The cumulative effects of bottom trawling and low oxygen on marine life

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In November 2016, Ocean Networks Canada (ONC) scientists co-authored a publication in Deep-Sea Research II on the effects of deep-sea bottom trawling on seafloor marine life, already stressed by the naturally low oxygen waters of the north Pacific. This is the first study to measure the effects on the fauna living on the soft-sediment seabed of Vancouver Island?S continental shelf and slope. Previous scientific research has focused on by-catch (species accidentally caught in the fishing net), particularly in areas where deep-water coral and sponge reefs occur.

This article is based on a University of Victoria Master?S thesis by Maëva Gauthier. The data originates from remotely operated vehicle surveys along the cable route for ONC?S NEPTUNE observatory in 2007, prior to the installation of the observatory.

The deep-sea video and sonar data from the surveys reveals a decline in invertebrate and fish populations, and a reduced biodiversity in the oxygen minimum zone?where oxygen saturation is at its lowest?off Vancouver Island (depth 600-1100 m). This coincides with the most heavily trawled areas primarily targeting thornyhead fishes (Sebastolobus alascanus and S. altivelis).
Commercial bottom trawling off the coast of British Columbia began in the 1990’s in response to growing market demands. It is still economically important, despite scientific evidence and public concern about the risks to seafloor habitats and marine life.

After the first 15 years, Fisheries and Oceans Canada estimated that the bottom-trawling fishery footprint impacted an area larger than Vancouver Island; specifically 38,000 km$^2$ along Canada’s Pacific coast, at depths ranging from 115 to 1100 m. In its latest yearly assessment, the estimated economic value of British Columbia’s groundfish fishery—which combines bottom trawls and other fishing gear—is $146 million (87,049 tonnes). This represents 40% of Canada’s entire market: $362 million (169 tonnes).
Bottom trawling represents the most pervasive human impact on the world’s continental margins, even when compared to oil and gas exploration, waste and litter disposal, and mining. As fish stocks become depleted in coastal areas, its footprint is steadily descending into deeper waters. Direct effects of bottom trawling have been extensively reviewed in scientific literature and include scraping and ploughing of the seafloor, sediment resuspension with a smothering impact on the seafloor fauna (benthos), destruction of non-target species, and organic loading from the dumping of waste from at-sea processing. Indirect effects include post-fishing mortality and long-term, trawl-induced changes in the benthos, such as reduced diversity and biomass, and changes in ecosystem structure and habitat heterogeneity.
Figure 3: Left, extent of the deep-sea red shrimp (*Aristeus antenatus*) fishery off the coast of Spain. The map highlights (in yellow) the fishing vessel tracks from GPS positioning data, showing the target fishing areas near the La Fornera submarine canyon. Right, the fishing activity in this region is so intensive that its negative effects are compared to the effect of plowing farmlands, exterminating entire seafloor communities and leaving behind a barren seafloor. (Map and image: Puig et al 2012).

Despite this grim picture, recent positive changes in bottom trawling policy aim to prevent its expansion into deeper waters. In 2016, the European Commission agreed to ban bottom trawling below 800 m in European Union waters; also, it established measures to prevent bottom trawling in vulnerable marine ecosystems, such as deep-water corals and sponge reefs.

Similar measures have also been implemented in British Columbia since 2012, in an unprecedented agreement reached between British Columbia’s Deep Sea Trawlers Association and key non-government organizations such as the David Suzuki Foundation, Living Oceans, and SeaChoice. In a move towards reducing the impacts on deep-sea habitats, the voluntary agreement put the following key fisheries management strategies into effect: 1) the fisheries footprint has been reduced by 8,000 km$^2$ through limiting the maximum bottom trawling depth to 800 m and banning trawling from areas where corals and sponge reefs are known to occur in high densities; 2) a habitat quota means that vessels can retrieve no more than 4,500 kg of corals and sponges annually; 3) a habitat encounter protocol requires vessels to immediately report if they retrieve over 20 kg of corals and sponges combined; and 4) a habitat review committee conducts ongoing evaluations of fisheries impacts on the ecosystem. As a result of these and other measures worldwide, a once overexploited fishery is now moving toward sustainability.
Understanding how these remote ecosystems are impacted by human activities is the key to sustaining deep-sea fisheries. This ONC study provides the first evidence that natural stressors can exacerbate bottom trawling effects. In this case, the north Pacific oxygen minimum zone has a profound impact on marine life, reducing abundance and biodiversity. The worldwide expansion of oxygen minimum zones or 'dead-zones' has been associated with climate change. Models predict a decline of 1 to 7% of the global ocean inventory of dissolved oxygen by the end of this century.

The study found that the deep-sea soft-bottom communities were adversely affected by both bottom trawling intensity (measured by a high-resolution sonar mounted in the remotely operated vehicle) and low dissolved oxygen waters (measured via Line P, Fisheries and Oceans Canada's long time-series of oceanographic data). ONC will continue to investigate these synergistic interactions of human-induced impacts and natural ocean variability along British Columbia's continental margin.

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