Biodiversity of seas and oceans under threat.

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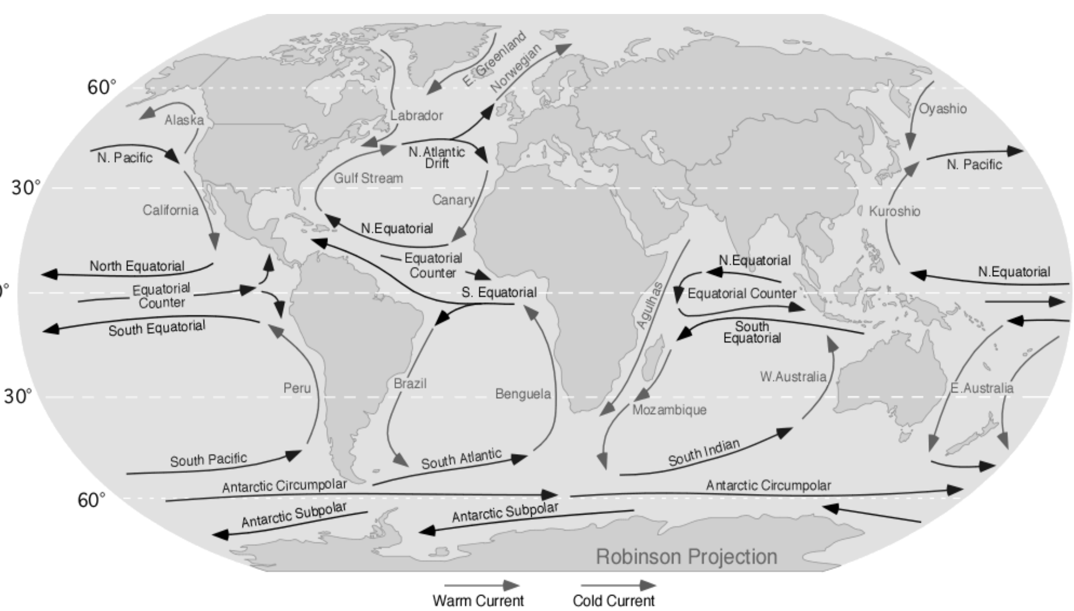
Introduction: where does our detritus go?

Quite some time ago I sat dozing in the sunshine on deck of the ferry from Harwich to Hook of Holland. All of a sudden I was rudely awoken by an unexpected commotion, just in time to see a member of the crew dispose of a large tray of used breakfast items over the railing: disposable tableware, egg shells, crusts and tiny jam jars. Horrified I found that rubbish was routinely thrown overboard. It struck home that our detritus, and that includes bodily fluids, doesn't disappear in a vacuum. It goes somewhere. But where does it all land up? What does it consist of? And if it goes into the hydrosphere, the watery part of the globe, what is it impact on the flora and fauna of the deep, in particular the trillions of microscopic creatures?

The system of ocean currents

Land amounts to less than a third of the earth's surface. The rest is covered in water, most of it unceasingly on the move. If it were not for the fact that the earth rotates from west to east, and that includes the atmosphere and oceans, the pattern of currents would be completely different. The ocean's currents are reinforced by winds, also generated by the earth's rotation and by the fact that some areas of the earth's surface catch more sunshine than others and are therefore warmer. Streams of ocean water are deflected away when they meet with land. See below a map of the ocean currents. As colour printing is expensive, the map has unfortunately to be in greyscale. (The light grey arrows denote warm water currents, the dark grey cold ones).



Corrientes-oceanicas, image from the Wikipedia Commons

The flora and fauna of the oceans is affected decisively by temperature. As a rule cold and therefore oxygen-rich water sustains much more life than even slightly warmer water. The way streams of different temperatures are transported, determines what can live where and whether it thrives.

The icy cold, eastward flowing Antarctic circumpolar current is the only current meeting and mixing with all three main oceans (Smith et al, 2003). It moves immense amounts of water round and round at surface level as well as at depth – down to 2000 metres. It is deflected just slightly when it meets with the southern-most point of Latin America. However, where the northernmost section of the stream bumps against the Chilean coast, it is forced northward and the same applies to the stream which encounters the coast of Namibia. Meeting another coast, or even a cape sticking out, currents may be deflected again, constrained by coastal walls. The map additionally shows some black arrows nearer the Antarctic coast; these mark the much less significant coastal counter current which flows westward (Gyory et al., 2001-2003).

Looking at the map again, you will see that the ocean currents move in big circular currents, called gyres, which are defined by the landmasses that keep them from flowing on unchecked. If you live in Europe, you will be familiar with the Gulf Stream, which contributes to the moderate character of the climate of north-west Europe. Strictly speaking it is the North Atlantic Drift, an offshoot of the Gulf Stream proper, with some tendrils reaching as far north as Murmansk on the coast of the Arctic Ocean. The fact that these currents are so complicated makes it rather unpredictable to guess where items (or semi-solid masses) come to land. Over time unfamiliar objects transported first downriver, then across seas and oceans have come to rest far from their origin. For instance, Murphy tells us of many a hard heart-shaped bean (*entada gigas)*, originally hanging from a vine in Costa Rica, which made the journey from Latin America to Europe with the western current, eventually to land in western Europe to be fashioned in a medieval teething ring or snuff box (2007: 5). Then there is the saga of 29,000 brightly coloured plastic bath toys lost overboard in the Pacific in 1992 to be caught up by different currents. Although most came to land on various Pacific coasts, some travelled all the way along north Siberia to end up in the UK or the east coast of the States. Admittedly this took them a great deal longer than the former, as they spent over a decade overwintering frozen in the ice.

In addition to the winds and currents whipped up by the earth's rotation, the 'ocean conveyor belt' is also driven by differences in salinity which give rise to a vertical flow. This is due to the fact that the seawater freezes in the polar regions with the result that salt water is separated out and sinks to the bottom (Broecker et al., 1985: 21-26). There has been some speculation that warming might give rise to drastic changes to this process.

The great ocean conveyor belt and the richness of aquatic life

The routes the earlier mentioned objects travelled are significant, as it helped researchers to understand the oceans' currents. Clearly they are no longer dependent on these accidentally observed paths; nowadays much more sophisticated technologies, satellite sensing, floating profilers, robotic sampling equipment and the like. Now there is one thing that is being transported poleward from the equator, which determines which creatures find their optimal living conditions in certain places and that is heat, with colder water flowing at depth towards the equator. While Benjamin Franklin using buckets found that the middle part of what is called the Gulf Stream was, as well-known among sea captains of the time, much warmer and faster than its fringes (Murphy, 2007: 32), it is now clear that the masses of heat transported by ocean currents are phenomenal. The Gulf Stream alone moves over one petawatt (i.e. 1,000,000,000,000,000 watt) of heat energy, according to Murphy the equivalent of the energy of 1,000 nuclear power stations combined (2007: 228). This heat is transferred in the tropics from the sea into the air by evaporation and also because oceans and atmosphere touch each other. This pattern of heat transfer is repeated in the different gyres with slight variations. In addition one should remember that no current system is totally separate –waters originating in different regions mix and mingle. The different temperatures, at surface, at depth and in different regions determine the water density and salinity of each area and ultimately which creatures feel at ease at a specific locations – always within an ever moving environment. Consequently the oceans and seas are of a richness of life difficult to conceive of, while each life form has its specific niche. In general cold water is more conducive to life as more oxygen can dissolve in the water and each species, which may serve as food for creatures higher up the food chain, is more abundant in colder waters.

The ocean food chain

The tiniest creatures are at the bottom of this food web: ’phytoplankton (tiny floating plantlets) which need sunlight to be able to photosynthesise as well as unicellular algae. And there are countless such organisms in just one drop of seawater. Together these constitute an impressive 90 percent of the entire ocean biomass. These microscopic creatures are then eaten by copepods, tiny crustaceans found in the oceans, both on the sea floor and floating from the surface, or by krill, another type of crustacean, which leads a life of vertical migration, on the seafloor by day, while spending the night near the surface. Again, their mass is larger than that of all human beings combined. Krill forms the main food for molluscs, such as the sea butterflies, but also for larger marine life, such as fish, seals and whales. Fish are in their turn preyed upon by predator fish, seals and penguins. However, krill is also fished commercially for fishmeal and the like to the detriment of the marine creatures higher up the chain.

A reflection of the former bounty of the seas

The seas and oceans have since time immemorial been regarded as having been created solely for the wellbeing of humans. Even now the natural world tends to be valued largely for what is called its ‘ecosystems services,’ as in the food and medicines we derive from them, rather then their mystery and grandeur.

Nearly all the sources, used by Roberts, professor of Marine Conservation, show that the productivity of British waters was regarded as inexhaustible as late as the nineteenth century. One had but to throw out a net and nutritious food would just swim in. Nature appeared to exist to provide for human beings. Even when fish stocks were seen to be falling, richer harvests were expected from the use of the more efficient trawlers which were brought in around this time (Roberts, 2007: 170-171). Later, still more efficient fishing vessels, culminating in factory ships have been brought into use, with even more devastating results, such as, for instance, the destruction wrecked by bottom-trawling fleets, able to scrape the sea floor more or less clean, suffocating anything left behind (Heesterman and Heesterman, 2013: 11, referring to Lees, 2002). Then, as now, consumers were exhorted to diversify, eat other kinds of fish and change their dietary habits, permitting the fisheries a little time to recover. The question is, whether this policy will not lead to overexploitation of these other species of fish.

One of the few places where shallow coastal waters still teem with marine life due to its isolation, including what Roberts calls *apex predators,* is the atoll of Palmyra, right in the middle of the Pacific Ocean (2007: x-xi). The atoll remains an exception, having been in the care of the US Nature Conservancy since 2000. For me personally the beauty of large shoals of fish swimming struck home most when visiting Monterey Bay Aquarium, seeing silvery pacific herring swimming round and round in a towering glass column just outside the door. Left over patches of aquatic life as it must have been a century and a half ago, present a window on the possibility to restore at least something of the former glory of the oceans. Our sea aquaria make it possible to see corals and small groups of fish, although they are unable to do justice to the beauty and the abundance of a real sea community which still exists in far away isolated places like Palmyra.

Ought-of-sight, out-of-mind places

As oceans and seas are without ownership, they have been used for centuries as universal dustbins, where anything untoward can be forgotten once disposed of.

In fact much of what goes into the sewers and is not filtered out at the treatment plant eventually ends up in the oceans. This includes toxic substances such as triclosan, an antimicrobial found in certain soaps and skin creams, while clotrimazole is used as treatment of fungal infections. Both are endocrine disruptors, that is to say, synthetic chemicals that either mimic or block hormones and disrupt the body's normal functions, when absorbed. The effect of the presence of these substances on brittle stars has been studied under laboratory conditions, as it seemed that the combination of CO_2 rich water, and triclosan in particular, would act as a ‘stress cocktail’ leading to loss of some of its arms (Kolbert, 2011: 118-119). The outcome of the tests was, however, not as clear-cut as expected (Röös, 2014: 3.1): The seas, and ultimately the oceans, are further contaminated by nitrogen-rich agricultural runoff. It is estimated that as much as half of the nitrogen contained in fertilizer washes down streams, eventually ending up in the oceans (Biello, 2008). This may well give rise to algal blooms and eventually to marine 'dead zones,' where the oxygen content has been depleted to the extent that micro-organisms are no longer able to survive and serve as food for larger creatures up the chain. Dead zones tend to be close to coast and river mouths. By 2008 some 150 of these zones had been identified (Chivian and Bernstein, 2008: 52).

We also read regularly of oil spills that put marine environments and coastal waters into jeopardy. Then there are plastics of different types, including tiny plastic micro-beads which nowadays are a common ingredient of many brands of toothpaste as well as certain beauty products, such as facial scrubs. Where in the past the required abrasive quality was furnished by microscopic wooden pellets, replacement by cheaper plastic has added yet another source of marine pollution. These tiny jelly-like globules are not dissimilar to fish eggs, so they may easily be mistaken for a tasty morsel by fish or sea bird and so enter the food chain. In addition, micro-beads can act as a magnet to pesticides. If this was not enough, certain types of plastic also mimic hormones.

Oceans as carbon dioxide sinks

Something else human beings send off into the oceans and then forget about, is much of the carbon dioxide (CO_2) we generate when using fossil fuel energy. When the large expanse of ocean is rated as to its capacity to deliver so-called *ecosystem services*, one's first thought runs on food provision. However, currently one of the most useful functions of oceans is to act as sinks for CO_2 and heat, amounting to roughly 30 percent of CO_2, while continuing to absorb a further million tons per hour (Intergovernmental Panel on Climate Change, 2013: B5). In addition, 93 percent of excess heat energy has been injected into the world's oceans in the last fifty years. Oceans help to regulate the world's thermostat to some extent, keeping its land masses from overheating.(Chambers, 2013). However, this benefit to humanity comes at a cost for the biodiversity of the oceans, while this cannot go on indefinitely. As well as surface heating, more heat energy appears to have penetrated deeper into the oceans in recent years (Balmaseda et al., 2013: 1758, Table 1: OHC (Ocean Heat Content) Linear Trends). In addition, the CO_2 input is giving rise to a change in the ocean chemistry. Combined with H_2O, CO_2 gives rise to the formation of a weak acid, H_2CO_3, leading to ocean acidification, or strictly speaking a lowering of the basic character of seawater. Instead of a pH (a measure of the acidity or basicity of an aqueous solution), measured at 8.2, this has gone down to 8.1. This does not sound much, but being on a logarithmical rather than a linear scale, the increase in acidity comes to about 26 percent. The impacts of these seemingly insignificant changes are potentially huge. Seawater is normally saturated with calcium carbonate and aragonite minerals, which allow marine organisms such as shellfish to build their exoskeletons and shells. But the acidification makes this more problematic. In fact, storing a number of Antarctic sea butterflies (*limacina Antarctica*), a tiny pteropod shellfish with a hair thin shell, in slightly more acidic water led to buckling and deformation of their shells (McClintock, 2012:119). Other species already suffering from the changing ocean chemistry are scallops, when in their larval state (Campbell et al., 2014), while the semen of a common species of worm, also found near British coasts, the lugworm, is affected in the presence of copper pollution in acid waters (Waldbusser et al., 2013).

If business-as-usual continues, scientists expect the basicity of the oceans to decrease further to about 7.8 by the end of the twenty-first century. That would mean more acidic by 150 percent. Seawater in a volcanic vent near Castello Aragonese, a small island west of Naples, which is continually subjected to CO_2 bubbling up from the depths, gives us a good idea of the effects of high acidity on ocean life (Kolbert, 2011: 106). The fact that the sea water is warming is not good news for other oceanic creatures either. Most people will have read about coral bleaching. This refers to the dying of a range of algae, which live in symbiosis with the corals; for many even a slight warming is fatal. As to the effect of a high CO_2 environment on reefs, this is how the Intergovernmental Panel on Climate Change puts it:

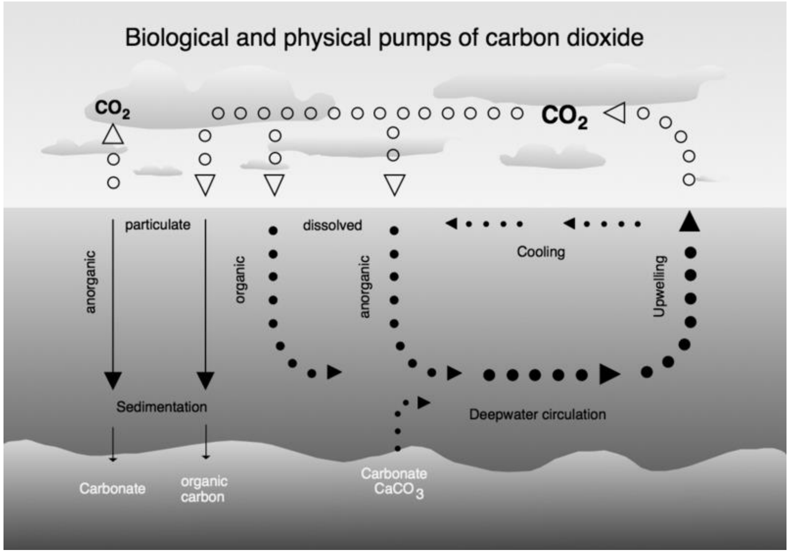
> Ocean acidification poses substantial risks to marine ecosystems, especially polar ecosystems and coral reefs, associated with impacts on the physiology, behavior, and population dynamics of individual species from phytoplankton to animals. Calcified molluscs, echinoderms, and reef-building corals are more sensitive than crustaceans (high confidence) and fishes (low confidence), with potentially detrimental consequences for fisheries and livelihoods (IPCC, March 2014: 17)

Loss of marine biodiversity and climate change linked

Reports are coming in of species moving poleward, away from their former abodes where they are no longer feeling comfortable. While it might seem a win for biodiversity that tiny predator hermit crabs are moving further north, it is in reality a loss, as they gorge themselves on food previously eaten by other creatures. Just recently, in June 2014, we learnt that a species of Mediterranean hermit crab (Diogenes pugilator) can now be found on British beaches as coastal waters of the North Sea have warmed by over a degree C since the 1950s (Türkay, Senckenberg Gesellschaft für Naturforschung, 2014; Schwimm et al.: 2014) The implication is that it has begun to fill a niche occupied by another species, while leaving its former haunts. At some stage several creatures are going to run out of colder spaces to move to, whether further towards the poles or up mountains. Warming of the oceans allows invasive species to move into regions which were too cold for them in the past, an occurrence that gives rise to increasing loss of biodiversity. An example of a more aggressive species moving south and up from the sea floor further to the north onto the slope of an Antarctic sea shelf, is the spiny king crab. It is a huge creature by crab standard, of some two feet diameter. With its big appetite it has begun hoovering up the small fry, whether clams, small crustaceans, sea snails or brittle stars. As these are currently the preferred fare of those higher up the chain, food scarcity on the shelves of the Antarctic Peninsula is the inevitable result (McClintock, 2012: chapter 6). Warming of seas and oceans is likely to give rise to a narrowing of ranges of marine organisms.

There are plenty of examples of flora and fauna migrating to warming areas, leading to increasing species loss. Much more has been written of the impact on climate change on biodiversity on the terrestrial biosphere than on marine life. Yet it is of major importance. In reality it is part and parcel of the same process in a mutually reinforcing loop (Chivian and Bernstein, 2008: 67*ff*; Roman and McCarthy, 2010). Importantly, much of the CO_2 that goes into the oceans is absorbed by tiny single cell organisms, phytoplankton or micro algae, the base of several aquatic food webs (NOAA, 2014). These are minuscule plants, that float on the surface and are able to grow hair thin shells of calcium carbonate (a few species use magnesium carbonate instead) with the help of sunlight. In death, their shells sink to the sea floor, the CO_2 safely locked inside the calcium of their shells.

However, with increased ocean acidification, the shells don't form properly and no longer take up CO_2, which serves to exacerbate the acidification, thereby making climate change worse. Another example is what Roman and McCarthy call 'the whale pump'; marine mammals feed near the seafloor and bring nutrient-rich matter back to the surface in their excrement, which tends to remain in suspension near the surface in the form of faecal plumes.



Air-sea exchange of CO_2, Creative Commons CC-BY-SA-2.5, original Hannes Grobe, 21:52, 12 August 2006 (UTC), Alfred Wegener Institute for Polar and Marine Research,

These nutrients are consumed by phytoplankton, the tiny plantlets at the bottom of the food chain, allowing them to thrive. In addition, the huge skeletons of whales, sunk to the ocean floor, store large amounts of carbon and nutrients, while they provide shelter. Although the decline in numbers of the giants of the deep, the baleen and sperm whales, is well over 66 percent and may be as high as 90 percent according to the authors, they think recovery is still possible, and would be of huge benefit for the oceanic ecosystem. As Roman notes: "Dozens, possibly hundreds, of species depend on these whale falls in the deep sea," The more whales are valued and protected, the greater the gain for biodiversity. Roman et al. even speak of whales as "Marine ecosystem engineers" in their latest paper (2014).

To Conclude

Preserving, or rather, improving upon the current state of the oceans is of the essence, both from a sense of self-preservation as well as an issue of human rights, both of our successor generations and of less affluent populations which rely on the oceans as a source of food. The future wellbeing of human society is bound up closely with the health of the oceans. Seen from a point of view as perhaps the most important 'ecosystem services provider', failure to take urgent steps to rectify the harm human beings are causing to the marine systems is ultimately harming humankind as well. Although we do well in looking at oceans with awe and wonder, practical measures can and ought to be taken without delay.

Several legal provisions to protect the integrity of seas and oceans already exist: Binding international law, such as the1954 *International Convention for the Prevention of Pollution of the Sea by Oil* ("OILPOL Convention"), the *Whaling Convention*, the 1973 *Convention for the Prevention of Pollution from ships* and the *Helsinki Convention*. Together they ought to add up to a comprehensive system of protection. But, what are the enforcement mechanisms and how effective are they? Then they also ought to include a ban on the use of plastic micro-beads in beauty products – already enacted in New York State - as well as on trawling for immature fish and sand eels for fishmeal.

Although it might seem that there is no action we as individuals are able to take, even that is not true. As well as lowering our consumption of endangered fish species, we can ensure that harmful items such as plastic mini-pellets, present in many brands of toothpaste and body scrubs are not being sent down the drains. It is a simple matter, once one knows what to avoid – just read the lists of ingredients: PP (polypropylene) and PE (polyethylene, PET (polyethylene terephthalate), PMMA polymethyl methacrylate) as well as nylon. (Macrae, 2014). Undoubtedly, there is need for an extensive education campaign to convince the buying public to boycot products that contain substances so detrimental to the health of our oceans. Greater care in general is vital of what is being washed away down the plug hole to float to the sea through sewer and river systems.

> "Controlling the way we dispose of supermarket packaging and the like is a simple business, but it would have a really beneficial impact on the marine environment. We

> need to control the amounts of fertilisers and nutrients we put on our fields, which also get swept into the rivers and the seas, triggering the growth of toxic blooms of algae. Finally, we need to protect our coastal zones, with their mangrove swamps and fragile banks of sands.“ (Roberts, 2012)

In an ideal world much of what now goes down into the sewers in a ‘flush-and-forget’ mentality, ultimately degrading our seas and oceans, might by many be regarded as a valuable resource to be recycled either as compost (Price, 2009) or converted into fertiliser and biogas by means of anaerobic digestion (Hickey, 2014: 22).

Also, as individuals, we can exert pressure on politicians to give support for action to make a priority of improving the state of essential ecosystems, such as the oceans. For instance, subsidies to agriculture to be spent on fertilisers need to cease, while promoting Integrated agriculture which should largely be based on organic farming, although making a modest use of fertilizers and pesticides. Such a system would seem to combine the best of both (Chivian and Bernstein, 2008: 400), provided contour ploughing to minimise agricultural runoff is practised.

In any case, a system of interconnected marine preserves, as proposed by Greenpeace and endorsed by Roberts (2007: 384), will be essential if stocks of fish, marine mammals, and not to forget sea birds that feed on fish and molluscs, are to recover. A good begin is the habitat protection afforded by the 2014 designation of a secure nesting beach and nearshore adjoining ocean region for loggerhead turtles on the US Atlantic and Gulf coast following a 2013 lawsuit by conservation groups (Center for Biological Diversity, 2014).

People may object to the high cost of the proposed multinational measures for a global marine refuge system (Marine Conservation Institute) and ask whether we can afford to implement these proposals. Our question is “How can we not afford to re-establish a healthy oceanic system? Humanity’s survival and wellbeing depends on a flourishing of the natural world.”

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