A vision for a global Continuous Plankton Recorder (CPR) survey integrated with single site and other ocean observing programmes

Philip C. Reid et al. (23 colleagues and adding from Aus, Can, Ind, It, Fin, SA, UK, USA )

GLOBEC Victoria, Canada June 2009
The oceans have taken up 90% of the increase in global heat since 1961.

The oceans are changing rapidly.

The oceans are >71% of our world.
GLOBAL TRENDS IN OCEAN HEAT CONTENT

Redrawn from Domingues et al. 2008 Nature 453. Courtesy of the authors.
“We face major challenges in understanding how ocean biology responds to global change and possibly more importantly how life in the ocean and associated biogeochemical cycles contribute to global and especially climate change. “

Reid et al. White Paper OceanObs 2009
Crucial role of plankton in climate

1. indicators of change
   • Evidence for large changes in plankton linked to climate
     Biomass
     Distribution
     Phenology
     Non-native species
     Impacts on higher trophic levels and the benthos

2. Feedbacks
   • Phytoplankton produce oxygen and fix carbon
   • As organic carbon approximately 35% of PP sinks below the photic
     layer each year (11 gigatonnes)
   • Changes in relative strengths of PP and export by the biological
     pump a key component of climate change
   • Albedo, heat absorbance, gases of climatological significance

3. Prognosis
   • A change in the composition and volume of planktonic carbon
     fluxes may reduce the uptake of atmospheric CO$_2$ by the ocean
Potential impacts of acidification

1. Indicators of change
   - Limited field evidence for changes in plankton linked to acidification

2. Feedbacks
   - Calcification contributes CO2 to the atmosphere
   - Evidence for reduced calcification of pteropods, foraminifera
   - Evidence for effects on picoplankton in oligotrophic waters

3. Prognosis
   - Concern that many species of calcareous plankton will not be able to survive because of the speed of the change.
   - All plankton species may be affected
Challenges

MONITORING
What is there and how is it changing?
Trigger areas?

GAPS IN KNOWLEDGE
Abundance
Biodiversity
Chemical composition
Physiology
Light absorption
Functional groups
Role of microbial plankton
Food web structure
Aerosol production
Rates of uptake of \( \text{CO}_2 \)
Production of gases
Aquatic Sciences and Fisheries Abstracts: 13 Areas

Reid 2003 Guijon presentation, see also Perry et al. 2004 IJMS
Location of long-term deep water monitoring reference sites
Ocean Sites

http://www.oceansites.org/
Monthly Ocean Basin Scale Sampling

The only routinely deployed sampling system that provides biological data on these scales in the oceans is the Continuous Plankton Recorder (CPR).

1. SAHFOS
2. NMFS
3. SOCPR
4. AusCPR
5. NZCPR
6. IrishCPR

Different instruments/methods
Implementing a Global CPR programme
The Survey covers >70% of the Southern Ocean October to March.

Approximately 40-50 tows each year
>4,000 samples p.a.
5 n-mile resolution
(90 tows in 07/08 IPY)

140,760 nautical miles of data have been collected since 1991

This represents more than 28,150 samples, 200+ taxa + environmental data.
Southern Hemisphere
CPR samples 1991 to 2008 inclusive
Northern Hemisphere
All analysed CPR samples 1931 to 2008 inclusive
The Continuous Plankton Recorder
Standard monthly Continuous Plankton Recorder routes in the North Atlantic
Taxa counted in CPR survey

- Bacillariophyceae: 86
- Dinophyceae: 17
- Other phytoplankton: 16
- Chordata: 26
- Ciliophora: 10
- Copepoda: 2
- Echinodermata: 7
- Miscellaneous taxa: 90
- Mollusca: 163
- Malacostraceans: 7
- Other Arthropoda: 4
- Other zooplankton: 8

Richardson et al. 2006 PIO
North Sea Phytoplankton Colour

Step changes in regional sea systems: Regime shift

Reid et al. 1998, Nature 391, 546 (updated)
Northern Hemisphere Snow Cover Mar-Apr

March - April NH snow-covered area

10^6 km^2

Years

Brown 2000

IPCC 2005 WG I
Northerly movement of plankton and fish

Beaugrand et al. 2003. Science 296, 1692-1694

Warm temperate slope species

2005 *Euchaeta hebes, Clausocalanus, Ceratium hexacanthum*
Poleward freshening and increasing salinities in low latitudes in the 1990s

Curry et al. 2003 Nature 426
See also Rignoul GRL 4 2007
Regime Shift in the NW Atlantic:


There may not be more biomass available through the year (Mar-Sept), but in 2006-2007 more than half occurred in only one month.
Changes in the North Atlantic subpolar gyre post 1995

Northern Bering Sea, Canada Basin Change 1998

Grebmeier et al. 2006 Science 311
Pacific diatom in the Northwest Atlantic circa 1998

Reid et al. 2007. Global Change Biology 13
Polar ice extent in September 1996-2005

X Marks the North Pole

Reid et al. 2007. Global Change Biology
CPR survey
% frequency of Coelenterate tissue in the North Sea
1958 – 2007

43800 samples

Updated from Attrill et al. 2007
Collapse in abundance of the dinoflagellate *Ceratium* in the North Sea
Time series of summed calcareous plankton from the CPR survey 1946-2005

Pteropods
Bivalve larvae
Echinoderm lar.
Brachiopod lar.
CPR pipefish records

Kirby et al. 2006 Biology Letters 2

Common tern chick eating pipefish 2004

Index of the spatial distribution of C. finmarchicus based on egg production rate/SST

IPCC Scenario A2

Pierre Helaouët SAHFOS
AusCPR brochure

The Australian Continuous Plankton Recorder (AusCPR) survey

The AusCPR survey is a joint project of the Climate Adaptation Flagship and the Australian Antarctic Division to monitor plankton communities as a guide to the health of Australian oceans.

For further information:
CIBRO Marine and Atmospheric Research
Andy Armstrong
Phone: 08 8221 1100
Email: a.armstrong@unsw.edu.au
Australian Antarctic Division
Contact: Terry Williams
Phone: (02) 6247 7263
Email: terry.williams@ga.gov.au

The AusCPR survey is a passive drifter system that uses a self-contained recording device to collect images of marine organisms. It is deployed in the Southern Hemisphere and is designed to monitor the distribution and abundance of marine plankton communities.

The AusCPR survey is a valuable tool for understanding the impact of climate change on marine ecosystems. It provides valuable data on the distribution and abundance of marine organisms and is used to monitor changes in marine communities over time.

Drifting biosensors of change

The system records images of marine organisms as it drifts through the ocean. These images are used to track changes in marine communities and to monitor the impact of climate change on marine ecosystems.

The AusCPR survey is an important tool for understanding the impact of climate change on marine ecosystems. It provides valuable data on the distribution and abundance of marine organisms and is used to monitor changes in marine communities over time.
Vision

A Commonwealth of regional CPR surveys covering the whole world Integrated with OceanSITES
Integrated with other biological, physical and chemical monitoring Contributing to GOOS, GEO, IMBER
Standardisation of techniques where possible
Permanent archiving of samples
Characterising marine food webs versus carrying capacity

Define Biogeochemistry, Ecosystem and Socio regional areas
Regional hotspots?

Capacity building/training

Modelling

Need advice from modellers on their regional and global data requirements
A commonwealth of regional CPR surveys

Global coverage of regional surveys
Monthly sampling where possible
Identification to species where possible
Routine molecular analyses
Sampling for microbial plankton
Associated measurements (instrumentation)
As close to real-time as possible
Standardised database
A focus on calcareous plankton
Claire Davies
AusCPR plankton analyst who recently visited SAHFOS

Training crucial

“Two different approaches to CPR sampling: SOOP and from a research ship - Differences in ‘experience’ of SAHFOS in procedures. - Little things that are missed in the new AusCPR. We have developed our own little approaches. Standardization really important.”

“Don’t expect it to be easy”

Special role for SAHFOS in training and QC?
Conclusions / Recommendations

- Global ocean changing rapidly
- Warming, changes in hydrological cycle and acidification
- Planktonic ecosystems good indicators of change
- Plankton changing rapidly
- What is happening outside well sampled areas??
- Hysteresis, tipping points?
- Crucial importance of the plankton in climate
- Decadal to 100 year plus prognosis worrying
- Improved ecological understanding of the oceans a high priority

NOT TACKLING ISSUES WITH URGENCY AND RESOURCES REQUIRED

- Need an integrated global ocean biological/biogeochemical observing programme NOW
- Establish a global CPR survey