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The Silent Threat

When, at the beginning of December 2008, a maritime accident off the coast of South Korea caused a spill from the tanker, the *Hebei Spirit*, I little imagined that just two weeks later I would be travelling there to try to assist in the emergency. With no experience of maritime oil tanker accidents, with two other colleagues who had extensive knowledge of contamination by petroleum products I was invited by the regional government of the affected area in South Korea to shed some light on the spill's impact on the bottom of the sea and the potential for the recovery of its communities,. At the beginning, a little dazed and trying in the shortest time to absorb the most that I could of the protocols, methodologies and past experience in this field, I understood how my colleagues had felt at the *Prestige* oil spill, an emergency that had also demanded rapid response and immediate actions.

When we arrived on the affected coast, there were hundreds of people in small, well-organized and disciplined gangs, cleaning off the oil that had arrived, stone by stone, with unshakeable determination. We saw them working away relentlessly on the beaches, cliffs and bays. In a short time, the greater part of the spill had been collected up, so much so that it was hard for us to find visible signs of the catastrophe at various places that we visited. It was then that I understood something that threw me: only 4% of the oil that enters to the marine environment is from accidents such as the *Hebei Spirit*.

It is estimated that more than half of the petroleum oil that goes into our seas each year is natural, from springs located in various sources the length and breadth of the planet (especially in the Gulf of Mexico). The remaining 46% is the result of refuelling, bilge cleaning and other routine operations. However, a report promoted by several associations, through the Oil Spill

S. Rossi, *Oceans in Decline*,
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Conference, notes other, lesser-known potential sources: at the bottom of the sea are 8,569 wrecks of ships that are considered to be of a medium or large tonnage, of which 1,583 are oil tankers and other 6,986 transport materials and people, or are warships. More than 75% of these vessels sank due to clashes or attacks in the Second World War, thus are what the experts consider 'mature', so that in many cases their structures have corroded and have begun to leak the oil that was their cargo and in their fuel tanks, derived from crude oil. After more than sixty years of waiting, some areas where subsidence has been especially intense may be affected by this deterioration, especially in shallow, closed seas such as the Baltic and around the Philippines.

The most affected areas of the planet are Southeast Asia, the Persian Gulf, the east coast of the United States, the North Sea and Baltic Europe. 'More alarming estimates tell us about 70–80% of ships with their tank, or tanks, filled', reports Jacqueline Michel of the Research Planning Incorporated of the United States. It is not easy to tell exactly what quantity of fuel had been carried by either tankers or freighters, and there are vessels for which there is no reliable information. In any case, even the more optimistic estimates speak of 2.5 million tonnes of submerged crude oil, while the most pessimistic put it at over 20 million. It is believed that transport tankers may each contain between 30,000 and 40,000 tonnes of crude oil, and other cargo or military ships have between 700 and 3,000 tonnes of fuel.

The issue is to find a solution to the silent threat. 'Recovering crude oil or refined fuel from ships is very expensive', says Dagmar Schmidt of the Environmental Research Consulting in New York: 'The majority cannot be made without underwater robots (ROVs) and few companies have the appropriate technology.' The *Prestige* case demonstrated that, with the appropriate technology, it is feasible to recover fuel from a ship that is thousands of metres down: after the accident, and more than 14,000 tonnes were pumped up by one company, REPSOL. However, fuel recovery from more than 250 m deep is considered to be a highly complicated and expensive operation, 'and the worst thing is who is willing to pay for it. Many sunken ships are due to acts of war, thus there are legally prescribed responsibilities', concludes Schmidt. In the study there is nothing about other contaminants, such as chemical weapons, hazardous or toxic cargoes or radioactive materials. Logistical and legal gibberish that does not facilitate the planning of an adequate clean up acts to the detriment of a system that hosts such a large number of potential threats to the balance of the submarine world.

The problem, once again, is that we can see the untimely discharge if it involves something striking, such as an oil rig accident. For instance, the inhabitants around the Gulf of Mexico witnessed the *Deepwater Horizon* explosion and subsequent inshore spill of crude oil (see below). The black tide had an immediate, scandalous effect: fish and birds die, and beaches and rocky areas are stained with crude oil, which quickly spreads over large tracts, prompting many people to clean the area to restore the site, trying to return it to its 'pristine' condition.

The effects of such a discharge are many and varied, and may be both immediate and postponed for a long time. One of the first things to go is the light, in some instances decreasing photosynthesis in plants (microscopic, multicellular algae and marine). In open areas, with strong currents and swells, this effect is minimal, but in more enclosed areas where the water circulation is less it can be dramatic. Just before the end of the Gulf War, more than 700 km of coastline were affected by the discharge of millions of tonnes of crude oil, forming in some places a continuous and impenetrable black or dark brown film. One community in the column of water, phytoplankton, was unaffected by this lack of temporal light, due to its regenerative power and great resistance. However, for the shallow communities of spermatophytes and areas of coral reefs (which have symbiotic algae inside), the immediate and prolonged lack of light caused by the fuel slick in certain areas resulted in mechanical asphyxia.

In 2001, ten years after the oil discharges in the war, only about 20% of the marshes affected by the sabotage by Saddam Hussein's forces—between 90 and 95% of them—had recovered from the asphyxia caused by the oily coating on water, sediment and plants. In areas like these marshes, where the flow is weak and there is a low water renewal rate, the effects can last for centuries, according to some experts. There are still some areas that are not fully recovered. But in more exposed areas, beaten by strong waves or witnessing daily a strong tidal motion, the effect is much less prolonged. After the crash of the *Exxon Valdez* off the coast of Alaska, the more exposed areas fared better than the backwaters or secluded coves, with macroalgae, where the water barely circulates.

The methods for cleaning up spills, as we have learned much from recent disasters, are vigorous: in the case of the *Exxon Valdez* in 1989, involving more than 40,000 tonnes of crude oil (260,000 barrels), the cleansing was so conscientious that it sterilized an important part of the rocky areas, making it take far longer to recover. Several methods were used: hot and cold pressure, injections of sand, water steam, pulverized dry ice… Paradoxically, the more intensively washed areas recovered slower those areas than had been treated less vigorously, the worst being where pressurized hot water hoses had been used. This had literally sterilized the substrate, killing any organisms. That's why, in the case of the *Hebei Spirit*, the conscientious volunteers were cleaning the area stone by stone, with cloths and biodegradable products. Those areas least accessible by land or by sea were left unattended, yet the sea, typically more aggressive in such places, achieved this patient washing without the intervention of man. Waste fuel, coating rocks, sand, gravel and everything in its path in an oily mass, quite apart from the obvious ecological damage due to suffocation and mechanical traction involves visual and landscape damage that affects us in a special way. As we have said before, wild or rural landscapes affected by the oil slicks incite the population to remove as soon as possible the stain that both affects us and makes us feel so guilty.

But there is another component, much less visible and therefore overlooked, which is many times more damaging to the ecosystem if there is a spill, either by accident or by a continuous toxic drip. Dumping fuel in any form, or other contaminants such as radioactive or toxic chemical residues, causes changes in marine ecosystems. We've all heard how an area is closed to fishing following a disaster. Along the Galician coast and part of the French coast after the *Prestige* incident, it was months before fishermen could go out again, though the closure was, in some cases, only a precaution. After the first few months, much of the crude oil enters a latent phase, as while the oil has disappeared from our field of vision it has not gone from the affected area. This can continue for a short or longer time and be either intense or less so, depending on the type of discharge, yet at this stage the oil tends to take its toll, especially on certain links in the food chain. The most vulnerable are those organisms in which toxins accumulate, as they lack the opportunistic nature of other species and their way of reproducing. In one way or another this decreases, through morphological change, such as genetic mutation, or reduced immunity, their progeny and their ability to survive.

After the disaster of 2002, on the Galician beaches, for example, between the high and low tide marks there was a major reduction in the numbers of creatures fixed to the rock. In 1995 there were more than 2,500 in an optimal state of health, but this had been cut to less than 800 by 2005, and they were in a precarious state of health. The recovery in this area had been more rapid than in many others, depending on the substrate, the type of crude oil and the hydrological and geographical characteristics of the area. It also depended on the affected community. Plankton did not appear to have been much affected by pollution from the *Prestige*, due largely to their short life cycle and its wide fluctuations from year to year. The intertidal zone was affected in a quite different way, yet it is also one of the communities that is recovering, thanks to the continuous purifying action of the sea, concentrated due to the area's high-energy tides, currents and waves.

In terms of deferred effects, the outlook is less well known for those areas of platform that lie tens or hundreds of metres deep and attract trawler fishing: 'We know that the type of fuel that the *Prestige*, due to its low solubility, did not affect the respiratory system of the fish,' explains Francisco Sánchez of Institute Spanish Oceanography of Santander, 'but much fuel has been brought into the system in the form of marine snow (aggregates of organic matter that float in the water), and enter the food chain mostly through its predatory organisms.' Much of the crude oil, when fragmented, can enter the mud and sand on which many commercial species feed.

In the clean up after the *Prestige* incident, the largest crude oil slicks were converted into smaller droplets, then tiny particles. Once ingested by an organism, the particles' effects depend on the type of hydrocarbon. For example, it is known that after the *Exxon Valdez* disaster the eggs and larvae of fish and invertebrates such as mussels and sea urchins were malformed, causing higher mortality rates and a much lower than expected subsequent reproductive rates. Most of the studies after the spill focused on the early stages of life of the species that were of ecological or economic interest, being more fragile, thus potentially more affected by the accumulation of contaminants. There were also studies that focused on adult humans, for example research into cancer, infections, reduced immunity and other effects that can last for generations in places where a pollutant is present for a long time. The recent BP disaster will have long-term implications, and today we are seeing only the tip of the iceberg. Probably in ten years we may be able to make an objective assessment of the real impact of a release crude oil almost twenty times greater than that of the *Exon Valdez* spill.

Most hydrocarbons are degraded by certain bacteria, fungi, protozoa and phytoplankton. But not all. Some—the most recalcitrant—can go years without being affected in the least. The worst is when they come to be part of the sediment, where the biodegradation processes slow down tremendously. Depending on their concentrations and the reactivity of the metabolic processes in the organisms' cells, the damage may be major or minor. The worst thing is that effects spread gradually from one organism to another causing diseases, vulnerability to parasites or death.

The quantities of oil spilled during the last forty years have been declining dramatically (apart from catastrophes such as BP's *Deepwater Horizon*). If we collect the total discharges in this period, 56% were in the 1970s, and in the first decade of 2000 we have seen less than 3%. There has been progress both in the ecological sense and in the irretrievable and useless waste of a valuable product. What remains clear after gaining much experience is that we should conduct long-term monitoring. Only in this way may we assert with confidence trends in any ecosystems that are exposed to pollution from the discharge of oil or other contaminants in future, compared to their initial condition, and quantified in the form required. Logically, we ideally need some notion of how things were before an accident, yet this has not always been possible and we must employ a certain degree of realism regarding the affected areas. A series of indices of the state of health of ecosystems (integrating data chemical, physical, biological and ecological data, and also those from the engineering, management and the economy of the area) will allow us to deal with the silent threat, that which is hidden behind the phenomena of contamination by organic and inorganic agents, in a consistent and well-structured way. Unfortunately, as we have said before, the problem goes beyond oil being spilled by accident, due to both widespread practices in both maritime traffic and the disposal of hulls of tankers that have transported crude oil (which should be all mandatory, by now). From leakage along the way, continuous discharges of all kinds and this huge number of wrecks waiting in latency will make things even worse if nothing is done. Let us remember once again that our oceans are the synergistic sum of effects; we are adding to the equation more variables that are detrimental to their proper operation. The future impact of radioactive drums being opened up by the erosive action of the sea, shipments of bombs or chemicals from previous wars, now about to 'hatch', sunken ships, or those that have lost part of their payload and that have ended up at the bottom of the sea may be felt by the living populations of the seas in just one locality or spread around the globe.

BP Disaster

On 20 April 2010, eleven people lost their lives in an explosion on an oil rig that extracted oil from a depth of more than 1,500 m. A series of mechanical and human failures led to what is considered to be the greatest ever oil catastrophe involving oil extraction. The *Deepwater Horizon*, in something less than 90 days, poured out some 4.9 million barrels (780,000 cubic metres). To understand this magnitude, just remember that the *Exon Valdez,* in one of the largest oil spills in history, discharged 'only' 260,000 barrels.

As we will see in a later chapter, underwater mining and the extraction of oil from the deeps is a reality. In August 2010, two other platforms were about to become operational at more than 4,000 m down. And so the practice continues, in the Arctic, deep and remote zones, prospecting in unexpected places… We need oil, and we need it now. So, although experts continue to say that what happened was 'virtually impossible', experience shows us again and again that impossibilities are precisely what we must take into account, as humans are capable of creating the most advanced technology and at the same time making the biggest mistakes. ‘Despite being a very rare accident, we cannot fail to pass over it’, says Paul Bonner, Professor of Petroleum Engineering at the University of Texas.

It’s always a bad time for something like this, but it is agreed that many economic, social, physical and ecological variables made things even worse: it was the time of migration for birds, the hurricane season, the fishing season and beginning of the second main wave of tourism in the area. The oil slick expanded from 1,500 to 10,000 km^2 in just five days (from 25 to 30 April), penetrating the marshes, beaches and delta of Florida, Alabama and Louisiana. But, as insists Prosanta Chakrabarty, a Louisiana University ichthyologist, it was ‘not only pelicans’ that were affected by a disaster of this magnitude. Unlike other accidents this occurred at depth, and the dynamics of the spill is very different. ‘The stain will introduce oil and gas at medium and great depths’, says Samantha Joye of the University of Georgia. ‘Part of the oil evaporates, but another will enter into the pelagic and benthic system with yet unknown consequences.’

In fact, a state of anoxia that is both harmful and little understood has been added to the consequences that this area suffers, year after year, thanks to the ‘dead zones’ (see next chapter), water with little or no oxygen generation due to algal production at the surface and bacterial decomposition. We now know that this has affected many communities. ‘One of the worst affected areas on the border between the land and sea are the marshes’, says Brian Silliman of the Department of Biology of the University of Florida. After two years these wetlands were still coated in crude oil, and the system still does not function well. ‘Even though time has passed, the erosive effects remain incalculably devastating, with loss of biodiversity and biomass’, insists Silliman. The fact is that part of what often wears down those communities we do not see, as it takes place at depth. ‘Deep corals, of slow growth, have been very affected’, says Nancy Prouty of the US Geological Survey. Flocculent material covers these organisms so they cannot eat, breathe or perform in these conditions. ‘These organisms can grow in diameter about 15–30 μ, very little,’ adds Prouty ‘implying that a disturbance like this can leave out a lot of colonies.’ In adjacent areas, more than 45% of corals were damaged. ‘More than 90% of colonies were affected, with what that implies for its recovery’, witnessed Helen White, a chemist at Haverford College.

After the first onslaught of the *Deepwater Horizon* accident, some of the solutions were worthy of *Marvel* comic, such as proposing closing every channel with stones to prevent the entry of oil, or to send a fast and running barrier of sand down the coast, involving some 68 million cubic metres of sand, at an estimated a cost of $350 million. 'It was simply awesome', said Joseph Kelle, a geophysicist from the University of Maine: 'Those who proposed this have simply not have thought about the consequences.' Bacteria have begun to break down the oil, but the spill will affect the system for decades.

What is clear is that we are a long way off mastering this type of exploitation. Once it has happened, a catastrophe at these depths is exceedingly complicated to combat efficiently. But it is not enough to look at what is happening today with the *Prestige*. A study carried out between March and October 2006 found that the *Prestige* was still pouring out fuel. Even after the initial spill and recovery by REPSOL the ship had more than 50,000 tonnes of fuel onboard, and this has continued to escape from its tanks despite efforts to seal the leaks. The study, carried out by Saioa Elordui-Zapatarietxe of the Institute of Science and Environmental Technology of the Autonomous University of Barcelona, focused on the dispersion of the fuel in the various layers of water. 'In this area we find a very complex structure of oceanic masses, with surface waters, Mediterranean and deeps', the scientist says. 'Fuel discharges were especially intense in October 2006, four years after its collapse.'

These discharges could be observed from the surface, but their concentration was greatest in the layers closest to the wreck. Bearing in mind that in this and other areas more fish from very deep zones are being extracted all the time (an increase from 5% in 1970 to 35% in 2007), the release of fuel that had been circulating in just the remotest layers of the ocean may end up interfering with fishing.

The Tragedy of Plastics

We have gone from generating about 30 million tonnes of plastic per year in the 1970s to more than 200 million at the start of the new century. Bottles, containers, dividers, packaging balls to protect products, bags and a long et cetera form a long production chain in which the various forms, compositions and textures of plastic have become part of the technological and economic success of our society. Plastic is cheap and useful, and a kilo of packaging costs no more than €1.3 and occupies a considerable volume. Far from being optimal for recycling, a part of these products (around 10% of plastic produced, depending on the area of the world) goes into the sea via sewers, rivers or floods. In fact, around 80% of floating debris comes from the mainland. Surface currents and tides carry it and tend to make it accumulate in the centre of the bounding oceanic currents. In the middle of these systems, like in the Sargasso Sea in the North Atlantic, and in the North Pacific, the winds are slack and currents weak. 'Plastics accumulate in areas with little traffic by navigation, away from the coast', says Rei Yamashita of the Japanese University of Mie Kuroshio: 'In one of the most important in the world, the current moves large quantities of floating objects from the coasts of China, Korea and Japan, strongly industrialized countries, to the rotation of the central Pacific.' In this area, plastics may form in excess of a million elements per square kilometre. And waste, in large quantities, also arrives here from the coast of California and Oregon. In this and other areas, as in the North Sea, the accumulation is a very worrying fact: 'Only in the restricted zone between Great Britain, the Netherlands, Germany and Norway has it been quantified, by pelagic fishing, underwater robots and visual transects, that there is up to 600,000 tonnes of floating and submerged waste', says Gerard Cadée of the Netherlands Institute of Marine Research: 'More than 80% of the floating debris of medium and large size bears marks of having been bitten by seabirds, which indicates that they take it to be part of their diet.'

The problem is much more than aesthetic. Plastics (the main culprits) of various shapes, textures, buoyancies and sizes are interfering in the components of marine ecosystems. David Shaw reports that 'The intake by marine creatures such as whales, birds, turtles, fish and squid bodies is very high.' Shaw works in the Institute of Marine Science at the University of Alaska, and has seen that, especially as chicks, species such as albatross and petrels are the hardest hit: 'Adults see the small pieces of plastic, including plugs or balls of Polyexpan (gel-forming reactant, used in waterproofing), as potential prey, ingest them, head to the nest and regurgitate.' The intake is selective, since textures, shapes and certain colours confuse the birds, which identify the plastic with potential prey. If they have not already died, the birds regurgitate these objects, affecting the lives of their progeny, their future generation. Unfortunately, it has recently been discovered that many of these small- and medium-sized plastics, moreover, are capable of accumulating toxins such as DDT and PCBs: 'Toxic build-up in the floating plastic has been proven,' says Dr Lorena Rios of the University of the Pacific, 'and the worst thing is that 44% of the species of marine birds consume them routinely.' The problem would be merely an interesting fact if the amounts of plastic that floats were insignificant, but in certain areas of accumulation, as in the Sargasso Sea and the North Pacific twist, there is a huge, highly variable mass several times more extensive than the Iberian peninsula. 'We were able to see that in these areas the relationship between the weight of the plankton and the weight of the plastic and other floating objects was one to six: that is, per kilogram of plankton, there are six of waste', reports Charles Moore, along with retired Professor Curtis Ellesmeyer of the Algalita Marine Research Foundation, both researchers who have been involved for more than a decade on this problem. 'We do not know the extent to which so much material has affected marine ecosystems, pelagic or benthic, but it is clear that they are interfering in the food chain and the proper functioning of the system.' In some areas, it has been calculated that the 'cloud' of objects can reach between 20 and 30 m deep. Recent research has estimated between 5 and 13 million tonnes of plastic entered the marine system in 2010. 'The worst thing is that the prospect for 2025; if we continue at this rate,' says Jenna Jambeck of the University of Georgia in the United States, 'it may be up to an order of magnitude greater.'

The problem is exacerbated when we consider that the plastics become fragmented. Visible plastic does not interfere so much as microscopic bits. 'We don't know very well the parameters such as the speed of collapse or the effect on real organisms', says Andres Cortazar of the Faculty of Sciences of the Sea at the University of Cádiz in Spain. 'Although the concentration may not be as high as is thought in many places, it is essential to understand the impact on food chains, especially that of small pieces'. In just one cubic metre there may be 100,000 tiny bits of plastic. 'These sometimes-microscopic pieces of plastic cause abrasion, ulcers, blocking of the digestive system by toxins, metabolic disorders, malformations… shall I continue?', says Stephanie Wright, in an extensive review of the subject.

In addition, we have the problem of degradation. Items break down slower at sea than on land, partly because the temperature is constant and low and partly because at sea there is more protection from the action of the sun's ultraviolet rays. While studies vary in terms of their conclusions, estimates of degradation of most solid waste of artificial origin (bottles, bags, etc.) indicate that its disappearance exceeds the scale of a human lifetime. While a bus ticket takes only two to six weeks to vanish, a plastic bag can spend fifty years in circulation, and a PVC bottle more than five hundred.

The Mediterranean, due to the great urban, agricultural and industrial concentrations on its shores, is one of the places most affected by this phenomenon. In the Catalan coast there is between 1,000 and 1,200 cubic metres of floating waste every year just in the area near the coast (in the summer of course, due to the crush of tourism). 'The other problem is that these objects have demonstrated that they can be bearers of invasive species, such as the algae that form red tides,' says Mercedes Masó of the Institute of Marine Science-CSIC, 'polyps that release young jellyfish or small thalli of macroalgae, for example; this partly explains the rapid expansion of some algal blooms.' In Catalonia, a flotilla of dozens of ultralight boats records pollution spots and collects floating solids when they pose a problem for tourism. But tourism itself produces much of the tide of waste, especially in certain areas. 'In Mallorca there can be up to 36 objects per metre along on the beaches, more in the summer, up to twice that of the winter; and there are no major rivers to blame', notes Martínez-Ribes Lorraine of the Mediterranean Institute of Advanced Studies, CSIC. The amount of waste always increases in summer, when antisocial people decide to use both beach and sea for their trash. Overall, what can we do for the sea? The issue of plastics is one that is only now beginning to be studied rigorously. Until recently, only a handful of specialists have been trying to draw attention to the possible effects of the huge discharge of solid waste that our seas have to endure. It seems that we are now taking it a little more seriously… but maybe the effects have already been so damaging that we cannot reverse them in the short term.

Mercury in the Arctic

As oil derivatives, many other compounds enter the marine system and can harm both organisms and mankind. Their tendency to accumulate as they remain in the food chain has been known about and tested for several decades, when studies on DDT and mercury made it clear that higher organisms (eagles, dolphins, seals, bears and humans) were the ones to suffer the aftermath through foetal malformation, disease and metabolic deficiency. For this reason, the following example is of mercury and the latest findings in the Arctic, a system particularly vulnerable to the accumulation of toxic substances.

While extracting the last ice cores to check the accumulation of pollutants, Dr Feiye Wang's team, from the University of Manitoba (Canada), confirmed that mercury levels seemed to have stabilized in the environment yet not in the animals of the Arctic. Emissions of mercury during the last decade have decreased: the regulation of waste and alternative treatments in various industrial processes seem to have had an effect. However, during the same period of time, in animals like beluga whales and polar bears the levels of so-called organic mercury, or methyl mercury, have increased by an order of magnitude.

This apparent contradiction may be due to one of the side effects of climate change: 'everything that is happening in the Arctic is very complex; people see above all changes in the level of the sea or open navigation steps, but biologists see the outstanding impact on flora and fauna.' Methyl mercury is a highly volatile substance, and it travels long distances by air from temperate places, where there is more industrial activity, to the poles, due to air currents. This liquid metal is absorbed by contact with seawater and may form molecules of methyl mercury, easily assimilated by the tissues of creatures forming the various links of the food chain. It seems that times of thaw, when the crystal structure of water changes, are the most delicate, since this element is then absorbed more easily.

Unfortunately, methyl mercury has a long history of negative effects on wild flora and fauna, and humans. Its accumulation caused scores of deaths and hundreds of affected people in the Minamata Bay in Japan, but its victims are spread all over the planet, from the Amazon to the Inuit of Canada and people of Greenland. The places where the population is most vulnerable are those where a large amount of fish is consumed, and people tend to have levels of mercury in the blood far above the average. 'When the water is liquid, there is no greater absorption of this element', says Wang, 'but due to climate change water at the North Pole stays frozen for less time, so the amount of mercury absorbed by the system tends to increase.' In fact, the mercury that is trapped in the ice is retained, and does not circulate through the marine environment until the ice thaws. 'We have stopped issuing mercury in an uncontrolled manner,' says Dr Gary Stern, Department of Fisheries and Oceans, again at the University of Manitoba, 'but agencies such as belugas continue its tendency to accumulate in the body.' Dr Stern has made a scrupulous follow-up of these cetaceans since 1981, and says that we 'are aware that there is a tendency to build up from the most basic parts of the food chain (microscopic algae) to the highest (beluga whales and polar bears).' This is normal, because as we rise in this chain toxic molecules accumulate in our tissues, and also have an effect on the various types of prey taken by a single individual. 'The build-up that we detected is insufficient to explain the gap between what is emitted and what accumulates. There has to be something else.' According to this expert, it could be centuries before there is control of this metal entering the environment. This is one of those little-known effects of climate change, called 'wicked' by some specialists, because they are not expected and not easily visible. Some scientists predicted that areas of the Arctic would be free from ice in 2015. Today, in 2018, there is a quasi-permanent passage in which the ice is weak or non-existent. It is the freezing and the thawing of polar water that seem to be favouring the entry of mercury into the marine system, so that, although the emission source has decreased, much of the mercury currently circulating in our atmosphere could, through the poles, end up in our oceans.