Pilot Assessment of Changes in Plankton Diversity

MSFD Descriptor: 1 - Biological diversity
MSFD Criteria: 1.6 - Habitat condition; 1.7 - Ecosystem structure

OSPAR COMMISSION

Key Message Phytoplankton form the base of marine food webs and respond rapidly to environmental change. Variations in plankton community composition affect other pelagic and benthic organisms. This pilot study shows that diversity indices detect trends and significant shifts in community composition. Integrating this indicator with other plankton indicators will improve future assessments

Background

Phytoplankton are plant-like microscopic organisms that occur in the sunlit layers of the ocean and freshwater systems (**Figure 1**). Monitoring phytoplankton can help inform our understanding of how sustained long-term and / or rapid changes in biodiversity can alter marine ecosystem functioning and impact the services they provide to humans. Phytoplankton are already being used as indicators for water quality assessments, such as in the European Union Water Framework Directive (WFD).

While plankton diversity has been adopted as an OSPAR common indicator for the Celtic Seas, this pilot assessment presents results for five sites in the Greater North Sea and Bay of Biscay and Iberian Coast since the only data available to test this indicator was from these regions (**Figure 2**).

Species composition and abundance are influenced by changes in physical and chemical environmental conditions. As a result, phytoplankton communities can fluctuate in space and time. Human-induced disturbances such as pollution and / or eutrophication (i.e. excessive nutrients) can drive marked changes in community composition because only some species can cope with the changed habitat conditions. Consequently, the dynamics of the phytoplankton community, and thus its structural attributes (e.g. diversity, dominance or size structure), will differ from those of natural (undisturbed) communities. To help assess dominance, an analysis of community variance is made over time. Low community variation characterises a site with average species composition over time (little change over time), whereas large community variance may indicate sites that have shifted to a species-poor state.

Figure 1: Five examples of phytoplankton groups. Phytoplankton are extremely diverse, varying from photosynthesising bacteria (cyanobacteria), to plant-like green micro-algae, silicon-armoured diatoms, dinoflagellates, plant-like green algae and calcite-plated coccolithophores (drawings not to scale). [adapted from Sally Bensusen, NASA Earth Observing System Project Science Office and NASA Earth Observatory]

Figure 2: Locations of the five time series. This assessment uses the previous boundary between the North Sea and Celtic Seas, however this will be updated in the next assessment

Results

For this pilot assessment, which is a proof of concept, plankton diversity indices have been calculated to examine the seasonal and annual variability in phytoplankton community composition at five sites: four in French waters and one in Spanish waters. The amplitude of the variation in the phytoplankton community was also assessed to identify years where significant changes, or shifts in species composition, have taken place.

The results of this pilot assessment show that diversity indices are useful to describe the structure of the phytoplankton community and also variability of this structure.

Results cont...

Species dominance is highly variable between years and variations are site-specific (**Figure 3**). For the longer time-series (i.e. sites in the Bay of Biscay), a peak in dominance is shown in 2007–2008 but a long-term trend is difficult to identify. For the shorter time-series, i.e. sites in the Greater North Sea (Roscoff and Wimereux), there appears to be a tendency towards increased dominance from 2006 onwards, although care should be taken in trying to interpret trends for such a short period.

For Ouest Loscolo and Le Croisic in the Bay of Biscay (which both have a time series of 26 years), 2007 and 2008 were identified as years with a temporary shift to relatively high community variation (**Figure 4**). Inspection of the phytoplankton community composition, revealed unusually high abundance of *Leptocylindrus* spp. at Ouest Loscolo and a peak in abundance of *Lepidodinium* spp. at Le Croisic. However, the reasons for the high abundances of these species are still unclear.

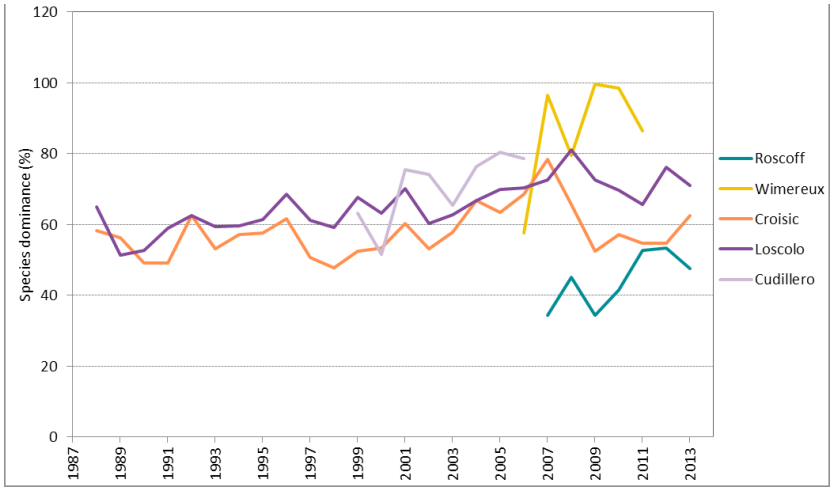

Figure 3 (top): Trends in percentage species dominance (annual averages) at Roscoff (2007–2013), Wimereux (2006–2012), Le Croisic (1988–2014), Ouest Loscolo (1988–2014) and Cudillero (1999–2006). Higher values indicate dominance by few species, whereas lower values indicate a more even balance among species

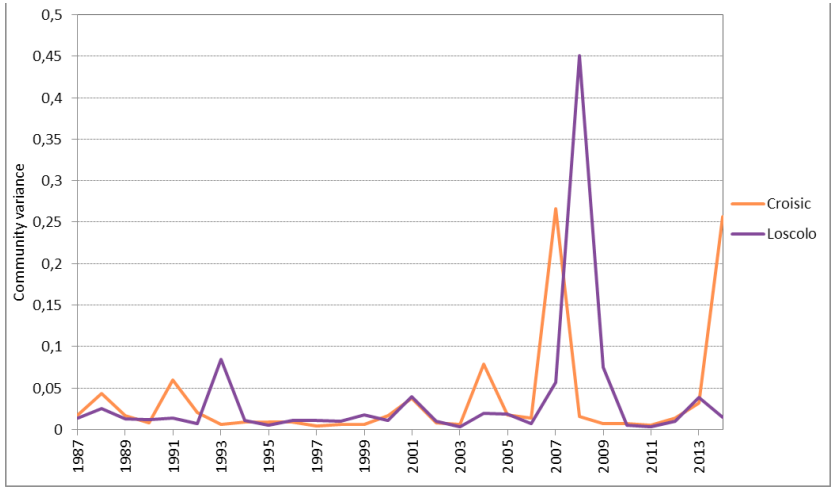

Figure 4 (bottom): Figure 4: Annual average phytoplankton community variance for Ouest Loscolo and Le Croisic

Conclusion

For the longer time series in this pilot study (Ouest Loscolo and Le Croisic, both Bay of Biscay), the diversity indices show 2007 to 2008 to be years with high dominance values. A corresponding shift in community composition was also identified. The community composition data showed these extreme events were marked by an unusually high abundance of one genus, namely *Leptocylindrus* spp. (a diatom - at Ouest Loscolo) and *Lepidodinium* spp. (a dinoflagellate - at Le Croisic).

As would be expected, the number of species is related to the dominance in the community. When one or a few species become extremely abundant (i.e. dominance increases), the overall number of species in the community (richness) decreases. Variations in the number of taxa and the dominance of phytoplankton species appear to be site-specific. This variation will be a reflection of the prevailing physiographic conditions and human pressures at the individual sites but could provide early warning of where there will be consequences for other pelagic and benthic organisms.

This pilot assessment shows that plankton diversity indices are a promising tool to assess plankton communities. However, for a more robust assessment of pelagic habitats, other measures such as total biomass / abundance of the community and information on functional groups should be included so that a multi-metric indicator could be developed.

The proof of concept presented here may be applicable to data in the Celtic Seas. It is also expected that it would also be suitable for application in other OSPAR regions, depending on data availability.

Knowledge Gaps

For a regional assessment, better acquisition of region-wide plankton data is required, including offshore stations. Appropriate training of taxonomists (to ensure comparable results) as well as the integration of semi-automated sampling techniques (to increase spatial coverage) are recommended for the implementation of monitoring programmes on a regional scale.

This indicator has been used as a proof of concept to assess the state of the phytoplankton community. For a more robust assessment of the pelagic habitat, information on the community structure of phytoplankton should be supplemented by other parameters, such as total community biomass / abundance and the dynamics of their functional groups.

This document was published as part of OSPAR's Intermediate Assessment 2017

The full assessment can be found at www.ospar.org/assessments