 million per year, mainly due to its harmful effects on fishing. Unfortunately, the effects of marine invasions (fishing, health, tourism, etc.) are far less quantified than those on land, due to our eternal ignorance of the marine environment. And all taxa can become invasive species, going from seemingly harmless to a serious social problem. On South Atlantic island coasts, goats have come to incorporate in their basic diet algae that are exposed to the tides…

Although we know that the movements of species from one side of the planet to the other are totally inadvisable, some have been premeditated, voluntary and 'studied'. In the overwhelming majority of cases, they have ended up as an ecosystem fiasco. For example, researchers from Thiagarajar College in south-east India conducted a study showing how harmful an invasive alga can be to coral reefs in one of the biosphere reserves in this country. At the end of the last century, people looked into the possibility of importing for industrial treatment this seaweed (*Kappaphycus alvarezii*) from its place of origin, the Philippine archipelago. In 2001, following studies by the Marine Chemical Research Institute of the Gujarat region, Pepsi-Cola cultivated it for use in a food stabilizing product. For some time, it had been thought that this alga was 'ecosystem friendly', meaning not only was it non-aggressive to other species but promoted biodiversity.

However, an accidental introduction of *Kappaphycus alvarezii* into the Hawaiian archipelago in 1976 had already had negative consequences. The alga proved to be harmful to the development and survival of the corals in the area: by growing on top of the calcareous structures, it prevents the arrival of light and food to polyps, choking the animals that form the reef. For the time being, its spread in Indian waters is asexual, but if it starts to produce spores it could spread to other reefs and invade the surrounding ecosystems in this part of the country. Pepsi-Cola has disengaged, saying that the origin of the invasion is probably the Marine Chemical Research Institute that brought it in, in the late 1990s. The Chemical Institute has replied that it stopped experimenting in 2003 and that the propagation sites are in the plantation area of the food company. The reality is that the cultivation of an alien species had been promoted in full knowledge that it could be harmful to a native ecosystem (Fig. 15.1).

However, not all invasions can be considered harmful to humans or the ecosystem. In South Africa, for example, ten non-native species have been officially detected, yet one of them has had an apparent benefit for the country's ecosystem and economy: the European mussel. Since its introduction in the mid-1970s, *Mytilus galloprovincialis* has formed dense, fast-growing mats, displacing the native mussel. It is capable of forming several layers where the native one creates only one, and a stock of some 35,400 tonnes has been counted along more than two thousand kilometres of coastline, especially in the western part of the country, where production is

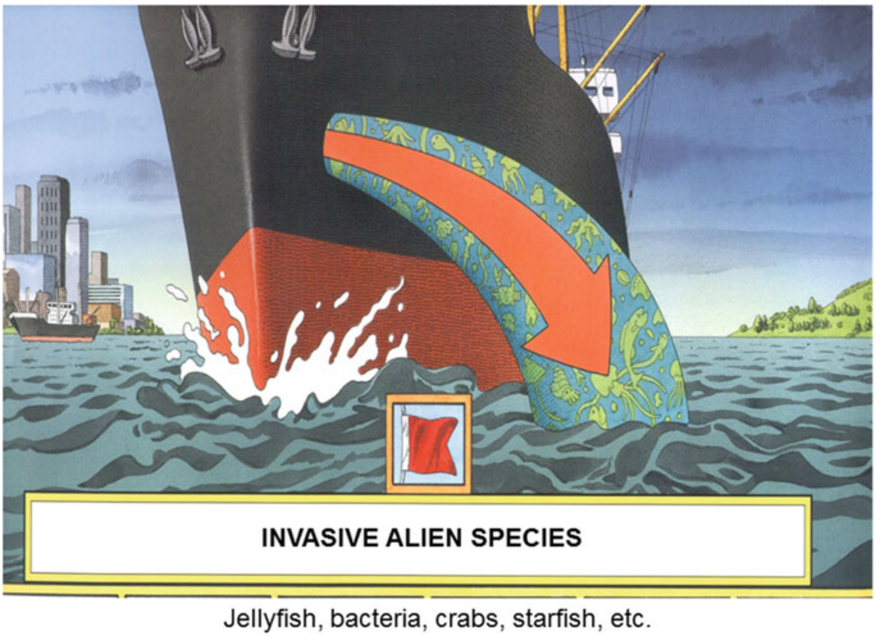

Fig. 15.1 Ships' ballast water is the main means of entry for invasive alien species into our oceans

concentrated. Faster to grow, better able to withstand desiccation and more capable of efficiently filling space, native mussels in South Africa have been left standing, in many areas. But the most interesting thing is that the fauna and flora associated with the new tenant are at ease in their new home, being more abundant, with more diversity per square metre and finding more food to eat. Due to the large pulses of larval production (up to 20,000 per square metre), there have been no predators to control it, neither sea snails such as *Nucella* species, nor birds such as the oystercatcher, which however are seen in greater numbers thanks in part to the abundance of food offered by the new inhabitant of the hard substrate of these coasts. The cultivation of this bivalve, as is to be expected, has increased and the European mussel has become a popular meal from a high-quality catch.

Interestingly enough, while in this part of the world the European mussel triumphs, thousands of kilometres to the north, in the Wadden Sea, it languishes. There, an Asian variety of oyster (*Crassostrea gigas*) has invaded the area, thanks to intensive aquaculture. In this case, the apparent effects on local biota have been as good or better than those in South Africa. Algae, bryozoa, hydrozoa, ascidians and barnacles have increased in number, biomass and diversity, and also moving organisms, which enjoy the greater particle retention of sediments by these rougher and better-oriented organisms than by their twin-shelled mussel relatives. In this case, there is something that makes oysters better than mussels: they clean the water of plankton in suspension. The more than two thousand mouths per square metre are powerful vacuum cleaners that suck better, not only because they are more numerous than their mussel colleagues (whose density is about 1,300 individuals per square metre) but because they suck faster. Therefore, in the case of the coasts of the Netherlands, Germany and Denmark, as well as those of South Africa, invasion has not only adapted but has apparently meant no loss to the community, marine or human.

How do invasions enter the area? The main vector of invasions is undoubtedly the ballast water of ships. Since the end of the nineteenth century, all ships have had to carry a certain amount of water either in their interior or outside to compensate for the load that they carry and thus sail safely. This water may be taken in at the port of Hong Kong but, when the consignments of teddy bears, cars or soybeans arrive at the port of Marseilles, for instance, it needs to be evacuated, and there may be as much as 120,000 cubic metres (and more) of foreign salt water. This is a very large volume in which all kinds of organisms enter and leave: microscopic algae, jellyfish, crustacean zooplankton, larvae of various species of invertebrates… the problem is not so much being taken on with the liquid ballast as surviving the weeks or months of passage from one port to another across the planet. But many organisms can cope with this, as they enter a quiescent state, waiting for better conditions, as we spoke about in the chapter on red tides. It may also be that organisms are attached to the outside of the hulls of vessels, as fouling or even, as we saw two chapters ago, in plastic bags that can drift around from anywhere on the globe, making long 'migrations'. Aquatics and mariculture are also common means of entry into ecosystems.

Algae are some of the most passively proliferating groups on the bottom of the planet, coming from ships, aquariums or marine cultures. Of all the algae, one of the most successful has been *Sargassum muticum*, an ugly seaweed from Japan where, in its native habitat, it grows to a moderate size (about 1.5 m long) and has a limited niche. However, it has been exported to areas of the East Atlantic, probably through both oysters and maritime traffic, and is now highly developed in some coastal areas (growing up to 10 m long in some parts of the French coast). It can develop a monopoly on space, excluding native species, and can become dangerous when it is entangled in ships' propellers. There are many more examples (some are discussed in the following sections) in the various seas of the planet.

The next question is how to stop the invader? How to end the invasion? There is no magic formula. And, at sea, the issue is more complex than on land because of our greater ignorance of how the system works and, in many cases, because the species can move more quickly, given the natural and artificial connectivity of the oceans. The first step is clear: avoid the main entrance, which is intense maritime navigation. The ships' liquid ballast has to be treated, and all kinds of techniques have been thought out (and applied) in this respect. Mechanical separation, by filtering, and ultraviolet treatment are used to kill the organisms. Heat is applied, ultrasound and biocides are used, the water is deoxygenated… yet all these treatments have problems. For example, ultraviolet radiation is incapable of killing all the organisms, cavitation (ultrasound) is very expensive, deoxygenation is complicated, heat is not efficient for all species and is cumbersome (and expensive in terms of the energy required) and mechanical separation does not retain everything—on the contrary, a large number of organisms are left. Combining several techniques is one solution, but some of the most effective treatments cost at least €280.000 (treating about 3,500 cubic metres per hour) for normal ships with about 100,000 cubic metres of ballast water. That's a lot of money. The worst thing is that there has to be consensus, otherwise biological pollution can be controlled in one port yet go unnoticed in another, because there are no mechanisms to regulate it. In July 2009, only eighteen countries in the world had signed an agreement on the treatment of ballast water, which represents only 15% of merchant countries.

Once the invasion has become a reality, we move on to the second phase: killing the alien. On land, this is still difficult, despite decades of experience (in some cases centuries), yet at sea it is far harder. Everyone agrees that early eradication is the most effective method: find it, exterminate it. But this requires specialists in the field, operational public and private bodies and money, sometimes a great deal of money. Moreover, there are various proposals for the eradication of pests at sea. Examples? For algal blooms, one is the introduction of viruses or pathogenic bacteria that cause cell lysis and population decline, but the apparent lack of specificity has made this measure dangerous for other, non-hazardous, algae. In the case of the *Carcinus maenas* crab that has invaded the western Atlantic coasts from the east of the Atlantic, as well as the seas of Asia, Africa and Australia, one remedy would be a small, single-celled organism or a multi-celled parasite; in both cases there would be a 'castration' of the voracious crabs that eat everything on the bottom. But the possibility of mutation of the parasites is an eternal problem. Will they change and become less specific? Will they attack native species? The remedy may be as bad as the complaint.

The same possible disadvantage of biological control applies to algae and their specific herbivores. *Caulerpa taxifolia* (see below) is an alga that herbivores shy away from in their 'artificial' environment; the sea urchins, fish and sea slugs in the places that they invade will have little to do with it. When the alga spreads, there is a possibility of introducing a sea slug (nudibranch) that has been found to be highly effective as a biological controller in its place of origin, denuding it. The problem is that no one knows if it would continue to be specific to that alga or, worse, how it would affect the fragmentation of the plant, which had been shown to be a good method of dispersing the invader. Biological controls are too new at sea, far too new. There is little or no knowledge of the consequences, and on land they have often proved ineffective. There are several proposals, but actual implementation is almost nil.

In the end, it all comes down to one thing: we know too little, we have too little information and we lack the perspective to assess its consequences. Meanwhile, invasions continue to transform ecosystems, altering the cycles of matter and energy, depriving native fauna of space and resources. There have always been biological 'invasions'; there have always been alterations in systems due to alien species. What is not clear is whether at any other point in our natural history there have been so many at the same time and in so many places on the planet in just a few decades.

The Mediterranean: A Sea of Invasions

If the Mediterranean is the sea with the most history on the planet, it is also the one with most invasions of alien species. Already in the sixteenth century the arrival of the first allochthonous organisms began to be travel with the Spanish galleons full of cocoa, gold and silver. Sessile organisms such as algae, ascidians and bivalves were undoubtedly the first tenants of these immense, rigid, floating substrates that arrived mainly from the Americas. But we would be mistaken if we believed that everything was unintentional, since the so-called Portuguese oyster (*Crassostrea angulata*) was introduced knowingly at the end of the same century, especially to southern Spain and, of course, Portugal. But without a doubt, the main impetus did not come until the end of the nineteenth century when the Suez Canal was opened and the so-called lessepsian invasions began. From 1869 onwards, something occurred that rarely happens in the history of the planet: bringing together two of the most distant bodies of water in the world, those of the Red Sea and the Mediterranean. The first place officially to detect an invasion of its waters was the city of Jaffa on the Israeli coast in 1891, and in 1925 it was considered appropriate to make a biological laboratory dedicated to monitoring the species from the Red Sea. From the 1950s onwards there were around thirty or forty new invasive species per decade, until today there are more than 300. Of these, as many as 96% are from the area adjacent to the Suez Canal, the so-called erythreian species also found on the Mediterranean coast.

Some of these species are so abundant that already in the early 1900s there were fish and molluscs in the markets of Alexandria and in the Lebanon. In the 1940s, a fish in the same group as the red mullet (*Upeneus moluccensis*) contributed no less than 15% to the catch in Israel, rising to 83% in 1954–1955, a particularly warm winter. With oscillations, catches stabilized at 30% in the 1960s, confirming the displacement of the native species (red mullet, *Mullus surmuletus*). Some of these lessepsian invaders are now seen as a pest, such as the swimming crab, *Charybdis longicollis*, which can represent up to 70% of the benthic biomass on sandy seabeds along the Mediterranean Levant coast.

The increased frequency of maritime traffic from both the Suez Canal and the Strait of Gibraltar has besieged the Mediterranean, especially in recent decades. But aquaculture has also contributed to the problem; from species professed to have been introduced for exploitation, to organisms that have accompanied others, there has been a flow between quite separate areas that has caused more than one problem.

Oyster farms quickly became big business on the French Atlantic coast, especially from the nineteenth century onwards. The non-native species, those from the Pacific, seemed to be more profitable than the native species, so they were imported and conditions favoured their growth. The businesses soon saw such benefits that they decided to introduce them to the French Mediterranean coast. With the oysters came two problems. The first was the epibionts; that is, the animals and plants that live on the rough outer surface of the oyster. One example is that of the Japanese oyster *Crassostrea gigas*, which carried algae and animals on its surface that were then introduced into the system. Ten of the fifteen species of macrophyte algae carried by this bivalve have been identified as originating in the Japanese archipelago. The second problem with these oysters is that their success replaces the native ones (*Ostrea edulis*). As both filter feeders eat the same and settle on the same hard substrates, the native oysters in the area have found themselves cornered and in some places disappeared, as *Crassostrea gigas* is quicker to grow. The final blow was delivered by a plague of a parasite that affected *Ostrea edulis* more than its competitor, possibly because the origin of the parasite was from distant seas and the latter was more accustomed to it.

Problems increase with the Mediterranean invaders, as algae that have long covered the rocky substrate grow each spring. Of the sixty invasive algae, eight can be considered as a serious problem for Mediterranean benthic ecosystems. Some examples are that in April and May, *Asparagopsis armata,* an alga possibly of Australian origin, grows into huge, continuous carpets. It was first detected in Banyuls sur Mer, France, in 1922, and is an organism that has several advantages, apart from the obvious acclimatization, over other fleshy algae: (1) it is avoided by herbivores (such as sea urchins); (2) it can reproduce vegetatively (a fragment can grow into a new plant); and (3) its hooks allow it to cling to new colonizable substrates when displaced by the currents. These advantages make it more competitive, thus more suitable for expansion.

Something similar happens with another species of alga, *Caulerpa racemosa*, which officially appeared at the beginning of the 1990s to colonize the seabed at a depth of more than 70 m. It is another example of recent expansion, and it is found in places as disparate as the Island of Elba and the Mar Menor. In Tuscany alone it has grown from 3,000 square metres to more than 300 ha in two years. Once they have found the optimum conditions and are able to withstand the first seasonal onslaught, the alga spread by covering both soft and hard bottoms, with varying success, forming a complex web in which the native fauna and flora are altered in abundance and diversity. It can cover more than 60% of the available space, reducing the presence of other native algae, especially incrustations. Interestingly, it seems that it has taken up the space previously occupied by native algae, but it is tolerated by another invader that prefers deeper environments, *Womerseleyella setacea*. It is a complex system of competition.

Many other species have invaded the Mediterranean, causing real problems. But it is a sea accustomed to invasions and, although they pose a problem for its functioning and impoverish its ecosystems, many of the species that have entered will end up forming a synergistic part of its sea bottom and water. Some experts have suggested that the establishment of new tropical species may be partially favoured by global warming. In the section on climate change, we will see how some species have been conquered, in stages, in less and less time, especially mobile species such as fish and cephalopods, both from east to west and from south to north.

'Killer' Algae

Caulerpa taxifolia has become a paradigmatic alga in terms of invasive marine plant species. The first time I heard of it was in 1991 from Professor Charles Boudouresque in Marseilles and, like the data showed, we all felt that it was a growing threat along the north-west Mediterranean coast. Boudouresque told us that the most likely source of introduction was tropical water aquariums. Uncontrolled washing of an aquarium for non-native species can pose a real problem for the ecosystem. In 1984, in front of the Oceanographic Institute of Monaco, a metre-square mat of this alga was detected for the first time, and, since then, it has been observed in various places. In 2000, an estimated 6,000 ha were affected in the Mediterranean, and only two years later the estimates put its coverage at more than 30,000 ha.

This alga can withstand emersion, low temperatures and even desalination. A simple fragment of a few millimetres in size can start a small population that spreads at the expense of other native algae. Such fragmentation can be natural or manmade. Dispersion can occur by fragmentation or by reproductive elements carried on currents, animals (sea urchins, crustaceans, etc.) and by human means (anchors, fishing gear, handling). The progression has been rapid, and it has been documented at up to 99 m deep.

The main problem is that the algae does not have predators, as they all seem to shy away from it, and when they grow on top of other vegetation (in areas between one and 20 square metres) they create a network that tends to accumulate sediment and become denser, so they end up shading out and suffocating everything that is below them and needs light. The most serious case is *Posidonia oceanica*, which becomes coated and may not function properly because the light does not penetrate the covering, and the amount of nutrients available for its growth is reduced. *Caulerpa taxifolia* has it all: a wide ecological spectrum of settlement possibilities (even on soft bottoms), a well-off population persistence, high competitiveness, resistance to herbivores and strong reproduction. During the last two decades since the confirmation of its expansion, losses have been quantified in various areas both directly (damage to the ecosystem) and indirectly (damage to fishing due to the disappearance of recruitment and feeding sites, and damage to tourism due to the degradation of the coast, etc.).

After the initial alarm, however, several things gradually became apparent. The first is that the maps of algal extent and cover could be a little exaggerated: 'The algae cover is an order of magnitude smaller than was described', says Jean Jaubert of the European Oceanological Observatory of Monaco: 'With more extensive methodologies, we have been able to see that it is not as widespread as we thought.' Another of the reports that has come to light is that the algae seem to prefer disturbed, slightly eutrophic places where *Posidonia oceanica* was already in regression, dying or even dead, as Jaubert indicates. This would indicate that it is sometimes occupying ecological niches not exploited by spermatophytes. In addition, the effect on *Posidonia* does not appear to have been as severe in healthy grasslands. On the other hand, as of 2009 the algae seem to be regressing both in the place of origin (the Côte d'Azur) and in other places such as the Tuscany coast. Indeed, Monica Montefalcone of the University of Genova explains that, 'after a very sharp expansion between 1984 and 2001, *Caulerpa taxifolia* began to disappear in many places or to drastically reduce its distribution'. The system itself seems to have been adapting itself to the invading 'impetus' of the misnamed 'killer alga' that has now begun to be accepted as food by herbivores who, until recently, had not wanted anything to do with it.

This adaptation is not the case for another species, which has expanded in a more, shall we say, 'silent' way: *Caulerpa cylindracea*. This other invasive species in the Mediterranean has an abundance of one and a half times greater than *Caulerpa taxifolia*, has adapted better and spreads through the seabed, changing the diversity, complexity and sedimentation rates. 'This species also has its biological and physical controls,' writes Dr Piazzi of the University of Sassari in Sardinia, 'but each species has its dynamics, its way of proceeding.' *Caulerpa cylindracea* is actively ingested by fish and other organisms. The problem is that some of its molecules may be having repercussions on its predators and those who, in turn, ingest those predators. Recent studies by the Department of Environmental Science and Technology at the University of Salento in Italy warn of this possibility. '*Caulerpine* accumulates in the tissues of the bream,' explains Serena Fellini of this department, 'which is not surprising because we can find fragments of the alga in up to 86% of the fish's stomachs; the problem is that this accumulation causes problems in the hepatopancreas and in the species' ability to reproduce.' And it can also accumulate in the organisms that consume these fish, although the impacts are not yet proven. Ernesto Mollo of the Institute for Environmental Protection and Research of the Italian CNR speaks clearly of a new problem, that of 'invasive metabolites' or 'alien metabolites': 'It is a field that requires our attention, because we do not know how these types of molecules are influencing the food chains, the behaviour of species, their reproduction,' Mollo insists.

We have to understand what we're dealing with. In the case of *Caulerpa taxifolia*, in my opinion the problem has been magnified without being fully understood, to the extent that in some cases an ignorance of the issue on the part of environmental managers may have been a benefit. Far more agile tools must be provided to eradicate an outbreak of invasion immediately, but in this case, because of all that the 'killer alga' issue involves, I think it is another lesson to be learned by authorities and scientists. However, on the other hand, we cannot ignore that there are species that really are changing the ecosystems and the way that the organisms that inhabit them interact and survive, as in the case of *Caulerpa cylindracea*. There is a long way to go, and we cannot afford to ignore any detail.

A Problematic Crab

Species introductions are often not only deliberate but are intended for the social and economic benefit of a region. In general, these introductions are always harmful. We are going to illustrate this by a story that reflects this kind of blunder by people who obviously had little or no understanding of the functioning of ecosystems and their equilibrium. Between 1961 and 1969, Russian scientists and fishing technicians decided to introduce a valuable species of crab from the waters of the Aleutian Island arc (between Canada and the Kamchatka peninsula) south of the Barents Sea (northern Norway and Russia in Scandinavia). In that period, more than 1.5 million larvae, 10,000 juveniles and 2,600 adults were released into the fjords of the northernmost, Russian part of Scandinavia, in the hope that Russia, too, could establish and profit from the imposing king crab (*Paralithodes camtschaticus*), one of the largest arthropods on Earth.

The king crab went from about 15,000 adults in the late 1960s to more than 12 million in 2002 (between 1.2 and 2.8 tonnes per square kilometre). With a shell of more than 22 cm wide and weighing more than 10 kg, this underwater beast can be worth around €40 a kilo, and is a highly profitable catch in the Pacific area, where tonnes were extracted (until its virtual collapse in some areas, as we have already seen). Such a plan should have had great results: the fishermen in that area were to enjoy a new source of wealth, given that many fisheries were in decline due to a lack of fish. But it turns out that this little friend is a voracious predator, an insatiable consumer of everything, dead or alive, at the bottom of the sea.

Juveniles feed in shallow areas between 50 and 60 m deep, on the lamellar algae on rocky or stony bottoms near the coast. Adults migrate to greater depths to feed, to between 300 and 400 m, looking for all kinds of food. Among their preferred prey are bivalves, starfish and low-mobility benthic fish, but they make ascents to take carrion or sessile invertebrates such as alcyonarians or ascidians. In short, they wipe out everything. And they are considered, within the system, to be one of the highest links in the food chain, precisely because they are insatiable carnivores. The bivalve-rich bottoms (especially scallop-like shells) are like carpets of food, where the crabs crush the outer structures of their prey without great difficulty. After a period of growth to maturity, the crabs moult and reproduce again in the algae forests, where they prey on everything before them. In just two years, the prey can drop by up to half its biomass in the affected area (up to 450 broken shells per square metre in just 48 hours), forcing other predators to move or disappear. A single female crab can carry more than half a million eggs, which is understood to be why the expansion was so rapid. In fact, it is one of the most studied cases of marine biological invasion, because it is known exactly when it started and where it is right now: in just forty years (1961–2001) it managed to reach the west coast of Norway going around the northernmost fjords. Since 2002, it has been regularly on the market in Norway.

Although it is still not entirely clear how it will affect the functioning of the ecosystem, it is known that the fishermen are desperate because their bottom-set nets and longlines are found with less than 60% of the fish intact, the rest having been eaten by the crabs while on the bottom. The fishermen have to set their fishing gear far from the coast, fleeing from the predatory plague, but even so the crabs are invading every habitat, every corner, every fjord. The profit that the crabs make as a piece is not negligible (in 2005 they earned €12 million in Norway alone), but the price has been devalued outrageously and traditional fishing has experienced considerable regression yet has not been compensated for at all. 'The problem with the capture and impoverishment of the Atlantic is overfishing,' says Walter Courtenay of Florida Atlantic University in the United States, 'and what we need to do is to manage resources well, not to introduce new species whose consequences for the balance of the ecosystem are unpredictable and generally very negative.' He and other specialists are alarmed that a politician or manager has addressed the issue of recovering fisheries by introducing a new species. In a recent model, a 'simple' conclusion is reached: the crab must be completely exterminated if the ecosystem is to return to normal and recover. The long-term productivity of the system depends on the complexity of the food web. In other words, if such a destructive species spreads further, only short-lived organisms adapted to the crab catch rate will survive.

Meanwhile, the king crab continues its expansion, and in 2008 an Italian group found a specimen in the depths of the Western Mediterranean…