

INTRODUCTION

The Continuous Plankton Recorder: towards a global perspective

The Continuous Plankton Recorder (CPR) began its first routine deployment to collect plankton samples in the North Sea in 1931. The better part of a century after that event, the Recorder is used for sampling plankton widely in many oceans.

The CPR is designed to be towed behind ships of opportunity (such as commercial and passenger vessels) and to collect plankton samples along the ship's path. The samples provide information on the broad scale spatial distributions of larger hard-shelled phytoplankton and robust mesozooplankton organisms (Richardson *et al.*, 2006). Changes in these distributions provide indices for the biological health of the ocean including those required for fisheries and for assessment of climate change impacts. Today there are five regional CPR surveys. Studies of the North Atlantic and North Sea have been carried out by the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) based in Plymouth, UK. This survey has collected samples in an essentially unchanged fashion since the 1940s. The northwest Atlantic, including the Gulf of Maine, has been sampled since 1961 by the National Oceanic and Atmospheric Administration (NOAA) laboratory in Narragansett, USA. This has been managed by the National Marine Fisheries Service (NMFS) since 1974. A survey in the Southern Ocean has been operated for 19 years by the Australian Antarctic Division based in Hobart. The North Pacific has a more recent survey, a North Pacific Marine Science Organisation (PICES) project managed by SAHFOS, and is now in its eleventh year. The most recent study is one of the East Australian Current and the ocean between Tasmania and Antarctica. The AusCPR survey began in 2009.

At the 2009 Global Ocean Ecosystem Dynamics (GLOBEC) Open Science Meeting in Victoria, Canada, CPR users from many of the above surveys met to examine new results from each of the regional surveys

and to begin discussions on stronger links between surveys and how it may be possible to integrate their products. The themed section of papers in this issue showcases some of the recent results from North American researchers. The papers include studies spanning much of the oceanic food chain and studies on phytoplankton, zooplankton, whales and seabirds demonstrating the relevance of the CPR to whole ecosystem studies.

The contribution by Jossi (Jossi, 2010) provides a valuable reference for future global studies that might integrate data from several surveys. The comparability of the NOAA/NMFS and SAHFOS North Atlantic CPR surveys was studied, in particular the collection and processing of samples and identification of taxa. These are the two lengthiest of the sister surveys and cover adjacent regions. The NOAA/NMFS survey was set up with equipment and protocols from SAHFOS with the aim of fully comparable operations and data as would be desirable if CPRs are to be deployed in other regions. Few issues were found that would prevent data integration, although taxonomic consistency was raised as requiring a prefacing review if data were to be integrated from multiple surveys.

Four of the contributions focus on phytoplankton and zooplankton and their interactions with each other and local oceanography. Head and Pepin (Head and Pepin, 2010) update previous time series from the Newfoundland and Scotian shelf regions and adjacent deep water areas. Interdecadal variability in phytoplankton and zooplankton taxa was linked with changes in arctic freshwater outflow in the shelf regions and increasing temperatures in the deep water regions. The resulting increases in stratification have influenced the functioning of these ecosystems and the interactions of the lower trophic levels. They also provide a baseline of abundances of acid-sensitive taxa caught by the CPR, which show no signs as yet of being adversely impacted by declining pH.

Pepin and Head (Pepin and Head, 2010) compare phytoplankton indices from CPR and satellite data from regions of the north-west Atlantic over a 9-year period. While the two data sets did not correlate in all regions they were found to be complimentary in that the CPR provided taxonomic information while the satellite data provided better spatial and temporal coverage. Large interannual changes in spring blooms in shelf regions were detected by both data sources.

Pershing *et al.* (Pershing *et al.*, 2010) combine the western Atlantic plankton data collected by the NOAA/NMFS and SAHFOS-managed surveys described in Jossi (Jossi, 2010) and Head and Pepin (Head and Pepin, 2010) for the first time, covering an area from the mid-Atlantic Bight to the Labrador Sea. Changes in many of the sub-regions were strongly size structured, with small and medium copepods varying together and often positively related to indicators of phytoplankton abundance. While unable to provide a complete mechanistic solution, the study discovered anomalies of copepod abundances that propagated down the coast, an insight only possible because data from two surveys were combined. This is a tantalizing hint of what might be achieved with a more fully 'global' CPR survey.

Record *et al.* (Record *et al.*, 2010) focused on copepod taxonomic richness in the Gulf of Maine and its changes through time. Increases in richness during the year were linked with temperature such that highest diversity occurred in late summer but on an interannual scale the variability in taxonomic richness was linked to the phytoplankton biomass. Both temperature and phytoplankton biomass represent energy inputs into the system. Given the recent attention on biodiversity, this study highlights the need to understand changes in biodiversity of a region over time, something only possible with lengthy, consistently collected data sets.

Patrician and Kenney (Patrician and Kenney, 2010) use CPR data to help explain the absence of the North Atlantic Right Whale from Roseway Basin (SE of the Gulf of Maine) for a period of 7 years in the 1990s. The main whale prey in the region is late-stage copepodites of *Calanus finmarchicus*. Abundances were lowest during the period of the Right Whales absence and increased again as whales returned to forage. A low salinity/density event coincided with the reduced numbers of *C. finmarchicus*, indicating a change in circulation that may have influenced advection of zooplankton into the area.

The single contribution from the North Pacific (Sydeman *et al.*, 2010) matches observations of seabirds with simultaneous CPR sampling on a lengthy seasonal transect spanning the North Pacific. There were many relationships found between seabirds and some

zooplankton groups but no overall relationship between seabirds and total zooplankton density suggesting that the seabirds respond more to taxonomic-based groupings of zooplankton than they do to overall zooplankton density.

Each of the regional surveys has continually demonstrated their value to addressing issues in their local basins, as the examples present in this group of papers show. However, the CPR Survey community now recognizes the opportunities that could be achieved through a more holistic approach. The workshop convened at the GLOBEC 2009 Open Science meeting began to explore how it might address local issues within a broader geographical context and how global issues require a global approach. Achieving this requires a series of actions. These include increased communication between surveys, defining common quality controls, sharing and pooling of data, knowledge and data products are all necessary steps towards achieving a more integrated global approach to the study of plankton. This new scientific focus would bring together these surveys to examine how integration and intercomparison might enable the global ocean to be better studied. Many indicators of change, such as phenological shifts or changes in species distributions, are independent of the methods used to generate the data and would not prevent data integration. Intercalibration exercises should be undertaken where possible, however, to allow conversion factors to be generated.

Today CPR surveys cover many ocean basins, but a vast amount of the ocean remains unsampled. Some of these regions are particularly susceptible to global change processes and obviously need to be addressed. Equally important, the process of coordinating existing CPR studies that began at the Victoria 2009 meeting requires further discussion and commitment. Plans are currently underway to continue this in Plymouth, UK in autumn 2011.

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