

Large Changes in Canada's Oceans and Their Impacts on Ecosystems and Fisheries

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Canada's marine environments are undergoing large-scale changes defined by shifts and trends in their mean physical or chemical states over decadal time scales or large spatial scales (ocean basin-wide). These changes affect biological communities and human societies through impacts on marine ecosystems, subsistence practices, especially those of Indigenous Canadians, commercial and recreational fisheries, ecotourism, and other ecosystem services.

Climate models and regional downscaling approaches are used to assess these trends and projections. Recent national assessments for Canada's three oceans highlight increased atmospheric and ocean warming (especially in the Arctic), modified ocean stratification affecting the nutrient supply for marine species, regionally varying changes in primary production, decreasing oxygen levels, advancing ocean acidification (OA) (most prominently in the Arctic), decreasing sea-ice extent and thickness, modified sea-ice characteristics and storm waves, and increasing, climate change-related extreme events. These observed trends are projected to continue into the future with continued greenhouse gas emissions (Steiner et al. 2015; Christian and Foreman 2013; Loder et al. 2013). Differences among future emissions scenarios become apparent only after several decades, as upcoming changes are already determined by past emissions. On decadal time scales, natural variability is expected to equal long-term trends in magnitude, complicating the detection of long-term trends in recorded observations. Furthermore, local

effects (e.g., topography-influenced ocean/atmosphere circulation) might mask trends locally. These results are reinforced in *Canada's Changing Climate Report* (Bush and Lemmen 2019), the *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* (Pörtner et al. 2019), and recent Arctic Monitoring and Assessment Programme (AMAP) reports (AMAP 2018a, 2018b, 2018c). The *IPCC Special Report* (Pörtner et al. 2019) indicates that many marine species have undergone shifts in geographic ranges, seasonality, composition, and abundance, with cascading impacts on ecosystem structure and functioning. This has impacted ecosystems and their services with regionally diverse (positive and negative) outcomes but negative consequences for health and well-being generally and for Indigenous Peoples dependent on fisheries.

The global assessment of biodiversity and ecosystem services by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019) indicates that 66% of the global ocean area is experiencing increasing cumulative human impacts, including overexploitation of marine species, land- and sea-based pollution, and land- and sea-use changes. It states that sustaining and conserving fisheries, marine species, and ecosystems can be achieved through coordinated interventions on land, in freshwater and oceans, and through multi-level coordination across stakeholders. The regional assessment report for the Americas describes how human-induced changes (e.g.,