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The Swamped Shoreline

There are so many of us! It is a well-known topic, much repeated, and is something that seems almost banal, yet it is an inescapable reality. We consume a great deal of energy and products, we need resources of all kinds and generate mountains of waste. One of the biggest problems is that more than half of the world's population lives less than 200 km from the coast, and all this activity, all that movement, has a direct impact on the sea. Coastal areas are, undoubtedly, one of the more pressured and threatened ecosystems on the planet, as a group of experts warned in 1990 in Kobe. One of the direct effects on our agricultural, industrial and urban areas is the production of nutrients (especially nitrogen and phosphorus), artificial organic contaminants (mainly derived from oil) and heavy metals. When there are nutrients in excess, some species are capable of assimilating them rapidly, multiplying tremendously, such as in single-celled algae's rapid development. These algae prevent the growth of organisms whose life cycle is slower, and swamp anything that cannot compete in the race to reproduce. In the end, a huge quantity of organic matter is created that then dies and is taken over by bacteria, resulting in hypoxia or anoxia (see below). The cost of reducing nutrients is very high, especially nitrogen and phosphorus. In the United States alone, wastewater treatments across the country in the last thirty years have cost some €360,000 million, a considerable amount.

As we shall see in the following examples, this effort is working, but is it enough? Unfortunately, there are few ventures that can claim with confidence that the conditions are gradually returning to 'normal': we would need a long time series study to tell us if the conditions were equivalent to a return to the pre-industrial state experienced in a particular town in the mid- to

S. Rossi, *Oceans in Decline*,
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late-nineteenth century. It is not that the specialists (including myself) want to return to those times. This is impossible, for obvious reasons of demography, expenditure of energy and materials processing, but that model uses a baseline towards which must aim. In the great city of Oslo, sediments have been studied using a few specific organisms as indicators of changes over time: 'Sediments are an excellent time integrator if you know how to read and take into account variables such as rates of sedimentation, temperature, currents, etc.', said Elizabeth Albe of the University of Oslo. The organisms used are the foraminifera, protists that live both in the water column and on the seafloor. Looking at various places in Oslo Fjord where sediment had been deposited each year, Albe and her colleagues were able to see that, over a century, there had been profound changes in the waters of this area of Scandinavia. 'The anthropogenic pressure had reduced the number of species of foraminifera as much as 73%', adds Albe. Eutrophication and heavy metals had been the main cause of the impoverishment of the fjord, also the reduction in the diversity of the system both at the bottom of the sea and in the column, due to intensive fishing. Despite thorough controls that now remain in this area, the current populations of these organisms are far below those found in 1900, the starting point of this study. Predictably, in following the time series through the sediment cores that were studied they saw that the most drastic change was in the 1960s, when industrial and agricultural expansion influenced decisively this and other areas of the world.

Many degrees of longitude and latitude distant, across the planet, there is another example of a short time series study, also one with major implications for the trends in many developed countries. In California, a rigorous study of over thirty years long has demonstrated unequivocally an improvement in many aspects of the state's marine ecosystems. The volume of solids in suspension has improved drastically in some cases, leading to the recovery of biodiversity in coastal areas and on the continental shelf. 'At the beginning of the 1970s, 75% of flatfish on the Central California coast were affected by a malformation of their fins, today that percentage to past to be less than 5%', explains Eric Stein of the Southern California Coastal Research Project of the United States. A reduction of 80% of waste derived from mineral and vegetable oils, or the virtual disappearance of PCBs and DDT, has to have had a concrete and palpable effect. It is not the total quantity of heavy metals and PCBs in the environment so much as its availability for pelagic and benthic organisms. However, a good environmental policy can bring about recovery even in badly punished environments. We must not forget that the sea has a capacity for recovery greater than that of terrestrial ecosystems, in many respects. Although the recovery of the fundamental pillars of predators, such

as large ecosystems or coral forests, is much slower, the system is capable of responding promptly to certain improvements introduced by humans if we follow guidelines, apply the supporting science and treat the chance of a recovery seriously (Fig. 13.1).

But human stupidity is great, and our memory of history and ability to learn almost non-existent. Let's explore a part of the planet in full development: the sea of the Arabian Gulf. Charles Sheppard, of the Department of Biological Sciences of the University of Warwick in the United Kingdom, and his colleagues conducted an in-depth analysis of the latest outrage to human progress: the runaway expansion along of the coasts of this region. Due to uncontrolled growth, every shore in Qatar, United Arab Emirates and Kuwait is undergoing a rapid degradation of its ecosystems. We must bear in mind that the waters of this sea, mostly off the Arabian peninsula, are very shallow and some areas have been flooded for only three or four thousand years, due to the ingress of the sea caused by the melting of glaciers and polar ice caps after the last ice age about fifteen thousand years ago. We are therefore facing coral reefs, mangroves, seagrass beds and quite recent macroalgae. Coastal ecosystems are areas where the sheets of shallow waters are very large. Since the beginning of the 1990s, when pressure began to be exerted for industrialization, the creation of ports, airports, canals or desalination plants, as well as residential complexes or luxury business centres, there is no more than

Fig. 13.1 Example of urban overpressure on the Mediterranean coast: Algarrobico Hotel in Andalusia, Spain. *Source* GreenPeace

40% of the coastal area left. In some cases, there has been such drastic alteration that it has led to changes in currents and areas of increased evaporation of water in an area of the world where the sea is already more saline due its hydrography.

In certain areas, such as the famous artificial islands off Dubai, the coastline has been increased by 11% (more than 90 km^2), gaining ground on the sea and degrading the surrounding areas by adding sand. More than 150 km^2 have been lost, where the turbidity, the addition of nutrients and changes in currents already reflect the drastic changes in the dynamics of systems. Such is the lack of foresight by the engineers and biologists of the region that there are already recurrent eutrophic algae blooms and an absence of hydrodynamics. In the houses on the artificial islands (priced on average between €2 and €3 million), the bathrooms are impracticable due to the concentrated dirt and pestilence. Environmental impact reports are opaque or confidential, giving the main actors (government or real estate and large infrastructure businesses) recourse to commercial or strategic protection. But the reality is that the changes in this place have been extremely fast. The area has gone from having 60% of the seafloor covered by live coral to less than 1%, and gravel and dead reef areas have gone from 10% to as much as 60% along the most developed western coasts. There, the second population of dugongs (*Dugong dugon*) on the planet and one of the most vulnerable populations of green turtles (*Chelonia mydas*) no longer find healthy meadows of flowering plants, as these have been replaced by fleshy algae's rapid growth, in the most fortunate cases. Systems of high complexity and difficult recovery, such as mangrove swamps, have gone into reversal at an alarming rate.

We must not forget oil exploitation, as the area's ports offshore installations (more than 800 throughout the coastal area) handle 60% of the world's oil, and with more than 25,000 tankers full of crude oil and derivatives. The area acts synergistically, adding fuel to the fire. We cannot ignore that it is one of the places in the world where desalination plants are most concentrated, extracting some 11 million cubic metres a day to meet the need for water in one of the driest areas of the planet.

Two mega projects may yet be completed that will affect this area irreversibly (always in our time scale, of course). The first is the construction of a mega dam of the Aswan type, in the south of Turkey, which would retain the waters of the Tigris and Euphrates. The retention of the waters and their sediments would decrease the water balance in a sea of very high evaporation (as we have said before, one of the most saline of the world). But that would not be the most devastating effect. Due to the conversion of the area to other sources of income for when the oil business ceases, there is a serious proposal

to build a new type of dam: to close the Strait of Hormuz. The purpose would be to create a hydroelectric plant with a waterfall from the Indian Ocean to the sea of the Gulf, of between twenty and forty metres high. Inside this dam, the sea water would evaporate. This project, if it takes place, would take an indicative budget of €44 thousand million and 30% of the annual production of cement and concrete on the planet. And it would close a sea. The traffic of oil and other goods is already achieved in other ways, but what is certain is that no one has stopped to think about what would happen to the coastal and oceanic ecosystems in the area, nor the serious consequences of a kind of gigantic Aral Sea, all to create energy. And no one has thought of people, of course—of the millions of inhabitants of the coasts here. The same engineering approach has been on the table for the Red Sea and the Mediterranean, although, in these two cases, I doubt that it will ever be progressed.

There are two further examples of nefarious coastal management: Cancun and the Riviera Maya, Mexico. Tourist expansion here has been the fastest and least planned ever known. Cancun alone has about four million tourists every year, spending more than $4 thousand million dollars. It is a very desirable cake and, for the sake of tourism, the regional and state government removes any real obstacle to unbridled expansion, even changing the opening hours to accommodate tourists from the east coast of the United States and Canada. Beaches have been transformed and mangrove swamps destroyed, and there has been strong eutrophication and erosion of the reef, which has gone from 40% live coral cover in the 1880s to less than 5% in 2010. There is no control, and the resident population, without proper services, has grown from about 60,000 inhabitants almost 800,000 in just two decades. As an example, the last stand of mangroves under the influence of the city of Cancun, the Tajamar, disappeared under bulldozers and trucks overnight (literally) to offer more expansion for the construction of hotels and apartments. 'Cancun lagoon has gone from being a precious emerald blue to a disturbing brown', explains Ernesto Arias of the Laboratory of the Ecology of Ecosystems of Marine Reefs, CINVESTAV, in Mérida, Mexico. 'Everything has changed, the chemical flows, availability of drinking water, biodiversity, the complexity of ecosystems', added Arias: 'The problem is that the waters smell ever worse, the beaches are no longer transparent and idyllic, the reef is poor and devoid of the life that there used to be, and our tourists feel more and more disenchanted.' In 2012, visiting its most iconic beaches, I found myself at six in the morning, with the resorts' employees, digging holes to dump the algae that grew out of control and that wreck the landscape. These algae are now rotting under the sand and leaving a worrying stench.

But the worst thing is that they are also out on the reef, which is lethally poisoned by pollution from uncontrolled nutrients and stifled by the lack of fish that had controlled both them and the feast of phosphates, nitrites and nitrates released by faulty hotel control system. But, no problem! This sector is already eagerly looking north to the Yucatan Peninsula, in the area of Holbox, planning the next expansion phase. Bread for today (for a few), hungry tomorrow…

There is no need to go so far afield to witness chronic coastal deterioration. The Mediterranean is the sea that has most suffered most from human action by all those who has swum here since time immemorial. But in recent decades it has experienced a series of profound transformations, especially in European countries such as France, Spain, Italy and Greece. On top of over 130 million coastal inhabitants of the Mediterranean, double that number of visitors migrates to its shores in summer in search of fun in the sun. By 2020 it will be a global movement of more than 345 million tourists, concentrated in the developed countries.

The Spanish case is especially striking, due to its poor coastal management. Spain is one of the main tourist destinations on the planet, and the sector earns about 11% of its gross domestic product, supports more than 2.7 million jobs, permanent and temporary, year-round and seasonal, and is worth approximately €40 billion every year, thanks to the nearly 60 million tourists who visit us—or come quasi-permanently, in the case of the pensioners from northern countries—each year. But that has a cost. Between 1987 and 2000 alone, there was an increase in artificial surfaces (marinas, docks, etc.) of more than 30%, which resulted in a total change for more than a third of the coastal strip from what it was at the beginning of the last century. No less than 34% of the first kilometre from the beach is now completely transformed, and our beaches have become, mostly, a constant press of people. Only 31% of the coast possesses what, according to European directives, can be considered a 'healthy' beach in terms of the concentration of people per square metre (one person every 6 square metres). In any case, this is not a superfluous measure. People value an absence of overcrowding, and appreciate the quality of the landscape and the identity of places. Has the transformation managed to deform both, making places unrecognizable? The problem is similar across Western Europe, even in areas where the tourism is not yet not as bad as in the Strait of la Mancha. The French and English coasts are also busy, with excessive building, problems of coastal transformation, pollution and the depletion of natural resources that that entails. However, we should recognize that exploitation has been uneven, even within developed countries, depending on regional policy.

From experience, I can say that the coasts of Lazio or Liguria in Italy, Tuscany or Sardinia have not experienced the same uncontrolled expansion as on the French Côte D'Azur, and the as yet undisturbed Corsica is the same. Driving from the marina at Bosa to the town of Alghero in Sardinia, I had to stop in disbelief at what I saw: not a single building for 41 km of coastline. Nothing. In Spain, the disparity occurs primarily between the areas on the Valencian, Murcia or Catalan coasts, and the coasts of Menorca, Ibiza and parts of Andalusia. However, the pressure is also immense in these places, and it continues to be subject to economic projections based on the building of second homes. While the impact of cement is year-round, the tourist is seasonal. A population like Roses can muster about 20 thousand inhabitants in winter yet rise to more than 200 thousand in summer, which involves a huge expenditure of energy and water and the production of waste, among other things. Just think of the gradient of disturbance at the bottom of the sea, an unmistakable imprint of our direct presence in the area. 'If we look at the seafloor of the Natural Park of Cap de Creus,' says Rafael Sarda of the Center of Advanced Studies of Blanes (CSIC), 'we see that 23% of the rubbish (mostly string, tubes, cables, bottles, etc.) is near the port of Roses, while on the same cape, in the most remote area of all the urban centres, there is just 7%'. Fishing products tend to be found more frequently near the shore and ports. In places like the seafloor or the platform of California, in every two hundred metres there are between one and twenty-four objects. This is not surprising, as it is estimated that up to 630,000 tonnes of rubbish are dropped from boats. Considering that only 20% of the solid waste is from boats and that the other 80% comes direct from the land, the amounts are vast. And everything remains there, in the background.

Everything including a shopping trolley, refrigerators and a bath, which I have seen with my own eyes at the bottom of the sea. And a bulldozer. It's huge. What on earth happened? Was it abandoned after its day's work to collect on the insurance? Many of these objects provide a new substrate for the establishment and shelter of certain organisms (part of the solid substrate), yet the majority may be toxic, can shatter ecosystems and be harmful for or affect fish, mammals and aquatic reptiles.

So much construction, so much use of the place as both an anchorage for pleasure boats and fishing, and so much waste have tangible consequences for fragile communities like that of the spermatophytes. As we have already seen, trawling has been one of the main culprits behind the marine system's regression in various places, but not far behind are the proliferation of ports, dredging of sand and waste, and the contamination of water by large urban conglomerates or by intensive fish farming. 'Loss of flowering plants is due

mostly to coastal development, in all its senses', says Charles Boudouresque, of the Marseilles Centre of Oceanology, France. The issue is that grasslands, which as we have seen are essential for a useful (for us) operating system, are declining widely. 'Many meadows of *Posidonia oceanica* have disappeared, but they have been replaced by others of *Cymodocea nodosa*', explains Boudouresque. What happens is that these others grow faster and are better adapted to unstable environments, but do not accumulate the complexity and diversity of *Posidonia*.

Between the 1980s and 1990s, over 2,900 km^2 of spermatophytes were lost, according to documented records, but it is estimated that this figure could be more than 12,000 km^2. Other estimates speak of up to 33,000 km^2 up to the beginning of 2000, implying that, if we calculated a surface of 177,000 km^2 of these plants around the world, we are talking about losses of between 7 and 19%. On the French coasts of the Mediterranean it is considered that there is no less than 19% of water below 10 m deep with a degree of anthropization. This depth is vital. All beds have a very narrow bathymetric range. They are plants; they cannot live below certain depths because they need light, finding a home at perhaps between 3 and 5 m and perhaps between 15 and 20 m, depending on the clarity of the water. Of course, in certain places they are found deeper, but the water clarity must then be greater, for it is the depth to which light reaches that determines whether the plant can create enough oxygen to compensate for its respiration (plants produce oxygen through photosynthesis). This problem, from the point of compensation, could also aggravated in a short time by the potential rise in the sea level, as the Intergovernmental Panel on Climate Change (IPCC) models predict. Plants have coped with continuous rises in sea level, but if a rise is too fast the conquest of new territory is difficult for a slow-growing organism. So, we must bear in mind that, on a human timescale, the regression of the seagrass *Posidonia oceanica* and other spermatophytes is irreversible. I always insist on the human timescale because, in the very long run, communities can always return to the previous balance or find new paths of complexity.

We need to integrate concepts to achieve viable management of our coasts. It seems that we have started to understand this point and, in many respects, the management of our waters, our sea bottoms and our coast have started to improve. The case for a much more rational management involvement remains urgent. Tourist exploitation, for example, has to strike a balance between the benefits that bring visitors with their needs and the preservation of landscapes, materials and resources for local people. It has to be considered holistically, and not only as the water needs of a golf course and the estates

surrounding pools in areas that have a chronic lack of potable water. And is not a matter of building advanced desalination plants or increasing the energy available for air-conditioning, but achieving a good integration of human and natural factors to arrive at the best solution.

We also have very robust systems and long time series health status indicators. There are specific indicators to help us to understand this human impact. 'We cannot assign coastal management randomly or to the wrong hands', says Adriana Brizon, of Portugal LABOMAR in Brazil's Federal University of Ceará: 'We have to conduct rigorous monitoring of coastal communities and bring out a number of problems so that future generations do not have a system that is marginalized, deprived of the diversity that it had a few decades ago.'

Part of my work is a search for this type of indicator in coastal systems and platform. All elements must be considered: plankton, benthos, seaweed, grass, fish… We always have to refer to the needs of the area, its socio-economy and the vital structure that it will support. 'If it is proven that coastal ecosystems, both on land and at sea, help us to survive, why treat them so badly?' asks Mark Spalding of the Global Marine Team at the University of Cambridge in England. 'It is clear that maintaining these ecosystems in good health will help us to have a dignified life. We must not waste this last chance of doing things properly.' It is a vision of the future, in the long run. You can, as we have suggested before, see that the problem is no longer developing little by little in the advanced countries. It is now in the emerging countries, which see in tourism, in large cities and giant infrastructures a great business opportunity, and whose respect for the environment and vision can be so short-sighted, just has ours been for many decades.

Dead Zones

The surprise of divers must have been immense when great shoals of fish from deeper areas invaded the shallows (about 20–25 m) off the Californian coast in the summer of 2002. For them, it must have been an impressive and pleasing spectacle, but the fish were fleeing. Crabs (*Cancer magister*) that had already been caught in fishermen's pots were not so lucky, and when they were taken out it was found that more than 75% were dead due to lack of air.

The reason for the flight and lack of air was the ascent of a mass of oxygen-poor water from the depths—a 'dead zone'. Dead zones are fast changing from something rather interesting to a serious problem for the health of ecosystems and fisheries. They are bodies of water in which, due to

an excess of decomposing organic matter, the oxygen level becomes very low. This is termed hypoxia, and it can progress to anoxia (a total absence of oxygen). It has become more common since the 1960s, with double the number and extent every decade since then. In 2007, there were more than 400 dead zones across in the world, covering just under a total of 250,000 km^2 (half of the surface of Spain). Some, like that of the Gulf of Mexico, fluctuate in size from year to year and place to place, growing off the coast of Florida from 5,000 to more than 15,000 km^2 in just a few months. In reality, this does not seem a huge figure, but it conveys to us the importance of what has been lost in terms of fishing and the functioning of the ecosystems. In Chesapeake Bay, which began to register acute hypoxia in the 1930s, there may have been a loss of around 5% of secondary production, which would mean less food for fish and an estimated loss at catch of 10,000 tonnes, especially in deep areas.

There are more dramatic examples. 'In the Baltic Sea, in a hypoxic deep sea in certain areas, no less than 264,000 tonnes of carbon are being lost in secondary production (zooplankton); that is, 30% of the potential production of fish in the area', says Rutger Rosenberg of the Department of Marine Ecology of the University of Goteborg in Sweden: 'This would mean more than 100,000 tonnes per year of fish lost to fishing,' The worst thing is that dead zones continue advancing, reaching increasingly shallower areas, which are traditionally more productive. Altogether, experts in the field estimate the losses of secondary production as between 350,000 and 730,000 tonnes in the whole of dead zone. 'If we extrapolate the consumption of 60% of that secondary production (copepods, cladocerans, etc.) to fish, we lose between 210,000 and 438,000 tonnes of fish a year on those approximately 250,000 km^2, Rosenberg concludes.

Dead zones are due in most cases to an increase in the amount of nutrients in the sea. In fact, the main areas where they are concentrated (the Baltic Sea, the Kattegat between Sweden and Denmark, the Gulf of Mexico, the Black Sea and the China Sea) have intensive agricultural, industrial and urban development. Nutrients (especially nitrogen and phosphorus in various molecular versions) reach the sea mainly from rivers and human activity. 'The increase in the quality of life and the cost of energy and materials are an important part of the equation', explains Robert Diaz of the Virginia Institute of Marine Science of United States.

Hypoxia is generated by bacterial respiration. This process is due to the consumption of organic matter from algae that has not been assimilated by other agencies. An excess will stay at the bottom, where it is consumed by aerobic bacteria. These bacteria need to consume oxygen to perform their

metabolic processes, and they take up oxygen from the water that surrounds them. Many species of bacteria are capable of withstanding very low concentrations of oxygen, but not animals, as a rule. In the Bay of New York, already in 1976 there was a mass mortality of organisms such as fish, crustaceans and other invertebrates in an area of over a thousand square kilometres, while other fish managed to avoid the undesirable area, migrating to deep waters.

This adds fuel to the fire. Scientists such as Brian Grantham of the Washington State Department of Ecology's United States study other types of hypoxia—seasonal, physical upwellings. These are distributed around the globe and are in the most productive areas of the planet. The winds that run parallel to the coasts of the Atacama Desert, Namibia and areas like Oregon and California move the surface waters, causing upwellings of deep, nutrient-laden waters. These nutrients naturally fertilize the surface waters where phytoplankton grow in abundance throughout the year, but especially in spring and summer. Despite supporting great secondary production (as we have seen in previous chapters), not everything is consumed and part goes to the bottom, where our bacteria are waiting. There is therefore a body of water in these areas that is hypoxic, usually at between 50 and 600 m deep.

Climate change could be forcing a different situation. On the shores near these upwellings, the difference in temperature between the landmass and the water may be increasing the intensity and frequency of these winds, causing upwellings that are more intense. In this case, the hypoxic area will extend upwards to shallower depths and be more persistent: 'While temporary wind records are poor, everything indicates that off the coast of Namibia there has been an increase in the intensity of the winds during the last decades', says Grantham. Indeed, the disruption off California and Oregon in 2002 coincided with a greater intensity and persistence of these winds. And, in Namibia, lobsters are found increasingly in waters that are shallower, fleeing from the dead zone.

But there's more. It is estimated that if 94% of these dead zones are in the coastal area, there will be an increase in the air temperature of more than 2 °C. Water will be heated proportionally (never to that extent, of course), and that will reduce the already poor availability of oxygen. 'Many factors are acting synergistically in these places,' says Andrew Altieri of the Smithsonian Tropical Research Institute in Panama, 'and we need to understand in what way they will impact the poorest and the services that they provide to us. We have gone from a few dead zones—10 to 15—in 1910 to over 400 in 2007; that we would have to reconsider.' Altieri estimates that up to 90% of giant clams disappeared from those coral reefs affected by this phenomenon

between 2004 and 2012. 'More than 3% of the coral reefs are affected by this problem, and the thing is increasing', concludes Altieri. Less certain is the impact that it will have the acidification of the oceans (see later sections on these dead zones). 'Due to the relationship between the amount of carbon dioxide increases and hypoxia, we know that the chemical balances might be altered in a very profound way in the near future in dead areas', says Frank Melzer of the Helmholtz Centre for Ocean, Jiel Research in Germany: 'The magnitude of these changes in coastal areas could be much greater than we thought.'

Paleoecology tells us that hypoxia is not a recurring phenomenon in many areas: in areas such as Kattegat and the Baltic Sea, it has no precedent and is human-induced. The majority of our seas' hypoxic areas are recent creations, but above all they are intense and recent. By making our ecosystems unstructured, allowing the more accelerated life agencies to dominate and turning the sea into a kingdom of microbes, it is possible that we are accelerating and perpetuating a human timescale process. Everything moves in a synergistic manner to a same destination of a 'marginalized' ecosystem.

The Destruction of Coasts

I've worked for a long time in the area between Estartit and La Escala, in Montgrí on the north-eastern Spanish coast (the Costa Brava). If you disembark at the first port, you see a fairly broad unspoilt space, preserved in part as military territory in the past and in part by the expertise of the various actors in the city, non-government organizations, scientists and the Departament de Medi Ambient de la Generalitat, who have managed to avoid the construction of houses, breakwaters, and so on, in that area. But it becomes puzzling when you arrive at Cala Montgó. On the right, seen from the sea, the Mediterranean forest still reaches the sea. On the left, the municipality has sold everything and you couldn't fit a single extra house in. There are no more places on which to build, and an invisible but tangible line of division between municipalities is evidence of this outrage, as a paradigm of human greed and lack of vision for the future. The same could said of coastal urbanization policy on ports and the maintenance of public spaces such as beaches, breakwaters and containment dykes.

The number of people who have embarked (never better said) on nautical leisure activities has grown almost exponentially in the past three decades, which has involved meeting the need for basic infrastructure to allow mobility along the coast for boats of limited range. In Spain, we have 325 leisure

facilities designed to accommodate boats, with more than 107,000 moorings (of which two-thirds are on the Mediterranean). Worldwide, these facilities began in estuaries, fjords, inlets and industrial ports, then between 1960 and 1970 there was a boom, especially in the Mediterranean, the north of France, Great Britain and United States. In Spain, the number of licences for sailing vessels rose from some 30,000 in 1990 to more than 43,000 in 2006, and after the economic crisis it decreased to some 37,000 in 2015. Sport fishing licences rose from 40,000 to more than 71,000 in the same period, decreasing to 57,000 in 2013. Despite the fact that the crisis slowed it down a little, gradually the place is being monopolized by a proliferation of these structures and causing alarm about the excessive numbers of users in these sectors. The latest crisis (people don't see what is happening at all) is once again talk of expanding ports and jetties, without learning from the past.

What risks are involved in the construction of a marina? Is it always necessary to build one? Many coastal towns have wanted to have one to promote the area and to ensure more permanent tourism throughout the year, as tourists with a boat and a second home do not stay only a month for their summer vacation. But have marinas managed to attract sufficient vessels to avoid going into deficit?

The first effect of a marina is an increase of the number of boats in the coves and beaches in the vicinity. This increases the impact of tourists on the ecosystem in a more or less controlled manner, depending on what measures have been adopted by the relevant administration in terms of the flow of people in these areas: more boats, more impact. While the number of marinas needed is questionable in terms of real need, problems resulting from their construction are generally fairly concrete (the environmental management usually is). Forming barriers and jetties along a section of a bay or beach requires a thorough study of the ocean currents, the grains of sediment (size, shape and composition) and the communities that are established in the area to avoid causing an accumulation of sand at the mouth of the port, the displacement of sediments and formation of sludge, or the destruction of communities of ecological interest if they become trapped by the changed current dynamics.

A port also produces an increase of waste of all kinds, from organic to hydrocarbons and heavy metals from the bilges, varnish, use of patent preparations made from copper or lead as antifouling, transfers of fuel, and so on. All this must be disposed of and will impact the areas adjacent to the port. Both sport and non-sport fishing increases, within the limits of the port and also in the most remote areas, due to the increase in population, occurring mostly in summer in that part of the coast.

The second part is the coast policy designed to maintain beach tourism. The beach is one of the main attractions on the Mediterranean, especially along the coast of the Iberian Peninsula. From late spring to the beginning of autumn, hundreds of thousands of people seek entertainment on the sand, which seems ever more difficult to retain. What is happening to the beaches on our coast? The proliferation of ports and jetties to a large extent has caused a double effect: an uneven accumulation of sand on the beach (more on one side than the other) and a failure to recover after major storms. These storms may be shortlived, maybe now a little more frequent and more virulent, heading inland from the sea and carrying off the finer sands, leaving the shore naked or with only a coarse gravel beach. The main currents, which are responsible for slowly building up the sand again after strong gusts have dispersed it, have been often displaced by the action of man: now, to keep the tourism, you have to produce a sandy beach artificially. Another constant is that the most abundant fluvial contributions decrease once there is a marina: industrial, agricultural and urban consumption reduce the flow in the rivers, and this is another fundamental blow to the accumulation of sand and mud. Indeed, the regeneration of beaches is a measure of erosion, but its effectiveness will depend much on the problems that arise.

Conducting a good study of its impact is essential before proceeding with beach regeneration, because it is certain that we will affect both the site of sand extraction (especially if it is taken from the bottom of the sea) and the place in which we are going to pour it (feedback is especially important). There will be an impoverishment of organisms where the sand is sucked from, and it is important if the place is surrounded by prairies of spermatophytes or rocky substrate with animals and plants. We have to remember that a significant proportion of what we extract is too fine to make it into the boat, and this falls down to the bottom to create a layer of a very soft mud of up to 30 cm thick on the seafloor. This slurry of inorganic particles can lead to serious problems for the organisms that remain at the bottom or near the site of extraction, among other things reducing the flow of oxygen in the water column. Another problem is that there have been instances when toxic substances that were trapped in the sediments or sand have been put into circulation, thus harming the environment. The effects, although local, can affect many fishery resources in the area, such as clams and other molluscs, which can disappear not to make another appearance for years. If the affected community is a meadow of flowering plants fed by currents along the ocean floor, the recovery can take more than a century.

In fact, my question is whether beaches should be regenerated. Is it worth make a big effort every year to lose it all in a few months? Some propose ‘hard’

or more drastic measures, proposing the construction of submarine concrete breakwaters (which would help mobile substrate retention) or the destruction of a large number of poorly erected breakwaters that hinder natural currents. We have both colonized and urbanized our surroundings; we are now looking for artificial corrective measures to amend our mistakes. Of course, I am the first to acknowledge that we need to enjoy our beaches and have marinas, but we should demand more rigour and at the same time more imagination from our authorities in managing our coast. We should not be afraid to propose solutions that are in keeping with the viability of the environment, not just our comfort.

Too Many Visitors

When a natural area becomes protected and is seen as being of ecological interest, it triggers a justifiable desire in people to visit the place and rediscover a part of nature that we lose if we live in the city. However, due to the fragility of these places, an excessive influx of individuals may damage them. We can see the influence of human beings on the flora in a nature reserve such as the Medes Islands, in Spain.

In place like the Medes Islands, what harm can come from people who love the sea and intend simply to enjoy the beauty of the seabed for a while by scuba diving? The bottom of the sea can be rich in species, shapes and colours. The most beautiful places are largely composed of slow-growing structures made by often fragile organisms (corals, gorgonians, bryozoans, sponges, etc.). These structures, as well as the large number of fish, obviously attract divers. To study their impact, a team of scientists studied a species of fragile bryozoan (*Pentapora fascialis*) at various points on the coast of Estartit and the Medes Islands. They basically measured its population density, diameter and height and noted its location in space (exposed, in crevices, on gorgonians). They considered the less frequented and the more frequented types of area (about ten divers in the first area and ten thousand in the second, each year). 'We looked for areas of similar composition, depth and similar biological community to find how to attribute the results to these parameters.' 'Over the years, in the most frequented places the density was lower, the height and diameter were lower (at the break) and the position of the colonies was more hidden away (cracks, holes or slopes) than in less frequented areas', says Enric Sala, marine ecologist for the National Geographic. In the little-frequented spots the bryozoan colonies were in the most exposed positions, and of larger diameters and heights. It showed the negative effect of

subaqua diving; and there is no reason to assume that the rest of the community is not equally affected.

To study the impact of dives, a team of scientists analysed the case of the purple gorgonian, *Paramuricea clavata*, a species that it has been considered necessary to protect due to its restricted distribution, slow growth and reluctance to recover. It has been established that the presence of humans on outcrops where this gorgonian lives causes significant damage to the population as they are inadvertently torn or broken by the force of flippers and aqualungs or by leaning on these fragile structures. The bryozoans would be depleted even by moderate frequentation by subaqua divers with some experience, due to these effects.

It is clear that forming a protected zone is always something positive, giving nature some respite from pressure imposed by humans, and providing what have been proved to be beneficial effects on the development of many species (see the chapter on this subject). However, there are always disputes—it never rains to everyone's taste! Conscientious follow-up of the various aspects of the biological, ecological and social (in this case marine) systems of prevention, tailored to each situation, is absolutely essential in carrying out a serious management project. We must not forget that a protected area is to be enjoyed, as well as preserved.