—シンポジウム/会合報告—
Symposium/Meeting Report

Report on the Southern Ocean Continuous Plankton Recorder (SO-CPR) Standards Workshop: SCAR Expert Group on CPR Research

Kunio T. Takahashi[1, 2 *], Graham W. Hosie[3], John A. Kitchener[3], David J. McLeod[3, 4], Catherine Stevens[5], Karen Robinson[5], Tanya Jonas[6] and Mitsuo Fukuchi[1, 2]

南極研究科学委員会の連続プランクトン採集器専門家グループワークショップ報告

高橋邦夫[1, 2 *]・Graham W. Hosie[3]・John A. Kitchener[3]・David J. McLeod[3, 4]
Catherine Stevens[5]・Karen Robinson[5]・Tanya Jonas[6]・福地光男[1, 2]

(Received June 17, 2011; Accepted August 15, 2011)

要旨： 2010 年 11 月 22−26 日に国立極地研究所にて「南極研究科学委員会（以下 SCAR）連続プランクトン採集器（以下 CPR）専門家グループワークショップ」を開催した．4 カ国から 12 名が参加し，南大洋 CPR 観測実務担当者の間で，観測データの品質管理，種同定やデータ分析手法の再確認，及び今後の活動についての詳細な討議を行った．前半は文献資料及び顕微鏡観察を通して，動物プランクトンの分類群ごとに種同定の情報交換及び具体的な分類カテゴリーの統一を図った．まとめられた種同定基準を用いて新たにマニュアルを作成することとなった．後半はデータ分析手法とデータマネージメント，さらには将来的な観測計画を確認した．今後，定期的にワークショップを開催し，各国間で統一された試料処理及びデータ管理を維持していくことで合意した．

Abstract: “Southern Ocean Continuous Plankton Recorder (SO-CPR) Standards Workshop: SCAR Expert Group on CPR Research” was held at the National Institute of Polar Research (NIPR) on 22−26 November 2011. Twelve participants from four countries attended. The purposes of the workshop were to ensure that consistent and high standards of species identification, methodology, and data quality were being maintained

[1] 情報・システム研究機構国立極地研究所．National Institute of Polar Research, Research Organization of Information and Systems, Midoricho 10−3, Tachikawa, Tokyo 190-8518.
[2] 総合研究大学院大学複合科学研究科極域科学専攻． Department of Polar Science, School of Multidisciplinary Sciences, The Graduate University for Advanced Studies (SOKENDAI), Midoricho 10−3, Tachikawa, Tokyo 190-8518.
[3] オーストラリア南極局． Australian Antarctic Division, 203 Channel Highway, Kingston, Tasmania 7050, Australia.
[4] オーストラリア連邦科学産業機構．Intergrated Marine Observing System- AusCPR Survey, CSIRO Marine and Atmospheric Research. Dutton Park, Qld 4102, Australia.
[5] ニュージーランド国立水圏・大気圏研究所． National Institute of Water and Atmospheric Research Ltd., Private Bag 14-901, Kilbirnie, Wellington, New Zealand.
[6] アリスター・ハーディ卿海洋科学財団． Sir Alister Hardy Foundation for Ocean Science, Citadel Hill, Plymouth PL1 2PB, UK.
*Corresponding author. E-mail: takahashi.kunio@nipr.ac.jp

南極資料，Vol. 55, No.3, 277−284, 2011
Nankyoku Shiryô (Antarctic Record), 55, No.3, 277−284,

amongst all participants and laboratories in the SO-CPR survey, and to discuss future contributions of the SO-CPR program to a global CPR network. The first three and a half days of the workshop were focused on assessing the accuracy and consistency of species identifications. We concluded that our species identifications and procedures are accurate and uniform, and that the SO-CPR database is of the highest possible standard. Certain taxonomic criteria developed at the workshop will be described in a new laboratory procedures manual. Four major gaps in the database (spatial, temporal, taxonomic, and data analysis gaps) were identified and discussed. Participants concurred that there should be more regular workshops to ensure that the high standards of the SO-CPR program are maintained.

1. Background

The principal goal of the SCAR Southern Ocean Continuous Plankton Recorder (SO-CPR) survey is the acquisition of a high quality dataset for mapping and monitoring changes in biodiversity in response to climate change, supported by the development of models at seasonal, inter-annual, decadal, and spatially local and global scales. The quality of the data is dependent on maintaining high standards of uniformity and consistency in the acquisition of data, especially in relation to taxonomic accuracy and resolution.

The SO-CPR program, started in 1991, was developed through a strong initiative of Dr. Graham Hosie at the Australian Antarctic Division (AAD) (Hosie *et al.* 2003). Japan joined the SO-CPR survey in 1999, and the CPR survey is one of the routine monitoring programs of the Japanese Antarctic Research Expedition (JARE) (Takahashi *et al.* 2006, 2009). Several countries now participate in the SO-CPR survey, with analyses of samples conducted at the AAD (Australia), NIPR (Japan), National Institute of Water and Atmospheric Research (NIWA, New Zealand), and Sir Alister Hardy Foundation for Ocean Science (SAHFOS, UK) laboratories. All personnel in the SO-CPR program are trained in Southern Ocean taxonomy by AAD personnel, using a single method and standard. However, it should be noted that SAHFOS staff, recognized experts in plankton taxonomy, are mainly self-taught in Antarctic species recognition on the basis of their analyses of Stanley−South Georgia−South Orkney assemblages. While the AAD endeavor to maintain consistent and uniform standards through opportunistic visits to all research laboratories, the Tokyo meeting provided the first opportunity to bring together all key personnel to exchange our knowledge and expertise in an intensive hands-on workshop, to ensure that our identifications and methodologies maintain consistent high-quality taxonomic results.

2. Purpose

The primary aim of the workshop was to ensure that all research personnel and laboratories involved in the SO-CPR survey are maintaining consistent high standards of species identification, methodology, and data quality. This quality control was considered necessary to conduct quality assured analyses of climate change effects on plankton. A secondary aim of the workshop was to discuss future SO-CPR operations, and the contribution of the survey to a global CPR network.

3. Workshop agenda and participants

Twelve participants from four countries attended the workshop (Table 1), including CPR analysts from each country and students from the Tokyo University of Marine Science and Technology (TUMSAT). The agenda for the workshop is in Table 2.

Table 1. List of workshop participants.

Name	Position	Affiliation	Country
Graham Hosie	PRS Zoopankton, Director SO-CPR	Australian Antarctic Division	Australia
John Kitchener	CPR Senior Analyst	Australian Antarctic Division	Australia
David McLeod	CPR Analyst	Integrated Marin Observing System - AusCPR Survey, CSIRO Marine and Atmospheric Research	Australia
Catherine Stevens	Post-Doctor, CPR Manager	National Institute of Water and Atmospheric Resarch	New Zealand
Karen Robinson	Plankton Analyst	National Institute of Water and Atmospheric Resarch	New Zealand
Tanya Jonas	CPR Senior Analyst	Sir Alister Hardy Foundation for Ocean Science	UK
Mitsuo Fukuchi	Professor, Co-Chair SCAR EG-CPR	National Institute of Polar Research	Japan
Kunio Takahashi	Assistant Professor, CPR Analyst	National Institute of Polar Research	Japan
Atsushi Ono	Post-Doctor	Tokyo University of Marine Science and Technology	Japan
Ryoji Toda	Student	Tokyo University of Marine Science and Technology	Japan
Aiko Tachibana	Student	Tokyo University of Marine Science and Technology	Japan
Motoha Ojima	Student	Tokyo University of Marine Science and Technology	Japan

Table 2. Agenda of the "SO-CPR Standards Workshop".

SO-CPR standards workshop "SCAR EG-CPR Research" Agenda	
22 Nov.	
10:00–11:00	Opening and welcome by Dr. Hosie & Prof. Fukuchi Purpose of workshop Outline of workshop schedule
11:00–12:00	Excursion within a NIPR-gain bearings and view facilities
13:00–17:00	Taxonomic group 1- Copepods -turotial and laboratory work, checking specimens
23 Nov.	
10:00–12:00	Taxonomic group 1- Copepods continued
13:00–	Excursion
24 Nov.	
10:00–12:00	Taxonomic group 2-Euphausiids -adults and developmental stages -turotial and laboratory work, checking specimens
13:00–17:00	Taxonomic group 3- Other crustaceans
25 Nov.	
10:00–12:00	Taxonomic group 4- Other taxa (the hard groups) -polychaetes, chaetognaths, pteropods, others
13:00–17:00	Review and standardization of laboratory methods Review of identification and counting rules -zooplankton -phytoplankton counting Collation oftaxonomic gudes, notes Metadata records Data quality Gap analyisis Standardization of at seas procedures

Table 2. Continued.

26 Nov.	
10:00−12:00	Future directions -short term, long term, field work and analyses -exchange programme between laboratories -incorporation of SO-CPR in globalplankton monitoring programme -80th Anniversary CPR Symposium Plymuth September 2011 -any other business
13:00−17:00	Wrap up meeting -future workshops -workshop report

4. Workshop summary

4.1. Taxonomy

The first three-and-a-half days of the workshop focused on assessing the accuracy and consistency of species identifications, of species currently registered in the SO-CPR database. The taxa were separated into four main groups:

- Copepods-the most taxonomically diverse and abundant group in the CPR database
- Euphausiids—the second most abundant and important group
- Other crustaceans (amphipods, decapods, ostracods, mysids)
- Other taxa (foraminiferans, pteropods, fish, cephalopods, larvaceans, medusa, salps, chaetognaths, polychaetes) — most of which are difficult to identify because they are easily damaged.

Each of the above groups was examined in tutorials and laboratory sessions (Fig. 1). A combination of taxonomic guides, personal notes, diagrams, photographs, and fixed specimens were used to check identifications. Identification rules and counting points were agreed upon for each taxon. Identifications are made to the lowest taxonomic level possible. According to AAD standards, copepods and euphausiids are to be identified to the species level whenever possible, or to the genus level or coarser if the specimen is damaged. For the euphausiid species *Euphausia superba* and *Thysanoessa macrura*, larval stages are to be identified to the three calyptopis and six furcilia stages to assess any phenological changes. The taxonomic rules will be further described in a new laboratory procedures manual.

Fig. 1. Species identifications during a tutorial (left) and laboratory sessions (right).

4.2. Collation of taxonomic information

The workshop agreed that we should establish an FTP site on an accessible server where participants can collate, archive, and exchange taxonomic notes, guides, drawings and photographs, as well as other information that will assist analysts and managers.

4.3. Laboratory procedures

Two laboratory procedures were reviewed: methods for Southern Ocean zooplankton, and the SAHFOS phytoplankton counting method. The review included methods for preparing silk (assessing the removal of formalin vs. the potential loss of phytoplankton), methods for sub-sampling high abundance samples, procedures for cutting silks (head rule) and identifying and dealing with moults, dead organisms (dead prior to capture), and juveniles from brood pouches, and a comparison of SAHFOS (on silk) and Southern Ocean (off silk) counting. The necessity for sub-sampling has been relatively rare to date, but when required, the Motoda Box Splitter was deemed the easiest and most efficient sub-sampler for splitting (Motoda, 1959). A separate assessment process is in progress for comparing different counting methods; however, the workshop agreed that, while direct numerical comparisons may be difficult, comparisons of patterns of data derived by different counting methods should still be possible. Micro-plastics are an increasing component of SAHFOS samples. It is not clear if these are present in the Southern Ocean or not, but the workshop agreed to keep notes of any observations.

4.4. Metadata records and data quality

We discussed the importance of maintaining detailed metadata information, which describes the data, when, where, and how the data were collected, and any variations in procedures. The SO-CPR metadata records of the Australian Antarctic Data Centre and the SAHFOS were discussed as examples. We also discussed methods for checking data quality when recording data and for logging into the database; we were satisfied that the quality control checks currently in place were sufficient to minimize errors. We identified one important data quality issue related to the reliability of GPS data generated by the New Zealand vessel operating between the Timaru and Ross seas. The inconsistent recording of position data, coupled with substantial gaps in the data, make it extremely difficult to calculate the cutting lengths of CPR samples, and subsequently to assign a time and position stamp on each sample. The problem may have been caused by a fault within the GPS hardware, as data from the previous year were not subject to these problems. We agreed that it is best to record at least one-hourly positions and course changes in the onboard CPR log to use as a backup in the event of auto-logged GPS system failures.

4.5. Gap analysis

Four major gaps in the dataset were identified and discussed: spatial gaps, temporal gaps, taxonomic gaps, and data analysis gaps.

Spatial gaps–Major gaps in the dataset occur in the mid-latitudinal area between South Africa and western Australia (southern Indian Ocean), the Weddell Sea, and the Amundsen Sea, and Bellingshausen Seas in the Pacific sector (Fig. 2). These spatial gaps are primarily due to the paucity of shipping vessels (e.g., in the Indian Ocean, Pacific

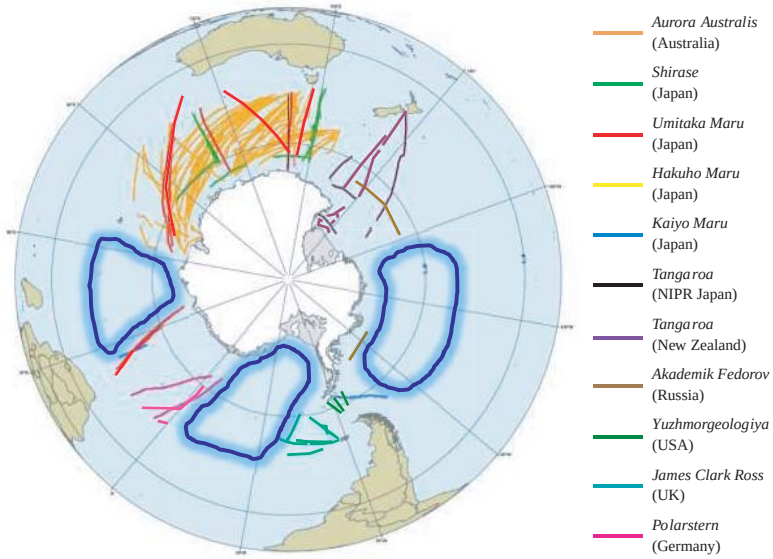

Fig. 2. Locations of SO-CPR tows from 1991 to the present. The different colors refer to the different vessels used. There are distinct gaps (identified by blue circles) where towing is either poor or non-existent because of the lack of shipping vessels.

sector), or to the fact that ships in the region are engaged in research activities (e.g., CTD) involving high sampling resolutions which effectively preclude CPR work (e.g., in the Weddell Sea). To help remedy this situation, a Russian group has agreed to participate in our program and to traverse the Pacific sector every two years; this region is noted for its high rates of sea-ice retreat. Korean and Chinese groups may also assist in this region. We need to find other vessels that can provide towing opportunities in all the gap areas.

Temporal gaps – Information on winter distributions and abundances of taxa is limited because of the lack of vessels operating in all regions between April and August. The CPR dataset contains data from only a few winter voyages. It was noted that the planned CPR tows from South Georgia will be extremely valuable for providing almost year-round data on plankton distributions, albeit at two-month intervals. The region off of South George is an area of concentrated krill fishing, and we should therefore be alert to any potential winter voyages in this area that could tow a CPR.

Taxonomic gaps – An obvious taxonomic gap in the CPR dataset is represented by the paucity of phytoplankton counts other than those collected by SAHFOS in the Scotia Arc, and from the tows south of Australia supported by the Australian Integrated Marine Observing System (IMOS) program. While it has always been desirable to include phytoplankton counts along with zooplankton counts on SO-CPR routes, this can only be achieved either by the commitment of more resources or by reducing the number of routes. We should be vigilant in the search for potential funding sources to support phytoplankton counts. The SO-CPR surveys use the Phytoplankton Color Index (PCI) scoring. The

inclusion of more detailed countings of adults and larval stages of the Antarctic krill *E. superba* and the big-eye krill *T. macrura* would enhance the SAHFOS South Georgia dataset and contribute to the database of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

Data analysis gaps –After 20 years of data collection, we have successfully compiled a substantial dataset that is now being used for biogeographic reports and analyses, including recent inclusion in the Southern Ocean Zooplankton Atlas (McLeod *et al*. 2010), use for comparisons of predator patterns and development of bioregionalization models (Pinkerton *et al.* 2010), analyses of temporal patterns in relation to environmental forcing factors (Takahashi *et al*. 2010), and the development of predictive models of responses to climate change. We should be actively promoting the availability and value of the dataset, especially its utility in the analysis of regional and global plankton patterns and the response of plankton communities to global climate change.

4.6. Future directions

Short and long term field work goals were discussed. Surveys operated by Australia, Japan, and New Zealand are well established and are producing excellent results. The US-AMLR and the Chilean Antarctic programs are very keen to make a number of tows per season across the Drake Passage between January and March. The SAHFOS has updated their schedule of planned surveys from South Georgia, which should operate throughout the year at two-month intervals.

The 80th Anniversary CPR Symposium "Plankton 2011: Biodiversity & Global Change –Past, Present, and Future" will be held in Plymouth, 22–23 September 2011. The CPR survey will be the focus of the symposium, but presentations on plankton time series distributions from all waters and methods will be accepted. We should encourage high attendance from Southern Hemisphere participants, and presentations that focus on the Southern Ocean. There will be a workshop associated with the symposium to discuss the development of a global CPR program on 20–21 September. We were in agreement that the Southern Ocean CPR program should actively contribute to a global and integrated CPR program. Workshops and exchanges of personnel between CPR program labs is an important part of this mission. This workshop and the recent exchanges between SAHFOS and southern CPR labs contribute to this process.

5. Outcomes

The workshop participants concluded that, despite the separation of laboratories, there were virtually no errors in the identification of zooplankton taxa, nor were there any variations in the procedures used between laboratories. Nonetheless, we will implement new procedural guidelines to minimize the possibility of any divergence from agreed-upon standards. The participants also agreed that there should be more regular workshops to ensure that standards are maintained. The principal outcome of the workshop was the assurance that our species identifications and procedures are accurate, consistent and uniform. We concluded that the SO-CPR database is of the highest possible standard.

6. Acknowledgements

The workshop was supported financially or through in-kind support by the SCAR Expert Group on CPR Research, NIPR, AAD, ACE-CRC, IMOS-AusCPR, NIWA, SAHFOS, and CSIRO. We are particularly grateful to NIPR for its generous support in organizing and hosting the workshop.

References

Hosie, G.W., Fukuchi, M. and Kawaguchi, S. (2003): Development of the Southern Ocean Continuous Plankton Recorder survey. Prog. Oceanogr. **58**, 263–283, doi: 10.1016/j. pocean.2003.08.007.

McLeod, D.J., Hosie, G.W., Kitchener, J.A., Takahashi, K.T. and Hunt, B.P.V. (2010): Zooplankton Atlas of the Southern Ocean: The Southern Ocean Continuous Plankton Recorder Survey(1991–2008). Polar Sci. **4**, 353–385, doi: 10.1016/ j.polar.2010.03.004.

Motoda, S. (1959): Devises of simple plankton apparatus. Mem. Fac. Fish. Hokkaido Univ. **7**, 73–94, http://hdl.handle.net/2115/21829.

Pinkerton, M.H., Smith, A.N.H, 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 Res. PT I. **57**, 469–485, doi: 10.1016/j.dsr.2009.12.010.

Takahashi, K.T., Hosie G.W., Umeda, H., Hirawake, T. and Fukuchi, M. (2006): Plankton sampling on board *Shirase* in 1999–2004—Continuous Plankton Recorder survey—. JARE Data Rep., **286** (Mar. Biol. **33**), 15 p.

Takahashi, K.T., Hosie G.W. and Fukuchi, M. (2009): Plankton sampling in 2004 – 2009 — Continuous Plankton Recorder survey—. JARE Data Rep., **311** (Mar. Biol. **39**), 31 p.

Takahashi, K.T., Hosie, G.W., Kitchener, J.A., McLeod, D.J., Odate, T. and Fukuchi, M. (2010): Comparison of zooplankton distribution patterns between four seasons in the Indian Ocean sector of the Southern Ocean. Polar Sci. **4**, 317–331, doi: 10.1016/j.polar. 2010.05.002.