Marine habitats assessment methods: application of OSPAR indicators of condition and function of benthic communities. Preliminary results from UK waters.

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Our ability to detect short and long-term changes in the community structure and ecological function of benthic habitats caused by human activities is very challenging. This is particularly the case for offshore habitats where data collection is limited. This talk will present preliminary results from the application of two indicators designed to assess the changes on the function and condition of seabed habitats. The indicator of habitat function (OSPAR BH1 – Typical Species Composition) evaluates the variation in the proportion of a set of typical species in the benthic community across a pressure gradient. The set of species is defined on the basis of their abundance and of their biological traits determining the sensitivity to the pressure.

The indicator of habitat condition (OSPAR BH2 – Condition of benthic habitat communities) looks at the deviation of biodiversity indices' values from a baseline condition to quantify and detect the impact of a pressure. Multimetric indices developed for WFD and OSPAR purposes are used for this indicator and their sensitivity and precision in detecting the effects of pressure are analyzed using a tailored R tool (BENMMI).

The analyses for the application of the function and condition indicators were done using data collected from a number of surveys in the North Sea, Scottish waters and English Channel. Testing were performed on a range of habitat types against trawling pressure.

Testing and comparison between these two indicators will help us to understand different aspects of the benthic ecology and explore the suitability for an overall assessment of the status of sea floor community and their applicability for the assessment of Good Environmental Status. We will also explore the current limitations on data and our understanding on the influence of environmental variables and prevailing conditions.

Interannual variations in the spring phytoplankton bloom in the Scottish North Sea

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Spring phytoplankton blooms play a major role in the seasonal cycle of North Sea ecosystems. Understanding how this bloom varies from year to year and which processes control this variability is crucial to unravel ecosystem functioning and project the impacts of climate change. To address this question, we combined a weekly time series of physicochemical and biological variables collected since 1997 at the Stonehaven monitoring site with meteorological and hydrographic data.

We characterise the interannual variability of the spring bloom at this location based on the changes in chlorophyll concentration and phytoplankton species composition. During the study period, the spring bloom showed strong variability. In years such as 1999 and 1998, a large bloom occurred while in others such as 2003 and 2004, it was almost absent. In a first attempt to explain this variability, we inspected the influence of *in situ* temperature, salinity and different nutrients. Unexpectedly, only winter phosphate concentrations were correlated with the size of the spring bloom, which may indicate phosphate limitation. However, as nitrogen is usually the most limiting nutrient, we suspect that this correlation relates to other processes that directly control both phosphate and phytoplankton growth in spring. Among the regional-scale processes investigated, we found that salinity and temperature variations in the North Atlantic inflow into the North Sea were followed by those at Stonehaven, suggesting a preconditioning of the spring bloom by this current. A further exploration of this hypothesis through the analysis of phytoplankton community composition could also reveal that the North Atlantic inflow may at times carry the seed population for the bloom.

As light availability for phytoplankton may also be a key factor, we also explore how daily to weekly variations in turbidity and solar radiation during the first half of the year modulate the spring bloom. One hypothesis is that sunny days with lower turbidity in winter can boost phytoplankton production. However, this might not necessarily lead to an increase in chlorophyll concentration, as intense micrograzer activity could prevent the accumulation of phytoplankton biomass. This could be the case in 2004, when the fast depletion of nitrate at the end of March, most likely due to a rapid phytoplankton uptake, did not result in a bloom. In future work, this hypothesis will be tested by a model that includes solar radiation, phytoplankton biomass and rates of nitrate drawdown, phytoplankton growth and grazing.

Altogether, our results point to a complex regulation of the spring bloom in the Scottish North Sea with processes operating at different spatiotemporal scales that modify the local environment. Integrating the mechanisms disentangled here into larger scale models will help to better understand the ecosystem dynamics of the North Sea and potentially of other temperate and polar areas.

Acknowledgements

We thank all the people from Marine Scotland that helped in the establishment and maintenance of the time series collected at the Stonehaven monitoring site. We also thank the Center for Environmental Data Analysis (CEDA) and the National River Flow Archive (NRFA) for making the meteorological and hydrographic data available. Ricardo González-Gil is supported by a Clarin-Marie Curie COFUND grant from the Government of the Principality of Asturias through the FICYT (ACA17-05).

Quality assuring physical, chemical, and biological measurements from seawater samples collected on Marine Scotland cruises 1960-2018

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For over 100 years the Marine Laboratory Aberdeen has measured physical, chemical, and biological parameters at hydrographic standard sections, together with *ad hoc* stations whose timing and location were determined by individual projects. As a result of these sustained observations Marine Scotland holds a unique collection of laboratory-analysed water sample data from a wide variety of coastal and offshore regions. We draw together these sample data into a single quality controlled data archive, to be used internally and within the wider marine science community to better understand biogeochemical trends and variability and their effect on the wider marine ecosystem, as well as to help us maintain and optimise our marine monitoring programme.

In creating the data base we used internationally agreed quality control standards to assess data quality by assigning quality control flags to each measured parameter. Chemical techniques used to determine nutrient concentrations were standardised in the early 1960's, thus we have constrained our analyses to data since 1960. The resulting data from 1960-2018 include ~40,000 water column profiles of seawater samples including measurements of parameters such as temperature, salinity, oxygen, silicate, phosphate, ammonia, nitrate, carbon, nitrogen, chlorophyll, and phaeophytin. We explored these data by assigning them to geographical regions, which were determined using Marine Scotland and external environmental assessment reporting areas, and then by applying relevant statistical techniques. Here we present the data, the methods used to quality assure the data, and some of the initial results of our analysis.

Acknowledgements

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Estimate of residual transport in the Fair Isle Gap

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The Fair Isle Gap (FIG), between Orkney and Shetland archipelagos (Scotland, UK), is one of the major gateways for North Atlantic Current to flow into the northern North Sea. This key passage of the northwest European shelf was monitored by a High Frequency (HF) radar system (5MHz CODAR) during the Brahan Project (2013-2014). The latter successfully demonstrates the technology and its support in refining our current understanding of the water circulation in this region. The FIG mean flow properties have been widely studied but HF radar dataset provides a complementary description about the spatial variability of the flow. North and east velocity components have been investigated using statistical analysis of both HF radar observations and shelf hydrodynamic modelling data against in situ measurements (single point current meters and acoustic wave and current profilers). The qualitative evaluation of dataset, using complex correlation, RMSE and regression analysis, shows a good agreement between HF radar, depth-average velocities from current profiler measurements and model hind cast. The best representation of velocity vertical profiles is determined and combined to the HF radar data in a view to estimate the residual volume transport through the FIG. The volume transport over the FIG is estimated on the basis of the vertical profile determined from in situ data. The transport estimate is compared with the HF radar observations and model predictions.

A research collaboration with the Naval Postgraduate School (California, USA) will be conducted in the immediate future. It will demonstrate the direct assimilation of (radial) data from HF radar as complementary approach for water circulation understanding. Coastal zone comes under increasing pressure (e.g. aquaculture, marine energy) and marine management require more accurate and systematic measurements circulation in the coming years. Consequently, these monitoring systems are likely to become increasingly used and a more in depth investigation needs to be made. The suggested methodology may be a contributory factor to the associated tidal renewable exploitation and water mass transport over the area of study.

MASTS will be the enabler of transfer know-how and skills currently not available in Scotland. In this context, production and dissemination of consistent outcomes represent a unique opportunity for me and MASTS to wisely collaborate on the management of coastal and marine resources.

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Using time series to understand trophic interactions and food web dynamics in local pelagic ecosystems

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Alterations in pelagic food-web dynamics, driven by environmental change, are being noted in different regions of the globe (e.g. in the NW Pacific, Ruiz-Cooley et al. 2017; in the North Sea, Capuzzo et al. 2018). Our ability to detect altered trophic interactions and our understanding of the mechanics that underlie changes to interactions is limited by the availability of relevant time series; this is especially important when investigating how shifts in the timing of interactions lead to altered dynamics between taxa.

Here we use 15-years of physical, chemical, and biological time-series data, collected in Scottish coastal waters (Bresnan et al., 2016), to better understand the trophic dynamics in a local food-web. We investigate the influence of synchrony between fish hatching and zooplankton productivity on recruitment variability in the lesser sandeel (Régnier et al. 2017), finding that year-class strength depends on this degree of synchrony. We also investigate the inter-relationships between kittiwake breeding success and sandeel abundance, *Calanus* copepods, chlorophyll and temperature (Eerkes-Medrano et al. 2017), and found kittiwake breeding success depended on local sandeel abundance, and sandeel abundance was linked to the timing of *Calanus* egg production.

Due to the central role of sandeel as a key trophic link between plankton and predatory fish, seabirds and mammals, this research is serving to inform outputs such as the Marine Climate Change Impacts Annual Report Card. This research also highlights the importance of time series data in identifying key interactions and/or phenological events that can affect ecosystems in response to climate change.

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Gregarine apicomplexan parasites of 'deep-sea' invertebrates

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Gregarine apicomplexans are single celled parasites of invertebrates in freshwater, terrestrial and marine habitats, infecting the intestine, coelom and reproductive vesicles of their hosts. They represent a transitional step between marine free-living photosynthetic apicomplexans and intracellular notorious parasites of humans and livestock, such as *Plasmodium* and *Toxoplasma*.

Most of the existing species descriptions are based on morphological data alone and only in the past 15 years have gregarines entered the molecular age. To date there are still not many gene sequences available in public databases.

Diversity studies on micro-eukaryotes are often based on environmental SSU rDNA surveys. Many of the sequences acquired using this approach are closely related to lineages previously characterized at both morphological and molecular levels, making interpretation of these data relatively straightforward.

Some environmental SSU rDNA sequences have been shown to belong to gregarine lineages, even though they had previously been described as novel phyla. A few of these sequences originated from deep-sea environments, but no gregarine species has been described on a morphological or ultrastructural level from the deep-sea yet.

In 2016, I had the opportunity to join Prof Ursula Witte on a research cruise on the RRS Discovery to Goban Spur and Rockall Trough in the North-East Atlantic. Invertebrates were collected from box core samples taken in depths down to 3620 meters. We will present and discuss new data on gregarine apicomplexan parasites isolated from invertebrates living in these deep-sea habitats.
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