: Peter Harris (Lead member and Convenor), Joshua Tuhumwire (Co-Lead member)

Consider how dependent upon the ocean we are. The ocean is vast – it covers seven-tenths of the planet. On average, it is about 4,000 metres deep. It contains 1.3 billion cubic kilometres of water (97 per cent of all water on Earth). But there are now about seven billion people on Earth. So we each have just one-fifth of a cubic kilometre of ocean to provide us with all the services that we get from the ocean. That small, one-fifth of a cubic kilometre share produces half of the oxygen each of us breathes, all of the sea fish and other seafood that each of us eats. It is the ultimate source of all the freshwater that each of us will drink in our lifetimes. The ocean is a highway for ships that carry across the globe the exports and imports that we produce and consume. It contains the oil and gas deposits and minerals on and beneath the seafloor that we increasingly need to use. The submarine cables across the ocean flo TJ0 Tc 0 Tw 34.29 0 Td(-)Tj0.001 Tc 0.173 Tw -34.29 -1.22 Td[f)-4(if)6(t)-4 contribute indirectly to our benefits from the ocean. Even those which have no connection whatever with us humans are part of the biodiversity whose value we have belatedly recognized. However, the relationships are reciprocal. We intentionally exploit many components of this biodiverse richness. Carelessly (for example, through inputs of waste) or unknowingly (for example, through ocean acidification from increased emissions of carbon dioxide), we are altering the circumstances in which these plants and animals li are part of our legacy and our future. They will shape the future of the ocean and its biodiversity as an integral physical-biological system, and the ability of the ocean to developed for this purpose, this Assessment is the first global integrated assessment of the marine environment (see further in Chapter 2).

Three possible focuses exist for structuring this Assessment: the ecosystem services (market and non-marketed, tangible and intangible) that the marine environment provides; the habitats that exist within the marine environment, and the pressures that human activities exert on the marine environment. All three have advantages and disadvantages.

Using ecosystem services as the basis for structuring the Assessment would follow the approach of the Millennium Ecosystem Assessment (2005). This has the advantage of broad acceptance in environmental reporting. It would cover provisioning services (food, construction materials, renewable energy, coastal protection), while highlighting regulating services and quality-of-life services that are not captured using a pressures or habitats approach to structuring the Assessment. It would have the disadvantage that some important human activities using the ocean (for example, shipping, ports and minerals extraction) would be covered only incidentally.

Using marine habitats as the basis for structuring the Assessment would have the advantage that habitats are the property that inherently integrates many ecosystem features, including species at higher and lower trophic levels, water quality, oceanographic conditions and many types of anthropogenic pressures (AoA, 2009). The cumulative aspect of multiple pressures affecting the same habitat, that is often lost in sector-based environmental reporting (Halpern et al., 2008), is captured by using habitats as reporting units. It would have the disadvantage that consideration of human activities would be fragmented between the many different types of habitats.

Using pressures as the basis for structuring the Assessment would have the advantage that the associated human activities are commonly linked with data collection and reporting structures for regulatory compliance purposes. For instance, permits that are issued for offshore oil and gas development require specific monitoring and reporting obligations to be met by operators. It would have the disadvantage that many important ecosystem services would only be covered in relation to the impacts of the human activities.

Given that all three approaches have their own particular advantages and disadvantages, the United Nations General Assembly endorsed a structure for this Assessment that combined all three approaches, thereby structuring the World Ocean Assessment into seven main Parts, as follows.

The Summary is intended to bring out the way in which the assessment has been carried out, the overall assessment of the scale of human impact on the oceans and the overall value of the oceans to humans, and the main threats to the marine environment and human economic and social well-being. As guides for future action it also describes the gaps in capacity-building and in knowledge.

environmental, social and economic aspects of the conservation of marine species and habitats.

Part VII finally looks at the overall impact of humans on the ocean, and the overall benefit of the ocean for humans.

Looking at a globe of the earth one thing that can be easily seen is that, although different names appear in different places for different ocean areas, these areas are all linked together: there is really only one world ocean. The seafloor beneath the ocean has long remained a mystery, but in recent decades our understanding of the ocean floor has improved. The publication of the first comprehensive, global map of seafloor physiography by Bruce Heezen and Marie Tharp in 1977 provided a pseudo-three-dimensional image of the ocean that has influenced a long line of scholars. That image has been refined in recent years by new bathymetric maps (Smith and Sandwell, 1997) which are used to illustrate globes, web sites and the maps on many in-flight TV screens when flying over the ocean.

A new digital, global seafloor geomorphic features map has been built (especially to assist the World Ocean Assessment) using a combination of manual and ArcGIS methods based on the analysis and interpretation of the latest global bathymetry grid (Harris et al., 2014; Figure 1). The new map inc83 Tw -3t001 Tc 0(c)4n9(t)iem2(a)10(t)

the margins of the continents. Examples include: the Kuroshio Current in the northwest Pacific, the Humboldt (Peru) Current in the southeast Pacific, the Benguela Current in the southeast Atlantic and the Agulhas Current in the western Indian Ocean. The mightiest ocean current of all is the Circumpolar Current which flows from west to east encircling the continent of Antarctica and transporting more than 100 Sverdrups (100 million cubic meters per second) of ocean water (Rintoul and Sokolov, 2001). As well as the boundary currents, there are five major gyres of rotating currents: two in the Atlantic and two in the Pacific (in each case one north and one south of the equator) and one in the Indian Ocean.

The winds in the atmosphere are the main drivers of these ocean surface currents. The interface between the ocean and the atmosphere and the effect of the winds also allows for the ocean to absorb oxygen and, more importantly, carbon dioxide from the air. Annually, the ocean absorbs 2,300 gigatonnes of carbon dioxide (IPCC, 2005; see Chapter 5).

In addition to this vast surface ocean current system, there is the ocean thermohaline circulation (ocean conveyor) system (Figure 3). Instead of being driven

Figure 2. The global ocean "conveyor" thermohaline circulation (Broecker, 1991). Bottom water is formed in the polar seas via sea-ice formation in winter, which rejects cold, salty (dense) water. This sinks to the ocean floor and flows into the Indian and North Pacific Oceans before returning to complete the loop in the North Atlantic. Numbers indicate estimated volumes of bottom water production in "Sverdrups" (1 Sverdrup = 1 million m^3/s), which may be reduced by global warming because less sea ice will be formed during winter. Blue indicates cold currents and red indicates warm currents. The black question marks indicate sites long the Antarctic margin where bottom water may be formed but of unknown volumes. The question mark after the "5" indicates that this value is certain.

Wind-driven mixing affects only the surface of the ocean, mainly the upper 200 metres or so, and rarely deeper than about 1,000 metres. Without the ocean's thermohaline circulation system, the bottom waters of the ocean would soon be depleted of oxygen, and aerobic life there would cease to exist.

Superimposed on all these processes, there is the twice-daily ebb and flow of the tide. This is, of course, most significant in coastal seas. The tidal range varies according to local geography: the largest mean tidal ranges (around 11.7 metres) are found in the Bay of Fundy, on the Atlantic coast of Canada, but ranges only slightly less are also found in the Bristol Channel in the United Kingdom, on the northern coast of France, and on the coasts of Alaska, Argentina and Chile (NOAA 2014).

Global warming is likely to affect many aspects of ocean processes. Changes in sea-surface temperature, sea level and other primary impacts will lead, among other things, to increases in the frequency of major tropical storms (cyclones, hurricanes and typhoons) bigger ocean swell waves and reduced polar ice formation. Each of these consequences has its own consequences, and so on (Harley et al., 2006; Occhipinti-Ambrogi, 2007). For example, reduced sea ice production in the polar seas will mean less bottom water is produced (Broecker, 1997) and hence less oxygen delivered to the deep ocean (Shaffer et al., 2009).

The complex system of the atmosphere and ocean currents is also crucial to the distribution of life in the ocean, since it regulates, among other factors, (as said above) temperature, salinity, oxygen content, absorption of carbon dioxide and the penetration of light and (in addition to these) the distribution of nutrients.

The distribution of nutrients throughout the ocean is the result of the interaction of a number of different processes. Nutrients are introduced to the ocean from the land through riverine discharges, through inputs direct from pipelines and through airborne inputs (see Chapter 20). Within the ocean, these external inputs of nutrients suffer various fates and are cycled. Nutrients that are adsorbed onto the surface of particles are likely to fall into sediments, from where they may either be remobilised by water movement or settle permanently. Nutrients that are taken up by plants and mixotrophic biota for photosynthesis will also eventually sink towards the seabed as the plants or biota die; *en route* or when they reach the seabed, they will be broken up by bacteria and the nutrients released. As a result of these processes, the water in lower levels of the ocean is richer in nutrients.

Upwelling of these nutrient-

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 3. Distribution of biodiversity in the oceans. Biodiversity data: Tittensor et al., 2010. Human impact data: Halpern et al., 2008, Map: Census of Marine Life, 2010; Ausubel et al., 2010; National Geographic Society, 2010).

Humans depend upon the ocean in many ways and our ocean-based industries have had impacts on ocean ecosystems from local to global spatial scales. In the large majority of ocean ecosystems, humans play a major role in determining crucial features of the way in which the ecosystems are developing.

The impacts of climate change and acidification are pervasive through most ocean ecosystems. These, and related impacts, are discussed in Part III (Assessment of major ecosystem services from the marine environment (other than provisioning services)), together with the non-marketed ecosystem services that we enjoy from the ocean and the ways in which these may be affected by the pervasive impacts of human activities.

seabed in providing oil and gas and other minerals; the non-consumptive uses of the ocean to provide renewable energy; the potential for non-consumptive use of marine genetic resources; the uses of seawater to supplement freshwater resources; and the vital role of the ocean in tourism and recreation. In addition, it is necessary to consider the way in which human activities that produce waste can affect the marine environment as the wastes are discharged, emitted or dumped into the marine environment, and the effects of reclaiming land from the sea and seeking to change the natural processes of erosion and sedimentation. Finally, we need to consider the marine scientific research that is the foundation of all our attempts to understand the ocean and to manage the human activities that affect it.

Our planet is seven-tenths ocean. From space, the blue of the ocean is the predominant colour. This Assessment is an attempt to produce a 360º review of where the ocean stands, what the range of natural variability underlies its future development and what are the pressures (and their drivers) that are likely to influence that development. As the description of the task set out in Chapter 2 (Mandate, information sources and method of work) shows, the Assessment does not attempt to make recommendations or analyse the success (or otherwise) of current policies. Its task is to provide a factual basis for the relevant authorities in reaching their decisions. The aim is that a comprehensive, consistent Assessment will provide a better basis for those decisions.

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