

Matters arising from the Expert Group on Continuous Plankton Recorder Research

Dr Graham Hosie and Prof. Mitsuo Fukuchi (Co-Chairs)

Introduction:

The EG on CPR Research was established at the SCAR XXX St Petersburg meeting 2008 and evolved out of the previous CPR Action Group. The purpose of the EG is to support and develop the SCAR Southern Ocean Continuous Plankton Recorder (SO-CPR) Survey, a collaborative project now involving 14 nations: Australia, Japan, Germany, New Zealand, UK, USA, Russia and the LA-CAML Consortium representing Brazil, Uruguay, Argentina, Chile, Peru, Ecuador and Venezuela. The Survey is primarily based at the Australian Antarctic Division. EG-CPR has four terms of reference listed below. The first ToR address the objectives of the SO-CPR Survey. ToR 2, 3 and 4 are specific to EG-CPR.

Membership:

Dr Graham Hosie (Co-Chair, AAD Australia)
Prof. Mitsuo Fukuchi (Co-Chair, NIPR Japan)
Dr Kunio Takahashi (NIPR Japan)
Prof. Dr Uli Bathmann (AWI Germany)
Dr Don Robertson (NIWA New Zealand)
Dr Catherine Stevens (NIWA New Zealand)
Dr Peter Ward (BAS United Kingdom)
Dr Brian Hunt (UBC Canada)
Dr Manuela Bassoi (UFRJ Brazil)
Prof. Peter Burkill (Director SAHFOS)
Dr Andrew Constable (CCAMLR)
Dr Bruno Danis (SCAR-MarBIN)

Drs Stevens and Bassoi have been added to the group since St Petersburg. Dr Stevens manages the CPR programme in New Zealand. Dr Bassoi is the principal LA-CAML contact.

Summary of activities in relation to the Terms of Reference :

1. Provide guidance to the SCAR Southern Ocean CPR Survey in order to meet the survey objectives.
 - a. Map the biodiversity and distribution of plankton, including euphausiid (krill) life stages, in the Southern Ocean.

The new Southern Ocean Zooplankton Atlas will be published in the 10th SCAR Biology Symposium Special Volume. Biogeographic analysis of the CPR data is continuing as the main zooplankton contribution to the CAML Biogeographic Synthesis Atlas for the Southern Ocean. Biogeographic modelling have identified persistent hotspots which coincide with predator distribution patterns.
 - b. Use the sensitivity of plankton to environmental change as early warning indicators of the health of Southern Ocean, by studying spatial-temporal variation in plankton patterns.

We are still analysing the apparent shift from krill to mesozooplankton dominance observed in the sea-ice zone of eastern Antarctica. The main environmental factors appears to be seawater temperature, annual sea-ice melt and chlorophyll *a*. The large blooms of pelagic foraminiferans observed in 2005 may also be a result of elevated chlorophyll *a* (Takahashi et al, 2010). Numbers seem to have returned to the long term average, but we are still observing localised large blooms south of Tasmania and New Zealand. Results will be shown during the 2010 SCAR-OSC (Buenos Aires), session #30 of “Continuous Plankton Recording (CPR)” under theme III of “Ecosystem Health”. The two EG-CPR co-chairs are conveners of this session.
 - c. Serve as reference on the general status of the Southern Ocean for other monitoring programs.

The SO-CPR Survey is a core biological component SOOS. The draft SOOS Implementation plan has recommended that the SO-CPR Survey be maintained and expanded and in particular fill gaps in the Pacific and Atlantic sectors and in winter. A member of CCAMLR continues to serve on the EG-CPR.

2. Develop and maintain the SO-CPR Database and to improve access for users.
The dataset currently holds ~25,800 records at 5 nmile resolution for about 230 species and krill developmental stages plus environmental data up to the end of the 2007/08 season (March 2008). This represents approximately 70% of the Southern Ocean. All 2008/09 samples are complete and data are being logged into the database adding another 2,474 records. The 2009/10 samples when processed will extend the data base to ~30,000 records. Data are held at the AADC and accessible through SCAR-MarBIN. It continues to be one of the largest data sets in MarBIN and consistently receives high download requests.

3. Expand and enhance the SO-CPR Survey to include more ships and repeat transects around Antarctica.
51 tows were conducted during 2008/09 from four vessels and 45 tows in 2009/10 from five vessels. This included tows in both years across the Drake Passage from the Brazilian vessel *Ary Rongel* as part of LA-CAML and between New Zealand and the Ross Sea from a commercial fishing vessel. The Drake Passage and Ross Sea tows will be regular annual surveys which will provide valuable new data in two important fishing regions. Future tows will also be conducted from Chilean vessels.

4. Provide appropriate advice on CPR methodology, data and results to SCAR and to the ATS.
A number of request for data have been received and duly delivered. All requests for advice on methodology have been answered. In fact, we have conducted a number of training courses at the AAD in Hobart, in New Zealand, Japan and on board ships for new and existing SO-CPR members. In November 2009, we conducted a training course in Rio de Janeiro for 14 people from six South American nations.

Meetings:

EG-CPR primarily meets electronically, specifically by email correspondence. During the last two years the co-chairs have met on a regular basis in Australia and Japan to discuss developments in the SO-CPR Survey. Dr Hosie has also met with most other members, except Drs Bathmann, Robertson and Ward, at least once in the last two years. Travel has been supported by the AAD, NIPR, CAML, LA-CAML, and SAHFOS. Dr Hosie continues to be a trustee of the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) Council. Strong links have been established with the northern hemisphere CPR surveys and we have been discussing with SAHFOS the formation of a formal commonwealth of CPR surveys and the development of a global CPR database of benefit to all users.

A proper EG-CPR business meeting will not be possible during SCAR XXXI, but we will need to meet at some stage soon to discuss a number of matters which include:

- review progress with current work, plan and set a programme for the next stage of analysis with a particularly aim of publishing relevant analyses in time for IPCC assessment,
- coordinate sampling programme for the next few years,
- discuss integration of research and data with other CPR surveys for a global CPR survey and database,
- discuss quality assurance and control to ensure maintenance of best quality data. All personnel involved with SO-CPR operations and analysis are trained by the AAD, except UK personnel who are trained at SAHFOS. However, we need to ensure that we are still maintaining the right methodology and correct species identifications between laboratories.

Prof. Fukuchi and Dr Hosie are discussing options for an EG-CPR meeting and QA/QC workshop to ensure that standards for CPR operations, sample processing and identification are being maintained.

CPR Representation at International Meetings:

In the last two years, the SO-CPR data were used or presented at the following workshops:

- The CCAMLR-IWC Workshop, Hobart August 2008, for the purpose of developing ecosystem models for management purposes.
- The Southern Ocean Sentinel Workshop, Hobart April 2009, for developing a monitoring program to look at the impact of climate change on marine biodiversity.
- The Polar Synthesis Macroscopic Workshop, Villefranche-sur-mer May 2009.

- PICES CPR Workshop, Yokohama September 2009.
- PelaSphere Global CPR Planning Workshop, Plymouth November 2009.
- CAML & SCAR-MarBIN Biogeographic Synthesis Workshop, Villefranche-sur-mer May 2010, with the CPR data being the main zooplankton contribution to a new Biogeographic Synthesis atlas of the Southern Ocean.
- The CPR Biogeographic Synthesis Workshop, Wellington June 2010, a follow up workshop to complete analyses started by the Villefranche workshop to be used as a showcase for other biogeographic analyses.

Training workshops:

In support of the New Zealand and LA-CAML tows the following training workshops were conducted:

- CPR methodology and maintenance training workshop, at the AAD November 2008, for Ms Karen Robinson (NZ plankton analyst) and Dr Manuela Bassoi (Brazil) LA-CAML CPR coordinator. The workshop was supported by CAML.
- Sample processing and data handling workshop, at the AAD March 2009, for Ms Robinson – supported by MFish/NIWA .
- CPR methodology and maintenance training workshop, in Rio de Janeiro in November 2009, to train 14 people from Brazil, Argentina, Chile, Peru, Ecuador and Venezuela. This workshop was supported by Brazilian National Science and Technology Institute on Antarctic Environmental Research (*Instituto Nacional de Ciência e Tecnologia de Pesquisas Ambientais e Antártica*, INCT–APA), BioMAntar, Brazilian Science and Technology Council (CNPq), LA-CAML and INACH

Survey Field Seasons:

SO-CPR had relatively quiet sampling seasons following the extremely busy 2007/08 season with 51 tows completed in 2008/09 from four ships and 45 tows in 2009/10 from five ships. Nonetheless, the 2008/09 and 2009/10 seasons were notable for successful tows conducted between New Zealand and the Ross Sea from a commercial toothfish vessel, and across Drake Passage by LA-CAML. The New Zealand tows are part of the collaboration with New Zealand Ministry of Fisheries and the National Institute of Water and Atmospheric Research (NIWA). A five year grant from MFish are supporting the tows from the fishing vessel, which greatly improves the monitoring of plankton in the western Pacific region. The South American CAML consortium LA-CAML officially joined the SO-CPR Survey with successful tows across Drake Passage from a Brazilian ship and a test tow from a Chilean vessel. This is an important region in relation to the krill fishery and also the proximity of the rapidly warming western Antarctic Peninsula. We will be conducting tows annually from both Brazilian and Chilean vessels, supplemented by tows by the US-AMLR programme and tows in the Scotia Arc area by the UK. A CPR is kept at the Chilean Antarctic Institute (INACH) in Punta Arenas, under the supervision of Dr Cristian Rodrigo, and is shared amongst the LA-CAML partners.

Expansion of the Survey:

As noted in the previous report at SCAR XXX, the AAD and CSIRO have collaborated to establish the Australian Continuous Plankton Recorder Survey (AusCPR) as a component of IMOS. AusCPR received substantial financial support to establish a regular route between Brisbane and Melbourne and to support the SO-CPR Survey, notably the counting of phytoplankton on routes south of Hobart. AusCPR has received additional support until June 2013 which will provide more routes around Australia, but most importantly support a series of routes that will extend from Cape York to Hobart and linking with the SO-CPR tows south of Hobart to produce a unique latitudinal gradient of plankton monitoring from the tropics to the Antarctic coast.

Similarly, the collaboration with MFish New Zealand and NIWA has led to the establishment of a domestic CPR programme with tows across the Chatham Rise, one of New Zealand's important fishing grounds. Japan is also developing local CPR surveys with advice for SO-CPR via Prof. Fukuchi. We have also been encouraging development of similar domestic surveys around South America.

Data collected by domestic surveys are maintained by national institutes and are not stored in the SO-CPR database. Only data collected in the Southern Ocean south of Africa, Australia, New Zealand and South America are held in the SO-CPR database. However, we hope that all data will contribute to a proposed global CPR database held at SAHFOS. This will place the Southern Ocean data and observations in a global context.

Dataset and Access:

The data set currently holds approximately 25,800 verified records at 5 nautical mile resolution from 1991 to March 2008 for about 230 zooplankton species and developmental stages of euphausiids. Records are coupled with environmental data (sea temperature, salinity, fluorometry and PAR). Coverage extends around most of Antarctic. Coverage is poor in the Pacific Sector (Amundsen and Bellingshausen Seas), Weddell Sea and south of Africa. Most of the data comes from the September to April period with occasional samples collected in winter.

All samples collected during the 2008/09 Antarctic season have been processed. Data are currently being verified and loaded in the data base. This should be complete by the end of August 2010. The 2009/10 samples are currently being processed and should be completed by the end of 2010, ready to start the processing of the first set of samples from the coming 2010/11 season. There has been a delay in processing the 2008-09 data and 2009/10 samples because of the large number of samples collected during 2007/08 in support of CAML. This was planned and the processing of samples and data entry are proceeding as expected. The 2008/09 and 2009/2010 data will expand the data set to approximately 30,000 records. In addition, SO-CPR has received support from the Australian Integrated Marine Observing System (IMOS) as part of the AAD's involvement with IMOS. This has provided an extra team member to count phytoplankton and protozoa, in addition to zooplankton, on CPR tows conducted south of Hobart as from 2007. So far, 74 species of phytoplankton and protozoa have been identified and counted on 818 samples.

The data are currently stored at the Australian Antarctic Data Centre and in SCAR-MarBIN, and also distributed to OBIS the data portal for the Census of Marine Life. The Australian component of the data is submitted to the IMOS eMII Marine Information data portal. The SO-CPR data continues to be the largest data set at SCAR-MarBIN and the most widely used on an annual basis. Copies of the data are also held by SO-CPR partners and is freely available from the AADC, SCAR-MarBIN or upon request to SO-CPR. The SO-CPR website is located at <http://data.aad.gov.au/aadc/cpr/index.cfm>.

Data Analyses and Outputs:

Major and data analyses and outputs for the last two years:

- The new Southern Ocean Zooplankton Atlas has been completed and will be published in the Xth SCAR Biology Symposium Special Volume in *Polar Science* (McLeod et al, 2010). The Atlas presents distribution maps of the 50 most abundant species in the CPR dataset, and focuses on the region south and west of Australia (60 to 160°E) which has the highest concentration of samples.
- We continued working with the NIWA Wellington Ecosystem Modelling group to assess Boosted Regression Trees modelling as a method to predict spatial and seasonal distributions of plankton. We focused on adult *Oithona similis* as an example, this being the most abundant species in the CPR samples. This work originally requested as a part of the 2007 CCAMLR Bioregionalisation Workshop. We were able to predict likely distribution and abundances of *Oithona* and identify the environmental variables that best predict the distribution; time of season or month, nutrients phosphate and silicate, sea-ice cover, sea surface temperature, and chlorophyll *a*. Persistent hotspots of abundance were identified which match similar predator distributions. Results were delivered to CCAMLR's WG-EMM and Scientific Committee (2008) and recently published (Pinkerton et al., 2010). The next step is to complete similar predictive analyses of each of the abundant taxa and developmental stages of krill.
- We have started a parallel exercise with NIWA of mapping whole zooplankton assemblages as the principal zooplankton contribution for the new CAML Biogeographic Synthesis Atlas of

the Southern Ocean. Generalised Dissimilarity Modelling (GDM) is being used to produce the synthesised maps of zooplankton assemblages, a better method than BRT for the analysis of species assemblages. As with the BRT approach we are able to determine the principal environmental variables predicting the plankton patterns, i.e. SST, chlorophyll, sea-ice and bathymetry. The next step for both the BRT and GDM modelling will be to apply the IPCC predictive layers to determine the potential changes in zooplankton due to climate change.

- We have investigated the use of network analysis to study species relationships and to help visualise patterns in the CPR zooplankton data (Raymond and Hosie, 2009). The results showed zooplankton community structures that are in good agreement with previously published results. Variations in community structure could be related to the temporal and spatial pattern of sampling, as well as to physical environmental factors such as sea ice cover.
- CPR sampling during CAML in 2007/08 provided a near-circumpolar survey. Preliminary analysis of the data showed distinct north-south zonation of zooplankton assemblages across the Antarctic Circumpolar Current, as per previous analyses, but the zooplankton species composition remained relatively consistent within bands of the ACC around Antarctica suggesting there is just one community.
- A comparison of CPR tows across Drake Passage in 2000 with Sir Alister Hardy's original 1927 CPR tows in the same region has shown a change in species composition from large copepods and chaetognaths to smaller copepods and other species (Takahashi et al., 2010).
- We are still analysing the apparent shift from krill to mesozooplankton dominance observed in the sea-ice zone off eastern Antarctica. The main environmental factors appears to be a combination of seawater temperature, annual sea-ice melt and chlorophyll *a*. The likely current scenario is continued warming of the Southern Ocean and sea-ice retreat will favour the smaller zooplankton, which are more typical of the Permanent Open Ocean Zone. Indications are that increased chlorophyll production, especially if due to smaller phytoplankton species will also favour the smaller zooplankton.
- We previously reported that large blooms of pelagic foraminiferans occurred in 2005 in both the SIZ and POOZ. Further analysis showed that this bloom suppressed abundances of other dominant species and the event may also be a result of elevated chlorophyll *a* (Takahashi et al, in press). The abundance of foraminiferans have returned to low numbers in subsequent years but occasional localised blooms have still been recorded south of Tasmania and south of New Zealand. The consequences of these large blooms on the rest of the ecosystem remains unknown but similar increases in foraminiferan numbers have been reported in The North Atlantic. It is yet to be established if these foraminiferan blooms are natural occurrences or a response to changing oceanic conditions.

Future work:

The EG-CPR schedule for the next two years to SCAR XXXII:

- Conduct a standards workshop to ensure that CPR operations and processing standards are being maintained.
- Develop a formal exchange programme between the SO-CPR laboratories and with other CPR laboratories to maintain those standards and to develop skills and collaboration.
- Work with SAHFOS to establish a Commonwealth of CPR surveys and associated global CPR database or network.
- In collaboration with SAHFOS and other CPR surveys, assess the global status of calcareous zooplankton, i.e. pteropods and foraminiferans.
- Review sampling schedule for the next two years, possibly five, with a focus on filling geographic gaps, e.g. Weddell Sea, Pacific sector, and temporal gaps, i.e. winter voyages.

Planned schedule of activities specific to the SO-CPR itself.

- Complete the biogeographic analysis of species assemblages for the CAML Biogeographic Synthesis Atlas.
- Conduct additional BRT modelling of other abundant species, including krill adults and larvae, similar to *Oithona similis* analysis.

- Include IPCC prediction layers in GDM and BRT models to determine possible effects of climate change on plankton distribution, abundances and composition.
- Compare CPR distribution patterns with predator patterns.
- Attempt to compare CPR distribution patterns with acoustic data.
- Complete analysis of SIZ species changes in relation to temperature, sea-ice and chlorophyll.

Budget:

Allocated funds of 2010 have not been used so far. The funds (US\$7000) were being kept to support an EG-CPR meeting at SCAR XXXI, which will not be happening. Instead, we plan to redirect the funds to support the standards workshop. We are still in the process on defining the venue, time and key participants from Japan, Australia, New Zealand, United Kingdom and South America). At this stage it is most likely to be in Tokyo, at NIPR's new laboratories, in November 2010, with 9 participants. For 2011 and 2012 we request \$4,000 in each year to support travel to meetings were necessary but more to support the exchange program between CPR laboratories for staff to improve their skills, maintain standards and collaboration.

Publications Using CPR Data 2008-2010:

- Gutt, J., Hosie, G., and Stoddart, M. (In Press) Chapter 11. Marine Life in the Antarctic. In (A. McIntyre ed) *Marine Life: Diversity, Abundance and Distribution*. Wiley-Blackwell.
- Hunt, B. P. V., Pakhomov, E. A., Hosie, G. W., Siegel, V., Ward, P. Bernard, K. (2008) Pteropods in Southern Ocean ecosystems. *Progress in Oceanography* **78**, 193-221
- Hunt, B.P.V. and Hosie, G.W. (2008) Southern Ocean biogeography and taxonomic resolution: what's in the name? *Marine Biology* **155**, 191-203
- McLeod, D.J., Hosie, G.W., Kitchener, J.A., Takahashi, K.T. and Hunt, B.P.V. (In Press) *Zooplankton Atlas of the Southern Ocean: The Southern Ocean Continuous Plankton Recorder Survey (1991-2008)* Polar Science (Special Volume)
doi:10.1016/j.polar.2010.03.004
- Pinkerton, M., Smith, A.N., Raymond, B., HOSIE, G.W., Sharp, B., Leathwick, J.R. and Bradford-Grieve, J.M. (2010) Spatial and seasonal distribution of adult *Oithona similis* in the Southern Ocean: predictions using boosted regression trees. *Deep-Sea Research I* **57**, 469–485
- Pinkerton, M.H., Smith, A.N.H., Raymond, B., Hosie, G.W., Sharp, B. (2008) Extrapolating Continuous Plankton Recorder Data through the Southern Ocean using Boosted Regression Trees *CCAMLR-WG-SAM 2008* 28pp
- Raymond, B. and Hosie, G. (2009) Network-based exploration and visualisation of ecological data. *Ecological Modelling*. 220: 673-683
- Raymond, B., Shaffer, S.A., Sokolov, S., Woehler, E.J., Costa, D.P., Einoder, L., Hindell, M., Hosie, G., Pinkerton, M., Sagar, P.M., Scott, D., Smith, A., Thompson, D.R., Vertigan, C., and Weimerskirch, H. (2010) Shearwater Foraging in the Southern Ocean: The Roles of Prey Availability and Winds. *PLoS ONE* **5** (6), 1-14
- Takahashi, K., Hosie, G.W., Kitchener, J.A., McLeod, D.J., Odate, T., and Fukuchi, M. (In press) Comparison of zooplankton distribution patterns between four seasons in the Indian Ocean sector of the Southern Ocean. *Polar Science (Special Volume)*
doi:10.1016/j.polar.2010.05.002
- Takahashi, K.T., Hosie, G.W. and Fukuchi, M. (2010) Monitoring observation of zooplankton in 2004-2009 Continuous Plankton Recorder survey. *JARE Data Report* **39**, 1-31
- Takahashi, K.T., Kawaguchi, S., Hosie, G.W., Toda, T., Naganobu, M. and Fukuchi, M. (2010) Surface zooplankton distribution in the Drake Passage recorded by Continuous Plankton Recorder (CPR) in late austral summer of 2000. *Polar Science* **3**, 235-245

Data and results were also presented at the following symposia and conferences:

- SCAR XXX 3rd Open Science Conference, St Petersburg July 2008.
- IV Latin American Symposium and VII Chilean Meeting On Antarctic Research, Valparaiso September 2008, as a key note.

- The Census of Antarctic Marine Life Symposium, Genoa May 2009.
- Xth SCAR Biology Symposium, Sapporo July 2009, in a dedicated CPR session.
- Symposium on the Antarctic-South American Interactions in the Marine Environment, Rio de Janeiro November 2009.
- SCAR XXXI 4th Open Science Conference, Buenos Aires July 2010, two key note and four other presentations scheduled in a dedicated CPR session.