TWAP
TRANSBOUNDARY WATERS ASSESSMENT PROGRAMME

The Open Ocean

Status and Trends

SUMMARY FOR POLICY MAKERS

VOLUME 5: OPEN OCEAN

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Administrative Boundaries
Source of administrative boundaries used throughout the assessment: The Global Administrative Unit Layers (GAUL) dataset implemented by FAO within the CountrySTAT and Agricultural Market Information System (AMIS) projects.

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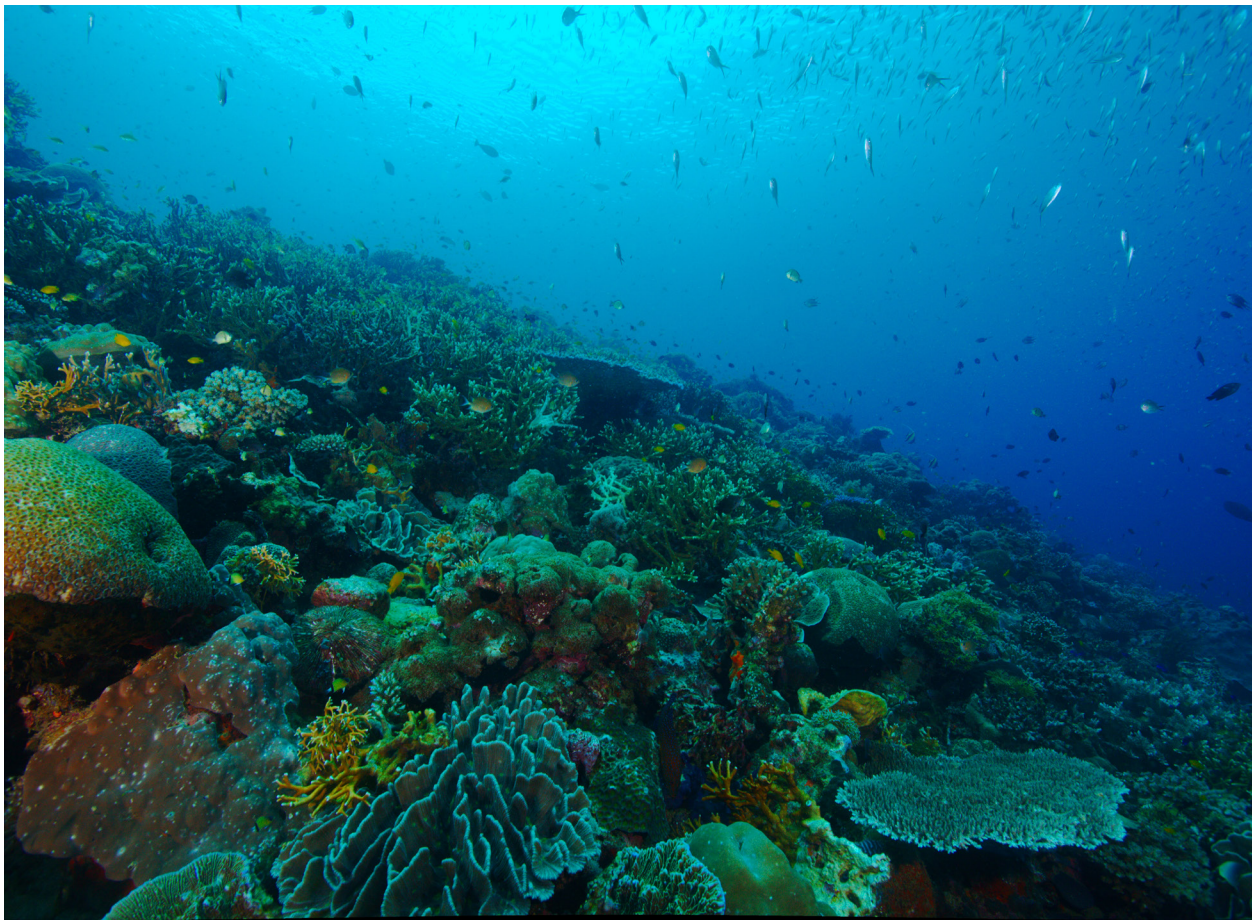
Summary for Policy Makers

The *Open Ocean Assessment* provides a baseline review of issues linking human well-being with the status of the open ocean through the themes of governance, climate change, ocean ecosystems, fisheries, pollution, and integrated assessment of the human-ocean nexus. It uses indices and indicators where data exist, in many cases with future projections due to global climate change, complemented by expert scientific assessment of numerous low certainty but potentially high impact issues where global ocean monitoring is inadequate.

Key Messages and Recommendations

1. **Urgent attention is needed to sustainably manage the open ocean ecosystems and their services.** The open ocean is the largest transboundary water space on Earth, covering about half of the entire surface of the planet, but also has impact on the entire global ocean. The open ocean's physical, chemical and biological characteristics are directly and indirectly threatened by human activity, especially via the effects of climate change. Damage to the open ocean will have severe consequences for marine ecosystems and services, and in turn human wellbeing.
2. **Understanding the impact of climate-ocean-human interconnections will help inform and improve sustainable development decisions.** The state of the open ocean is influenced by climate. Likewise, climate is influenced by the ocean. This feedback loop is out of balance, with stressors from human activities causing a decline in the health of marine ecosystems and negatively affecting ecosystem services and human wellbeing.
3. **Improving human development is a key way to reduce human risk to sea level rise at the coast,** by reducing vulnerability and boosting adaptive capacity. The risk comes from the hazard of sea level rise which will continue under all emissions scenarios, and human exposure and vulnerability.
4. **Unabated greenhouse gas emissions require immediate regulation to avoid severe consequences.** If greenhouse gas emissions continue unabated, IPCC projections from now to 2050 indicate a continued decline in the health of marine ecosystems and their associated services. This will have negative consequences for human wellbeing.
5. **The sustained and incrementally improved monitoring of key ocean and climate variables within the Framework for Ocean Observations, GOOS and GCOS is critical.** It is important that the open ocean's physical, chemical and biological characteristics are regularly monitored. This will provide essential trend data to properly inform decisions to manage the health of the open ocean ecosystems, with a view to maintaining viable ecosystem services and being able to measure and project human risk.
6. **Improved regulation is essential in reducing the over-exploitation of fish stocks and the impacts of climate change on them.** Fish stocks in the open ocean are vulnerable to over-exploitation from direct human impact. In addition, the indirect human impacts of climate change lead to declining fish stock health and shifting migratory patterns.
7. **Improved regulation is required to minimize the sources and impact of pollution on marine ecosystem health and human wellbeing.** There are multiple sources of pollution in the open ocean (including land, shipping and atmospheric) which have potentially massive impact on the health of marine ecosystems, and in turn, humans.
8. **Improved global transboundary ocean governance is needed to mitigate even local damage to ocean ecosystems within national waters.** Stressors such as climate change, whose mitigation solutions require global and regional governance and cannot be addressed by national action alone, dominate cumulative human impact on these local and coastal ecosystems.

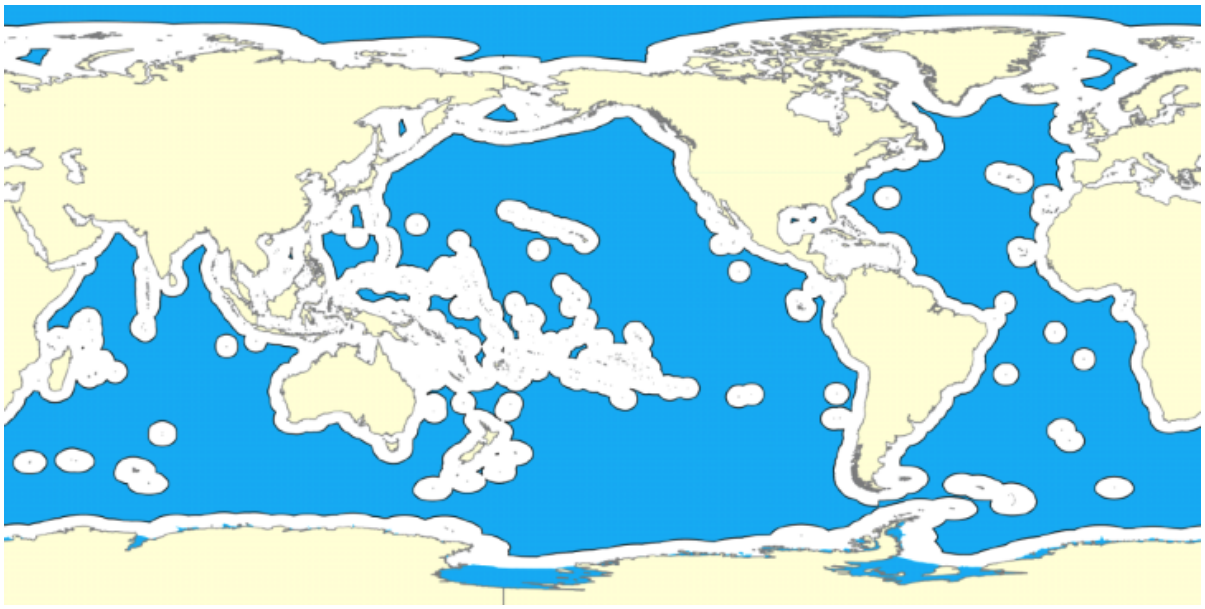
9. **Governance arrangements for the open ocean should connect to those for areas under national jurisdiction at the regional level.** Numerous governance arrangements (ranging from local, to regional, to global) exist for the open ocean and areas beyond national jurisdiction. These are often complex, with many gaps (especially for biodiversity) and/or regulations are not enforced. There is no co-ordination body actively addressing these challenges at global and regional levels. These arrangements should work on common principles.
10. **The TWAP Open Ocean assessment method provides a holistic overview of the state of open ocean ecosystems and their inter-connections with human wellbeing. It can be used to create a system of monitoring goals within the Sustainable Development Goals (SDG) framework and to support future rounds of the World Ocean Assessment.** This assessment is the first to look at the state of open ocean ecosystems and inter-connections with human wellbeing holistically using a method describing the relationship between human and natural systems from the point of view of ecosystem services. This has allowed an identification of data sources and gaps, and natural points of intervention for management. The methodology compliments the UN Regular Process, and the results also corroborate with World Ocean Assessment Summary (2015).
11. **An ongoing and robust scientific support enterprise is essential in providing confidence to policy and decision-makers that resources are being appropriately allocated.** The open ocean is under-observed and under-explored, and there is still more to be understood about its immediate and future impact on human society. However, a lack of certainty cannot prevent policy and decision-makers from acting. The results of this assessment reveal key issues that require immediate attention and action. As research and monitoring improve, strategies for managing these issues can then be refined in the light of increased scientific understanding.



The open ocean

The 'open ocean' is the largest areas of global commons, vital to life on the planet, and under the legal jurisdiction of no single nation but the common stewardship of all in 'areas beyond national jurisdiction' (ABNJ). This area is made up of the ocean beyond exclusive economic zones (EEZs). From a scientific perspective, the open ocean includes all areas beyond the shallow continental shelf break. Due to the strong connections between the open ocean and coastal areas, a global ocean perspective is often taken. Where indicators are shared with the Large Marine Ecosystems, this assessment has focused on ABNJ.

Areas Beyond National Jurisdiction (ABNJ) are blue. The white areas depict exclusive economic zones (EEZs) (or 'areas within national jurisdiction').



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Assessment indicators for an under-monitored open ocean

The Transboundary Waters Assessment Programme (TWAP) was initiated by the Global Environment Facility (GEF) to create the first baseline assessment of all the planet's transboundary water resources. The *Open Ocean Assessment* is one of five assessments of transboundary water systems (see *www.geftwap.org*).

The *Open Ocean Assessment* is focused on 6 themes broadly aligned with governance arrangements covering areas beyond national jurisdiction, including governance of issues requiring global transboundary solutions. It provides a baseline indication of the state of the open ocean and its ecosystems and services, their connection to human wellbeing including global connections to the coast; and where possible, projected future state at 2030, 2050, and/or 2100. This assessment involved data assembly, index and indicator development, and theme reviews by experts - assessing the indicators where possible and assessing scientific literature where sustained global monitoring does not exist.

The table below identifies the expert assessments, indices and indicators (including projections) used in the assessment. It also identifies the implied sustained monitoring requirement and present-day readiness of monitoring systems such as the natural system-focused Global Ocean Observing System (GOOS) to systematically capture the information needed to update this assessment in the future (based on the readiness scale of the *Framework for Ocean Observing* ranging from: concept, pilot, to mature). Even for mature portions of observing systems (i.e. the physics of ocean climate), sustained financial and institutional support as well as capacity for and coverage of global observations and information delivery remains patchy and fragile.

THEME	Expert Assessment	INDEX / INDICATOR (Baseline)	INDEX / INDICATOR (Projected to 2030, 2050, and/or 2100)	Sustained monitoring requirement for assessment *includes both natural system and human data*	Readiness of sustained observations *(concept, pilot, mature, from least to most ready)*
Governance	Existence of Open Ocean Governance Arrangements			Monitoring of governance arrangements covering ABNJ	concept
Climate	Climate and Ocean interactions	Ocean warming	Ocean warming	Physical / biogeochemical ocean variables	mature / pilot
		Deoxygenation	Deoxygenation (to 2090)	Oxygen	pilot
		Aragonite saturation state	Aragonite saturation state	Carbonate system	mature
			Sea Level Rise Risk Index (to 2100)	Sea level, temperature, cryosphere	mature / pilot
				human exposure and vulnerability to sea level	mature
Ecosystems, habitats and biodiversity	Ocean Acidification Risk	Primary productivity		ocean colour in situ validation	mature pilot
		Phytoplankton		phytoplankton	concept
		Zooplankton		zooplankton	pilot
		Coral reefs (tropical ecosystem)	Coral reefs (tropical ecosystem)	coral health	pilot
		Pteropods (polar ecosystem)	Pteropods (polar ecosystem)	zooplankton	pilot
		Biodiversity (based on OBIS records)		Biodiversity (species records)	concept
Fisheries	Sustainability of fisheries	Marine Trophic Index	Fish Catch Potential	fish catch data by taxonomic group and trophic level	mature
		Fishing in Balance Index		fish catch data by taxonomic group and trophic level over time	mature
		Bottom Impacting Gear		method of fish catch	mature
		Demersal Fishing		method of fish catch	mature
		Tuna trends 1950 to 2010		fish catch data	mature
Pollution	Pollution (general)	Plastics		time series of ocean contaminants from strategically selected sites	concept

Narrative of selected results

The results for all indicators and expert assessments are too many to show here, and can be explored in more detail on the *Open Ocean Assessment* web site *(onesharedocean.org/open_ocean)*. A narrative of selected key messages follows here.

A changing open ocean climate

The ocean's dominant role in climate of storing and distributing heat and moisture means it will drive changes of rainfall and drought over land. Sea level rise from heat expansion and melting land ice threatens coastal ecosystems and human habitat. Ocean climate changes through temperature, acidification, and deoxygenation have direct impact on ocean ecosystems.

Projected climate change scenarios

The **Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report 2014** (AR5) provides the most up-to-date comprehensive assessment of scientific information on climate change and the ocean and an overview of impacts already observed or expected from a range of climate change scenarios. The *Open Ocean Assessment* uses projections of the future state of the open ocean using the scenarios outlined in the **IPCC 5th Assessment Report (2014),** for 2030 and 2050, and when intermediate output was not available, for 2100.

Representative Concentration Pathways (RCP) are tools used by researchers to test the consequences different greenhouse gas emission scenarios, based on global political choices. There is a range of scenarios but this Assessment uses two:

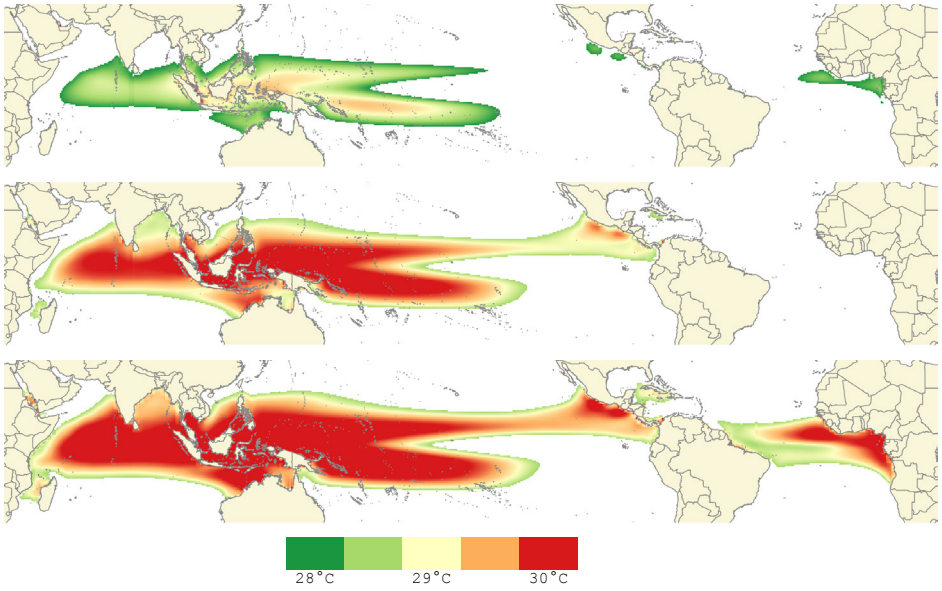
- **RCP8.5 'Business As Usual' *(BAU)*** – where nothing changes from the current situation, there is continuing growth of greenhouse gas concentrations in the atmosphere.
- **RCP4.5 ' two degree stabilization scenario' or 'Moderate Mitigation' *(MM)*** – where there is a continued rapid initial growth of greenhouse gas concentrations, but stabilizing concentrations from 2070 onward. Parties to the Paris Agreement of the UNFCCC adopted in December 2015 have agreed to hold "the increase in global average temperature to well below 2 °C above pre-industrial levels"

The ocean is warming

Ocean warming dominates the energy stored in the climate system in the last 40-50 years and accounts for approximately 93% of the excess heat accumulated between 1971 and 2010.

The area of regions with very warm water (>28°C), engines of tropical circulation and rainfall patterns, will increase substantially by 2050 under both the "Moderate Mitigation" and "Business As Usual" scenarios, with impacts on regional climate and ecosystems.

The open ocean 'warm pool' (>28°C) now (top), in 2050 under 'Moderate Mitigation' (middle) and under 'Business as Usual' (bottom) scenarios.



Ocean oxygen is decreasing

One of the major climate stressors of open ocean ecosystems is deoxygenation. The concentration of dissolved oxygen (O_2) is a major determinant of the distribution and abundance of marine species globally. Open ocean deoxygenation has already been recorded in nearly all ocean basins during the second half of the 20th century. Increased temperatures are responsible for approximately 15 % of the observed change, and the remaining 85 % is due to reduced O_2 supply from increased ocean stratification and increased deep-sea microbial respiration.

The North Pacific, the North Atlantic, the Southern Ocean, the subtropical South Pacific and South Indian oceans will all undergo deoxygenation by the end of the century (BAU scenario).

Observed (black line) and projected O_2 concentration change (per cent) relative to mean concentration in the 1990s. The black line shows historical simulations tuned with available observations. Colored lines represent four RCP scenarios: RCP 2.6 – blue, RCP 4.5 'Moderate Mitigation' – green, RCP 6.0 – lavender and RCP 8.5 'Business as Usual' – red.