Proposal Ref.No: 915 Submitted: February 13, 2014 Received: July 01, 2014 12:00 AM

Title: The North Pacific Continuous Plankton Recorder Survey

Period: July 2014 - June 2019

Name, Address, Telephone Number and Email Address of Applicant:
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Lead Principal Investigator: (Include name, affiliation and email address):
Sonia Batten, Sir Alister Hardy Foundation for Ocean Science [PICES], N/A, Research Scientist, soba@sahfos.ac.uk

Principal Investigator(s): (Include name, affiliation and email address):
1. Sonia Batten, Sir Alister Hardy Foundation for Ocean Science [PICES], N/A, Research Scientist, soba@sahfos.ac.uk

Research Priority:

Summary of Proposed Work:
The North Pacific CPR Survey is a ship of opportunity monitoring program that uses commercial ships to collect samples of phytoplankton and zooplankton, as well as some aspects of the physical environment, along their regular routes of passage on a seasonal basis. CPR sampling is a cost-effective, well-proven approach, which provides quantitative information on the base of the marine food chain and the health of oceanic ecosystems. CPRs have been in use since the 1930s in the North Atlantic, and are in fact increasing in their global use. Since 2000, there have been 2 regular North Pacific transects sampling waters of interest to the NPRB; an east-west transect that spans the Pacific, including through the Aleutian Island chain and southern Bering Sea, and a north-south transect between Washington state and Alaska. The North Pacific CPR survey is in its 15th year, and this proposal outlines the plans to continue it into the future.

The rationale behind the CPR survey is that phytoplankton and zooplankton respond rapidly to changes in their environment and thus pass the influence of this variability via the food chain to higher trophic levels such as fish, seabirds and marine mammals that have an interest and value for society. A consistent sampling program that records quantitative, taxonomically resolved abundances is needed to identify variability in the plankton, whether changes in biogeography, density, composition, or timing (phenology), any one of which factors may influence the success and robustness of the stocks of predators that depend on plankton. Our hypothesis is that the plankton will respond rapidly to ocean-climate variability through changes in abundance, distribution and timing and thereby influence higher trophic levels.

Community and Stakeholder Involvement:
The small size of the organisms monitored in this proposal make it difficult to involve local and traditional knowledge in this project. That being said, many of the crew on the commercial ship that samples the north-south transect into Cook Inlet are from Alaska and their interest and support for the study are obvious whenever we visit or talk to them about the project. They understand why it is important to monitor the base of the food chain that supports the resources they do see, and utilise. Engagement with the volunteer vessels is a vital part of the Survey and we maintain frequent contact and communication.

The PICES CPR-Advisory Panel, which meets annually, provides a mechanism for PICES member nations (including the US) to provide advice on how the Survey is meeting their needs in terms of addressing their particular stakeholder requirements. Other than this there is no direct stakeholder involvement in this
Links to NPRB Projects:
The CPR Survey was first supported in 2002 for one year as a special project (no project number) and from 2003 onwards through NPRB projects R0302, 0536, 601, F3803, 903 and 1001 (which ends in June 2014). During this time we collaborated with projects R0203, F0409 and 801 which collected marine bird and mammal observations along the CPR transects.

The CPR survey complements more recent NPRB programs and projects, such as the GOAIERP and the Seward Line sampling (projects 520, 603, 708, 804, 1002), by providing more extensive spatial and temporal coverage. The CPR survey can place the GOAIERP field seasons in context by sampling consistently across more years, indicating whether the field seasons were unusual (as was 2011). It also provides a seasonal context to the Seward Line sampling which only collects samples in May and September each year – the CPR transect intersects with the outermost Seward Line stations and collects samples each month, April through September. The lead PI of the Seward Line sampling (Russ Hopcroft) and the CPR lead PI (Sonia Batten) are actively collaborating within the Exxon Valdez Oil Spill Trustee Council’s long term monitoring program (Gulf Watch Alaska) which complements the NPRB program.

There is also limited comparability with projects in the Bering Sea such as the BSIERP, but in this case the CPR sampling extends data off the SE Bering shelf and into the southern deep-water regions as well the shelf between the Aleutian Islands through which the CPR transect passes.

CPR data and collaboration by S. Batten have also been identified in a proposal recently submitted to the NPRB in December 2013 by Sydeman et al., however, at this time the fate of that proposal is not known.

<table>
<thead>
<tr>
<th>Total Funding Requested From NPRB:</th>
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Proposal Applicant Signature and Affiliation:

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Research and Outreach Plan

A. Project Title.
The North Pacific Continuous Plankton Recorder Survey (suggested short title: North Pacific CPR)

B. Proposal Summary.
The North Pacific CPR Survey is a ship of opportunity monitoring program that uses commercial ships to collect samples of phytoplankton and zooplankton, as well as some aspects of the physical environment, along their regular routes of passage on a seasonal basis. CPR sampling is a cost-effective, well-proven approach, which provides quantitative information on the base of the marine food chain and the health of oceanic ecosystems (Reid et al., 2003). CPRs have been in use since the 1930s in the North Atlantic, and are in fact increasing in their global use (GACS, 2013). Since 2000, there have been 2 regular North Pacific transects sampling waters of interest to the NPRB; an east-west transect that spans the Pacific, including through the Aleutian Island chain and southern Bering Sea, and a north-south transect between Washington state and Alaska. The North Pacific CPR survey is in its 15th year, and this proposal outlines the plans to continue it into the future.

The rationale behind the CPR survey is that phytoplankton and zooplankton respond rapidly to changes in their environment and thus pass the influence of this variability via the food chain to higher trophic levels such as fish, seabirds, and marine mammals that have an interest and value for society. A consistent sampling program that records quantitative, taxonomically resolved abundances is needed to identify variability in the plankton, whether changes in biogeography, density, composition, or timing (phenology), any one of which factors may influence the success and robustness of the stocks of predators that depend on plankton. Our hypothesis is that the plankton will respond rapidly to ocean-climate variability through changes in abundance, distribution and timing and thereby influence higher trophic levels.

C. Project Objectives and Hypotheses.
Objectives

To maintain comparability with the existing data we are promoting an unchanged sampling regime:

1. To sample the north-south transect approximately monthly between April and September (occasionally beginning in March or ending in October), six times per year (Fig 1).
2. To sample the east-west transect 3 times per year in spring, summer and fall (Fig 1).
3. To analyse every 4th sample collected for phytoplankton and zooplankton taxonomic composition and abundance in line with the CPR standard methodology promoted by the Sir Alister Hardy Foundation for Ocean Science, SAHFOS. (Note that owing to the interests of a North Pacific CPR consortium member every sample on the Alaskan shelf and Cook Inlet is processed).
4. All samples to be archived and available for additional studies.
5. Each transect to be instrumented with temperature loggers (north-south) or a CTD-F purchased under a previous NPRB project (east-west) to provide some in-situ data on the physical environment.
6. A subset of samples to be processed rapidly (within 2-3 months of sampling but not QC’ed) to provide a first-look at the annual conditions. These preliminary results to be posted on project website regularly through the year.
7. Full quality-controlled data to be available within 1 year of sampling. In the past we have incremented the database on an annual basis once all processing for the previous year has been completed, however, incrementing the data base can be done twice-annually with little additional effort.
8. To produce at least 2 manuscripts by year 4, one to focus on the Aleutian Island/southern Bering Sea data and the other related to Gulf of Alaska plankton data and fish (likely in year 2).
9. To participate annually in the North Pacific Marine Science Organisation’s annual meeting, specifically the CPR-Advisory Panel and MONITOR Committee as well as the required attendance at the AMSS.
Figure 1. The location of historic CPR samples (red dots). Only processed samples are shown, there are approximately 3x as many unprocessed archived samples. Current transects that are proposed to be continued are marked N-S and E-W respectively. Other long term monitoring transects are shown in black; the Canadian DFO Line P and the Seward Line.

Hypotheses

Our central hypothesis is that the plankton will respond rapidly to ocean-climate variability through changes in abundance, distribution and/or timing and thereby influence higher trophic levels.

The last decade or so has seen increased variability in the Pacific Decadal Oscillation (PDO), a dominant mode of climate variability in the NE Pacific. Since 1998, the pattern of the PDO is no longer “multi-decadal”, but has been oscillating at a much higher frequency, changing sign every 5 years rather than every 20-30 years as seen in the past. We do not know if this pattern will persist for another decade or more, and the impacts on longer-lived species are not yet understood. There is also increased understanding of how climate indices such as the PDO and the NPGO (North Pacific Gyre Oscillation) relate to variability in marine ecosystems (DiLorenzo et al., 2008, Mackas et al., 2004, Mackas et al., 2013). Evidence from the NPRB’s recent Bering Sea program (BSIERP) also suggests that variability in zooplankton composition and abundance during relatively short warm and cold periods may drive stocks of Pollock in the Bering Sea (Stabeno et al., 2012). During preliminary analysis of the 2013 samples it was noted that warm water copepods were more abundant than had been seen for several years. Figure 2 demonstrates that mean numbers were slightly above 2007 and greater than any year since 2005 on the Alaskan shelf. Numbers are still very small compared to the abundance of typical copepod species for the shelf, nevertheless, the strong relationship between their abundance and mean annual SST indicates a potential change in ocean conditions that have been relatively cool (SST data are not yet available to update the time series for 2013). In late summer 2013 a shift in air pressure and wind brought high ocean temperatures to west coast waters, from Oregon to Alaska, which lasted for a few months (Crawford, 2014). Whether this heralds a switch to more persistent warmer conditions remains to be seen, and our immediate hypothesis to test is that ocean conditions will turn warm in 2014 and the plankton will respond accordingly with a change in community composition and seasonal timing. Section E describes results from the current work which illustrate some other relationships between plankton indices and ocean conditions.
D. Data Need and Application.
The North Pacific CPR Survey was initially set-up in response to the North Pacific Marine Science Organization’s (PICES) concern over the lack of open-ocean monitoring of lower trophic levels. Figure 1 also shows the location of two long-term monitoring transects in the NE Pacific that measure plankton, there are also stations in Prince William Sound and the Newport Line off Oregon; these are typically restricted to the shelf and slope, and separated from each other by large distances. The CPR data provides a link between these sites, which are also connected via the major currents of the NE Pacific, and also provides a broader-scale context for such locally focused studies. Other plankton monitoring programs such as the Seward Line sampling and net sampling within Prince William Sound have greater depth resolution but are spatially restricted and/or only sampled twice per year. In these cases it is hard to determine the geographic extent of any variability or to determine the seasonal cycle and changes in timing. The CPR data are thus complimentary by covering large spatial scales (sampling consistently from open ocean to shelf) and frequently enough to distinguish between-year changes in seasonality (see for example Batten and Mackas, 2009). For this reason the Exxon Valdez Oil Spill Trustee Council included the CPR and net sampling in its long-term monitoring program for the spill-affected region.

In addition to preparing reports for the individual agencies that fund the North Pacific CPR survey, providing data to scientists on request, and contributing to the scientific literature through research papers, CPR data have also been included in fisheries resource management reports: Annual updates are contributed to the Canadian Department of Fisheries and Oceans (DFO) “State of the Ocean” reports, see http://www.meds-sdmn.dfo-mpo.gc.ca/csas-sces/applications/publications/index-eng.asp and also to NOAA’s “Ecosystem Considerations Report”, see http://access.afsc.noaa.gov/reem/ecoweb/index.cfm. Alone among sampling approaches, the CPR Survey provides observations on the geographic scales of ecosystems that are essential to implement ecosystem-based fishery management (Witherell et al., 2000; Link, 2002). Ecosystem-based fishery management has evolved over the past decade to become the standard for U.S. waters managed by the North Pacific Fishery Management Council yet acquiring the ecosystem-level information required for managing fisheries remains challenging (cf. Arctic FMP 2009, 2.2 p. 4 Fishery Management Plan for the Arctic).

E. Project Design and Conceptual Approach
The project will generate seasonally-resolved, abundance and distribution data on several hundred planktonic taxa to increment the 14 year database that already exists for regions of the North Pacific, including the Gulf of Alaska and Aleutian islands/southern Bering Sea. The CPR does have limitations as a plankton sampler, as do all lower trophic level measuring systems; in the CPR gelatinous organisms are not well sampled, those smaller than the mesh size are under-sampled, and only the larger, hard-shelled phytoplankton are retained. However, the CPR is an internally-consistent sampler and there is a wealth of literature from the now global surveys that demonstrate that measured changes in abundance, timing and composition as seen by the CPR are real and meaningful and of clear value to policy decisions (see for example Edwards et al., 2010). At the scales of the LMEs of interest to the NPRB it is an extremely cost-effective way to monitor lower trophic levels with taxonomic and seasonal resolution. To maximize the value of the 14 year database already in existence, which has in the past been well supported by the NPRB, we are not advocating any changes.

Project design
CPRs will be towed behind the volunteer vessels on the two transects indicated in Figure 1, three times per year on the east-west (approximately April, June and September) and 6 times per year on the north-south transect (typically monthly between April and September), subject to the commercial activities of the vessels. The pre-proposal Advisory Panel review noted some concerns with the consistency of the area covered which we feel should be addressed here; as with all oceanographic sampling there are often unforeseen circumstances which influence where and how much sampling can be achieved, weather being chief among them. While we have no control over the activities of the ships and the route they choose to take between ports the previous decade and more of experience with these two transects has given us a degree of confidence. The sample map in Figure 1 shows almost 60 separate transects into Cook Inlet yet they overlay each other almost completely. The east-west transect is more variable in its path across the Alaska Gyre and into the southern Bering Sea yet of the 38 transects shown, all but 1 transited through Unimak Pass. Furthermore, mobile mesoscale features such as eddies and fronts may have as much influence on marine organisms as fixed topography so while it is essential to know where each sample was collected by latitude and longitude it is also useful to know whether a front or eddy was passing through at the time of sampling (which can be obtained via satellite imagery). So, although the position of the CPR transects can be variable, so too can the ocean, and while consistent coverage is a justified concern we feel that our sampling is quite consistent and placing our sampling in oceanographic context equally important.

The shipping companies that manage the volunteer vessels towing CPRs in the North Pacific have been involved in this project for 14 years (east-west) and 10 years (north-south) and have indicated their willingness to continue. Should economic, or other, forces necessitate their withdrawal, there are many other ships in these waters that could be approached. In our experience, a shortage of volunteer vessels is not a concern, and the North Atlantic CPR survey has been in operation for over 80 years.

After the ship arrives in port technicians trained by SAHFOS meet the vessel (in Anchorage and BC ports) and recover the CPR. The sampling mechanisms are offloaded, the samples removed and the gear serviced and returned to the ship for the next transect. In the laboratory, the filtering mesh is removed from the CPR and cut into discrete sections each representing 10 nm, or 18.5 km of the transect. Every 4th oceanic sample (74 km spacing), and all north-south Alaskan shelf samples (to meet the specific interests of another Consortium member in this oceanographically complex region), are subjected to microscopic analyses where phytoplankton and zooplankton are identified to the greatest practicable degree of taxonomic resolution, and counted. We established early on in the Survey’s history that processing every 4th oceanic sample provided adequate resolution while maintaining cost-effectiveness. We determined the decorrelation-length scales for the north-south transect and found that patches were occurring either at scales smaller than 1 CPR sample (i.e. less than 20 km) or larger than 15-18 samples (i.e. > than 300 km). This supports the belief that the CPR sampling resolution is adequate for a synoptic large-scale survey since an individual sample will pass through small patches of plankton and so provide
an ‘average’ of the small-scale patchiness. Samples that are spaced well apart, such as every 74 km, are likely to be representative and not likely to be within or outside of a patch.

All procedures are consistent with the CPR standard methodology developed and maintained by SAHFOS. The pre-proposal review included a comment by the Science Panel that they would like to see progress towards automation which deserves some comment here. Automation of methods has been of interest to SAHFOS for many years, as well as more recently to the Global Alliance of CPR surveys (GACS). The limitations of switching to automated counting are currently maintaining the taxonomic resolution that humans can produce (although molecular techniques which are more expensive can already supersede that) and maintaining comparability with the existing times series. A switch to a new method of counting would require a period of overlap where both old and new methods were run in parallel, and the cost of such an exercise is at the moment prohibitive. However, this is a rapidly-evolving field and it would be surprising if significant advances were not made during the course of the 20 year NPRB program.

The east-west CPR is also fitted with a self-logging CTD to record temperature, salinity and fluorescence at the depth of the CPR and the north-south CPR is fitted with a temperature logger. These instruments are downloaded after each transect, and at the end of each field season re-calibrated.

In addition to the basic abundance data for each taxon we also generate summary indices that form part of our regular reporting. For example, total diatom abundance and timing, timing of the mesozooplankton spring peak, total large copepod abundance or abundance of warm water species can provide a basic overview of the year’s status which is easily captured in a few figures and which can be shown to relate to physical conditions. In the current NPRB project (1001) which ends in June 2014 we have focused on changes within the large regions. As the database becomes more extensive over the five year span of this proposal and beyond we plan to investigate finer spatial structure to determine whether the whole region is responding in a similar way to the climate variability and the relative importance of local forcing.

The North Atlantic CPR Survey (started in 1931) demonstrates what can be achieved with a multi-decadal time series of consistent plankton observations, the high-impact work of Beaugrand linking climate, plankton and fisheries being only one example (e.g. Beaugrand et al., 2002) and we intend for the North Pacific Survey to achieve multi-decadal status. The lower frequency signals in the data resulting from climate variability can be more confidently determined from a longer time series, as well as the relationships with longer-lived higher trophic levels who may integrate variability in the ocean’s productivity over the course of their life-span.

Results from current and previous NPRB support
North Pacific CPR data have contributed so far to 17 peer-reviewed publications, with several more in review or in preparation and numerous grey-literature reports (such as the PICES North Pacific Ecosystem Report). The published studies cover a wide range of topics including climate variability impacts (Mackas et al., 2007; Batten and Mackas, 2009, Batten and Walne, 2011), input to fisheries studies (Rooper et al., 2012), larval crab distribution updates (Lindley and Batten, 2008), and links with seabird distributions (Sydeman et al., 2010). NPRB support, with other sources, has enabled the collection of the data that these publications relied upon, and we are certain that many future studies, with as yet unknown topics, will be forthcoming. Space limitations prevent a full description of all of the results and so we have chosen to focus here on results from the most recent support that focusses on the south-central Alaska shelf. These results are currently being written up for publication.

Figure 3 shows some of the phytoplankton indices and their relationship with physical variables. The annual mean abundance anomaly of large diatoms retained by the CPR shows a significant relationship with sea surface temperature; anomalies are positive in warm years (2011 stands out, however, as a year
when the temperature was not that low but diatoms were anomalously few). An index of spring diatom timing (not as precise as spring bloom timing, rather an index of whether the peak is early or late) is highly significantly related to the North Pacific Gyre Oscillation (NPGO) and the salinity of the surface waters, being early in years with lower salinity (increased run-off) and negative values of the NPGO.

These results show that the ocean conditions influence the abundance and timing of the diatoms, but the CPR data can go beyond the summary index of Total Diatoms. Over 80 phytoplankton taxa are recorded in the region shown in Fig. 3 and a nonMulti Dimensional Scaling (nMDS) analysis of the mean spring and fall abundance of each taxon each year shows that physical variables also have a role in structuring the community composition (Fig. 4).
Figure 4. nMDS plots of the phytoplankton community in spring (left) and fall (right) of each year. Analysis is based on Bray-Curtis similarities of taxonomic abundance between pairs of years. Years that plot closest together are the most similar in their community composition.

The x-axis in the spring plot is strongly related to temperature with warmer years tending to the left ($r^2=0.41, p<0.01$) while the fall x-axis is somewhat related to the thermocline depth in May (Hopcroft and Coyle, pers comm.) from the outer Seward Line stations ($r^2=0.24, p<0.05$). May is not the best time to measure the thermocline since it is usually becoming established at that time, so we suspect that this is more of an indicator of how early the water column stabilizes each year. Some taxa, such as dinoflagellates, require a stable water column and this may be how the fall community composition is influenced.

The physical characteristics of the ocean, coupled with the resulting phytoplankton dynamics, can also be shown to have an influence on the zooplankton. Fig. 5 shows the relationship between the annual diatom abundance anomaly and an anomaly of estimated zooplankton biomass from the CPR. Years with positive diatom anomalies have significantly ($r^2=0.50, p<0.05$) higher zooplankton biomass and *vice versa*. 

![nMDS plots of the phytoplankton community in spring (left) and fall (right) of each year. Analysis is based on Bray-Curtis similarities of taxonomic abundance between pairs of years. Years that plot closest together are the most similar in their community composition.](image)
Focusing in on the most abundant group of zooplankton we have determined that temperature has a strong role in determining the timing of the copepod seasonal cycle. An index of the midpoint of the seasonal cycle correlates significantly with SST for both larger species with typically an annual life cycle ($r^2=0.5$, $p<0.005$) and less strongly with smaller species which have multiple generations per year ($r^2=0.28$, $p<0.05$). Taxonomic composition of the spring zooplankton community shows significant forcing by diatom abundance and spring timing (nMDS analysis, $p<0.05$ in both cases along dimension 1).

There is much work to be done in teasing out which factors are the most important and what the consequent impacts on higher trophic levels will be, however, these results demonstrate that the CPR survey is already producing information that can significantly contribute to our understanding of lower trophic level ecosystem dynamics. Evidence from the longer North Atlantic and Southern Ocean CPR surveys shows that as these times series become multidecadal, value to scientists and policy makers becomes even more apparent (Edwards et al., 2010).

F. Communication and Outreach

Information on the North Pacific CPR survey, its data and products are made available to wider audiences in a diversity of ways. Each of these avenues for dissemination will be maintained through the life of the project.

1. Websites.

In addition to the specific requirements and websites of the agencies that contribute funding to the North Pacific CPR for data and reports, there are three organisations which include the Pacific CPR data in their websites:

- Sir Alister Hardy Foundation for Ocean Science. [www.sahfos.org](http://www.sahfos.org)
- Global Alliance of CPR surveys. [www.globalCPR.org](http://www.globalCPR.org)
- North Pacific Marine Science Organisation. [www.PICES.int](http://www.PICES.int)

A contribution towards revising and maintaining the Pacific CPR presence on the PICES website is asked for in this proposal for E&O, and the section on Data Dissemination describes this outlet and our plans in more detail.

SAHFOS has also created educational web pages aimed at school students (K to Grade 12) and their teachers as well as interested adults, see [http://lifeadrift.info](http://lifeadrift.info). The PI has used information from these pages in her classroom talks and referred teachers to them. Maintenance of, and updates to, this resource are included in the SAHFOS in-kind support to the North Pacific CPR Survey.

2. Fisheries Resource Managers.

As described above, CPR data are contributed annually to


3. Public and classroom lectures.

The PI has always striven to provide outreach on the North Pacific CPR survey to the general public wherever possible as demonstrated by activities in the last few months: A public lecture was given in Cordova (Nov 15th 2013) through the Prince William Sound Science Centre as well as lectures to two
grade 10 classes at Cordova High School. Through an initiative to bring scientists into classrooms the PI
also gave lessons to grade 4-6 students via Skype at schools in Texas and Maryland in
November/December 2013. The PI has agreed to remain involved in this program should other plankton
lessons be requested.

For specific E&O in this proposal funds have been requested to enable the PI to give another community
lecture, probably around year 3 of the project (given the recent talk in Cordova), as an add-on to
scheduled travel to Alaska.

G. Timeline and Milestones.

<table>
<thead>
<tr>
<th>Reporting period</th>
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| July-December 2014     | Sample N-S transect 3 times  
                          | Sample E-W transect 1 time  
                          | Complete preliminary analysis of 2014 samples and update web pages  
                          | QC of 2014 samples ongoing throughout  
                          | Attend PICES Annual Meeting |
| January-June 2015      | Sample N-S transect 3 times  
                          | Sample E-W transect 2 times  
                          | Complete QC of 2014 samples  
                          | Attend AMSS  
                          | Submission of semi-annual progress report |
| July-December 2015     | Sample N-S transect 3 times  
                          | Sample E-W transect 1 time  
                          | Complete preliminary analysis of 2015 samples and update web pages  
                          | QC of 2015 samples ongoing throughout  
                          | Attend PICES Annual Meeting  
                          | Submission of semi-annual progress report |
| January-June 2016      | Sample N-S transect 3 times  
                          | Sample E-W transect 2 times  
                          | Complete QC of 2015 samples  
                          | Attend AMSS  
                          | Submission of semi-annual progress report |
| July-December 2016     | Sample N-S transect 3 times  
                          | Sample E-W transect 1 time  
                          | Complete preliminary analysis of 2016 samples and update web pages  
                          | QC of 2016 samples ongoing throughout  
                          | Attend PICES Annual Meeting  
                          | Submit manuscript on Gulf of Alaska CPR data and fisheries links.  
                          | Submission of semi-annual progress report |
| January-June 2017      | Sample N-S transect 3 times  
                          | Sample E-W transect 2 times  
                          | Complete QC of 2016 samples  
                          | Attend AMSS  
                          | Submission of semi-annual progress report |
| July-December 2017     | Sample N-S transect 3 times  
                          | Sample E-W transect 1 time  
                          | Complete preliminary analysis of 2017 samples and update web pages  
                          | QC of 2017 samples ongoing throughout  
<pre><code>                      | Attend PICES Annual Meeting |
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<th>Period</th>
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<tr>
<td>January-June 2018</td>
<td>Give Public lecture in Alaska. Submission of semi-annual progress report</td>
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<td>Sample N-S transect 3 times</td>
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<td>Sample E-W transect 2 times</td>
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<td>Complete QC of 2017 samples</td>
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<td>Attend AMSS</td>
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<td>Submit manuscript on Aleutian Island/Southern Bering Sea CPR time series.</td>
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<td>July-December 2018</td>
<td>Sample N-S transect 3 times</td>
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<td>January-June 2019</td>
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<td>Submission of semi-annual progress report</td>
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<td>July-December 2019</td>
<td>Complete analysis and QC of 2019 samples</td>
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<td>Submit final report within 60 days.</td>
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<td>January-June 2020</td>
<td>Attend AMSS</td>
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**H. Project Management.**

The North Pacific CPR Survey Consortium has been financially administered by the North Pacific Marine Science Organisation (PICES) since 2008 and the Executive Director, Alex Bychkov, is included here as Grant Manager. The scientific and logistical components have been managed by the PI, Sonia Batten, since 2000 who is based in British Columbia. The PI commits 0.4 FTE to the project annually, unchanged from previous years. This level has proved sufficient to manage the program and meet the deliverables.

The North Pacific CPR Consortium was established in 2008 and currently consists of 5 members, including the NPRB. Other members are:

- The Exxon Valdez Oil Spill Trustee Council. This agency has also recently developed a long term monitoring program (also called Gulf Watch Alaska) to which the CPR survey contributes. The program is intended to be a 20 year program, renewable in 5 year increments. We are currently in year 2.

- Canadian Department of Fisheries and Oceans (DFO). This agency contributes both financially on an annual basis (since 2008) and with in-kind support by providing laboratory space for sample analysis, and facilities support (library, shipping centre etc). Renewal cycles are variable but at this time financial support is committed through March 2015 and will be sought each year, while in-kind support is open-ended.

- Dr Sanae Chiba, JAMSTEC. Dr Chiba contributes in-kind support through a Japan Society for the Promotion of Science award to her department to analyse all samples west of 170°E. This frees up Consortium funding to analyse samples in the eastern Pacific. The award has recently been renewed until 2017. The previous award also resulted in several publications which have added much value to their involvement.
Sir Alister Hardy Foundation for Ocean Science (SAHFOS). The CPR parent organisation and the PI's employer essentially “takes up the slack” by providing support as required, principally salary for the PI, to maintain the Survey at its current level.

The North Pacific Survey adheres to the CPR analysis and quality control protocols of the SAHFOS and the Global Alliance of CPR Surveys (GACS). Technicians in Anchorage and British Columbia have been trained by SAHFOS to carry out CPR servicing and sample processing; they visit the ships at the completion of each transect and recover the instrumentation, carrying out unloading of samples and servicing as required. All samples are initially processed at the DFO lab in Sidney, BC. Through a collaborative agreement between SAHFOS and DFO, a CPR microscope station is set up at the DFO laboratory in Sidney, BC where Batten and a technician undertake taxonomic analysis on a subset of the samples. SAHFOS is responsible for the remaining sample analysis, all QC aspects of the Pacific Survey and archiving of the samples. This format has worked well for the last 6 years, and we do not suggest any changes.

In addition, PICES convenes an annual CPR Advisory Panel meeting at its Annual Meeting, reporting to the MONITOR Technical Committee, comprising members representing each PICES member country, and the PI, who contribute advice. Reports from the Panel are available at http://www.pices.int/members/advisory_panels/cpr.asp.

Literature Cited


GACS (2013). Global Alliance of Continuous Plankton Recorders (www.globalcpr.org)


Data Management and Dissemination Plan

Data Management
The North Pacific Survey adheres to the CPR analysis and quality control protocols of the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) and the Global Alliance of CPR Surveys (GACS) which are the umbrella CPR organisations. After sample analysis is complete the data are checked at SAHFOS and not finalised until all QC procedures are complete. We have historically released finalised data in annual updates as the most efficient use of time, but it will not be an issue to release data in bi-annual increments. North Pacific CPR data are held by SAHFOS and GACS, and each have websites showing data availability and products, as well as by the PI. Data from the north-south transect are also submitted annually to EVOS, and publicly available through the www.gulfwatchalaska.org website. Since the inception in 2008 of the North Pacific CPR Consortium, administered by the North Pacific Marine Science Organisation (PICES), project web pages have also been maintained on the PICES website. Finalised CPR data and data products for key regions are available for graphing and downloading on the PICES website (http://www.pices.int/projects/tcprsotnp/default.aspx), and all data are available on request to the PI. See below for additions we propose to include on the website.

Dissemination of provisional results
One addition to the standard CPR protocols we have already made in the Pacific Survey is that 25% of the samples across the region are analysed rapidly and provisional (non-QC’d) data are available to the PI within 2-3 months of collection. (Note that the east-west transect does not return from Asia to a local port until about 6 weeks after sampling and so it is not possible to process these samples any more rapidly than within 3 months of sampling). These provisional data have been used in progress reports and in reports to management agencies as the most up-to-date indicator of ocean conditions. For this proposal we propose to add pages to the PICES project webpages which will show these preliminary data as summary plankton indices for key regions of the sampled area. As an example, the figures below (Figure 1) show provisional (2013) data for the Alaskan Shelf including Cook Inlet. They are superimposed on the long term mean, with the historical monthly minima and maxima that have been recorded for this particular region. An interpretation of these graphs would be that diatoms showed a strong spring peak in May and a secondary autumn peak in September, while abundances were quite high in June and September. Estimated mesozooplankton biomass was generally lower than average until September, while abundances were quite high in June and September. This suggests a bias towards smaller species, if biomass was low but abundance relatively high.
Figure 1. Preliminary results from 2013 CPR sampling as monthly means overlaid on the long term time series of CPR observations from the Alaskan Shelf/Cook Inlet region. Upper graph shows mean diatom abundance, lower graphs show zooplankton biomass (left) and abundance (right).

Figure 1 shows, therefore, for a particular region how the most recent months compare to typical and outlying years for summary plankton indices. We plan to provide such figures (3 per region; Total Diatoms, Total Zooplankton Abundance and Total Estimated Zooplankton Biomass) for the following 8 regions:

Figure 2. The eight regions for which provisional plankton indices will be regularly updated and posted.

These results will be updated three times throughout the year as initial processing of the transects is completed (normally the first data of the year are available in about June for the April sampling and the last in December, depending on the timing of the final transects of the year) likely in about July, September and December.
While these provisional data will be made available on request (as they have been in the past) we are hesitant to allow anonymous downloading of non-finalised raw data to prevent inconsistencies if the downloader were not to check back at a later date for the finalised data. If a request is received by the PI then a dialogue is initiated when provisional data are sent, and the requester can be updated once finalised data are available. We hope that by regularly posting provisional results and more frequently incrementing the finalised data we will provide a reasonable compromise between keeping people informed and allowing accurate interpretation of the CPR data.

Datasets to be produced.

1. **Plankton abundance data.** For each processed sample the location, local time and date of collection (the midpoint of the 18km sample is used to designate the position and time of sampling) and the abundances of approx. 300 taxa are recorded. In a typical year approximately 400 processed samples are added to the database. Files are not large – 0.5-1 MB for the year.

2. **Along-transect physical data.** From each north-south transect, temperature (at the depth of the CPR, approx. 7m) is recorded at 5 minute intervals via a self-powered Vemco temperature logger fitted to the CPR. From each east-west transect temperature, salinity, depth and chlorophyll-a fluorescence are recorded at 5 minute intervals via a Brancker CTD fitted to the CPR. In each case position of each record is calculated from ship’s log information. Again, files are not large; an Excel file containing all of the 2013 physical data was 1 MB.

**Dissemination Plan Summary**

The table indicates the proposed flow of data collection and dissemination:

<table>
<thead>
<tr>
<th>Data activity</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plankton sample collection</td>
<td>April – September each year</td>
</tr>
<tr>
<td>Provisional sample analysis completed</td>
<td>Within 2-3 months of sample collection, ongoing</td>
</tr>
<tr>
<td>Web pages updated with provisional summary indices results</td>
<td>Within 2-3 months of sample collection, 3 times per year</td>
</tr>
<tr>
<td>QC of plankton abundance data complete</td>
<td>Within 9 months of sample collection</td>
</tr>
<tr>
<td>Web pages updated with finalized data</td>
<td>Within 10 months of sample collection, two times per year</td>
</tr>
<tr>
<td>Physical data</td>
<td>Website updated and files available within 1 month of data collection</td>
</tr>
</tbody>
</table>
Resume: Sonia Dawn Batten Ph.D.

Sir Alister Hardy Foundation for Ocean Science (SAHFOS)
C/o 4737 Vista View Crescent
Nanaimo, British Columbia, V9V 1N8,
Canada

Tel: 1-250-756-7747
FAX: 1-250-729-2622
Email: soba@sahfos.ac.uk

Qualifications

Career History
2000 to present. Part-time Research Fellow. SAHFOS.
2003 and 2004. Temporary Instructor, Malaspina University College, Fisheries and Aquaculture program.
1996–2000. Assistant Director. SAHFOS, UK
1994–1996. Postdoctoral Research Fellow. SAHFOS, UK

Current Activities
During the past 19 years I have been working with the Continuous Plankton Recorder Survey through the Sir Alister Hardy Foundation for Ocean Science. Since 2000 I have been based in western Canada, co-ordinating the north Pacific CPR survey which in 2008 became the N. Pacific CPR Consortium under PICES. My main research focus has been the mesozooplankton; their distribution, ecology and role in the upper pelagic ecosystem. Since Sept 2011 I have also been the vice-chair of the Global Alliance of CPR Surveys.

Recent Relevant Publications (all supported in part by NPRB funding)

Relevant Other Publications (those partially supported by NPRB funding are highlighted)


**Collaborators during the last 4 years**

Boldt, Jennifer, DFO Canada  
Chiba, Sanae JAMSTEC, Japan  
Coyle, Ken, UAF  
Hopcroft, Russell, UAF  
Mackas, David, DFO Canada (now retired)  
Rooper, Christopher, NOAA  
Sugisaki, Hiroya, FRA, Japan  
Sydeman, William, Farallonones Institute for Advanced Ecosystem Research  
Walne, Anthony, SAHFOS  
Yoshiki, Tomoko, JAMSTEC, Japan
Results of Previously Completed NPRB Funded Projects

Name and Current proposal role: Dr Sonia Batten, Principal Investigator.

Projects 302, 536, 601, 3803, 903 are completed projects which were continuations of effort with the same objectives “A Continuous Plankton Recorder survey of the North Pacific and southern Bering Sea”.

Role and Affiliation: Principal Investigator, Sir Alister Hardy Foundation for Ocean Science

Funding Amount: $479,995 (total for all 5 projects)


(b) summary of the major results of the completed work and, if applicable, any direct contribution to fisheries management efforts;

Each successive proposal has added to the database and so the results from the current project, which are included in section E of the research plan, together with the publication list below, are an effective summary of the achievements.

While a direct contribution to fisheries management efforts is hard to demonstrate, data from the CPR project have certainly been sought by fisheries management agencies such as the Department of Fisheries and Oceans, Canada where a review of climate impacts on lower trophic levels was requested of the PI. This report makes extensive use of North Pacific CPR data and is currently in review. Data are also contributed each year to the DFO “State of the Ocean” reports, see http://www.meds-sdmn.dfo-mpo.gc.ca/csas-sccs/applications/publications/index-eng.asp and also to NOAA’s “Ecosystem Considerations Report”, see http://access.afsc.noaa.gov/reem/ecoweb/index.cfm

(c) publications and other products (models, software) resulting from the NPRB funded project.


(d) outreach activities.
- Project website maintained by PICES: [http://pices.int/projects/tcprsootp/default.aspx](http://pices.int/projects/tcprsootp/default.aspx)
- Batten participated in a PICES sponsored CPR workshop in Yokohama, Japan, in September 2009. The aim of the workshop was to increase awareness of the CPR within the Asian science community.
- Batten was lead author for the oceanic chapter of the second PICES North Pacific Ecosystem Status Report, and CPR data were fundamental to the lower trophic levels section of this chapter. Batten, S., et al., (2010). Status and trends of the North Pacific oceanic region, 2003-2008, pp. 56-105 In S.M. McKinnell and M.J. Dagg. [Eds.] Marine Ecosystems of the North Pacific Ocean, 2003-2008. PICES Special Publication 4, 393 p.
- Presentation by S. Batten to the Canadian Institute of Marine Engineering (Vancouver Island Branch) in April, 2005
- Article in September 2003 issue of ‘Fairplay Solutions’
February 13, 2014

North Pacific Research Board  
1007 West 3rd Avenue, Suite 100  
Anchorage, Alaska 99501

Ladies and Gentlemen:

We are writing to confirm the continued support by the Alaska Fisheries Science Center and Auke Bay Laboratories for the Continuous Plankton Recorder surveys of the North Pacific, and in this regard we recommend to you the proposal submitted by Dr. Sonia Batten to the NPRB's call for Long Term Monitoring Proposals.

Now in its 15th year, the North Pacific CPR Survey is the only long-term monitoring program capable of resolving taxonomic and seasonal lower trophic level abundances at geographic scales that are relevant to understanding the causes for the long term impacts of climate change on fisheries production and management. Updated climate projections by the IPCC underscore the continued urgency to identify and understand the trophic factors on which Alaska's valuable fisheries production depends. As has been amply demonstrated in the North Atlantic, a consistently-derived dataset spanning multiple decades in the Gulf of Alaska and Bering Sea would be an invaluable tool for tracking changes in the distribution of zooplankton assemblages. Investigators at Auke Bay Laboratory plan to use the existing data from the CPR survey to add context to findings of short-term ecosystem level studies. CPR survey data have the potential to add value to shorter term ecosystem level studies as a large scale frame of reference for changes in primary and secondary productivities that is not available from any other source.

We hope that the North Pacific CPR Survey will be included in the NPRB's Long Term Monitoring Program and we look forward to future collaborations.

Sincerely,

[Signatures]

Douglas DeMaster, Ph.D.  
Director, Alaska Fisheries Science Center  

Phillip R. Mundy, Ph.D.  
Director, Auke Bay Laboratories
February 12, 2013

Dr. Sonia Batten
SAHFOS
c/o 4737 Vista View Cr
Nanaimo BC V9V 1N8
Canada
soba@sahfos.ac.uk

Subject: Letter of Support: The North Pacific Continuous Plankton Recorder Survey

Dear Sonia,

This letter indicates the support of Fisheries and Oceans Canada (DFO) for your proposal to the Long-Term Monitoring Program of the North Pacific Research Board (NPRB): "The North Pacific Continuous Plankton Recorder Survey".

Fisheries and Oceans Canada is a strong supporter of this long term monitoring program. We have worked closely with you and your SAHFOS staff and while we look forward to a longer time series, we are very pleased with the amount of new information that has been gleaned from the existing time series. The CPR survey results are feeding nicely into our annual State of the Ocean reporting and similar activities within PICES. The science is good and the results are timely.

Wearing my manager’s hat, I find this to also be a well-managed program. The features I note here include:

- The program costs are fairly modest (always important to managers!)
- The sampling and analysis protocols are carefully controlled
- The data are well-managed
- The results are available in a timely manner
- There is a lot of consultation with users and experts, through the PICES CPR Advisory Panel and other fora.

Given the extent of collaboration, strong alignment with existing departmental programs, and the value of the results arising from the existing program, the Department intends to continue to provide in-kind contributions and financial support through PICES. At the present time, financial
support from DFO through PICES is committed through March 2015 and will be sought for succeeding years. The in-kind support (laboratory space for sample analysis and logistics support – library access; shipping and receiving etc.) will continue to be provided on a more open-ended basis.

Finally, I wish to reiterate the support of Fisheries and Oceans Canada for your research proposal and our commitment in contributing to its success.

If you require further information, please do not hesitate to contact me.

Sincerely,

Robin Brown
Manager, Ocean Sciences Division
Institute of Ocean Sciences
P.O. Box 6000
Sidney, B.C. V8L 4B2

Ph: (250) 363-6378
Fax: (250) 363-6690
Email: Robin.Brown@dfo-mpo.gc.ca
Dear Sir/Madam,

**North Pacific Research Board: Long-term Monitoring Program**

I am writing this letter to support the funding application of Dr. Sonia D. Batten, Sir Alister Hardy Foundation for Ocean Science, (SAHFOS) for the NPRB Long-term Monitoring Program.

We Japanese team started studying ecosystem variability in the western North Pacific in relation to large scale climatic forcing using samples and data obtained by the North-Pacific Continuous Plankton Recorder (CPR) survey in 2009. Funding of the Japanese team to conduct analysis of the CPR samples and data is secured up to FY2016~2017. We are very grateful to the NPRB for your past and present support that have made possible a long-term monitoring over the North Pacific.

With the recent increasing demand for global synthesis of ecosystem change, Global Alliance of CPR Survey (GACS) was established in 2011 with SAHFOS’s leadership and participation of scientists from eight countries including Japan aiming at better assessment and understanding of marine ecosystem responses to multiple environmental stressors at global scale. North Pacific CPR project, which has been conducted already more than 10 years, is without doubt an important component of GACS foci, and continuing the monitoring effort is indispensable to fulfill GACS goal. We will highly appreciate your further long-term support for the North Pacific CPR survey.

Best regards,

Sanae Chiba, Ph. D  
PI of the Japanese CPR Team 
Member of GACS  
Leader of the Marine Ecosystem Change Research Team  
Research Institute of Global Change, JAMSTEC
January 31, 2014

Re: Project: 14120114-A Long-term Monitoring of zooplankton populations on the Alaskan Shelf and Gulf of Alaska using Continuous Plankton Recorders

To whom it may concern:

The Exxon Valdez Oil Spill Trustee Council (EVOSTC) has funded the above-mentioned project for the last two years. In October 2013, the Council approved funding for Year 3 of Ms. Batten’s project for the EVOSTC fiscal year of February 1, 2014 to January 31, 2015.

Ms. Batten’s project is part of one of two long-term Programs, the Long-Term Monitoring Program, also known as GulfWatch Alaska. The Programs are administrated under five-year contracts, which include annual Council and Public Advisory Committee meetings to review the past-year's results and future fiscal year's requested funding. The current Council contemplates the Programs to be twenty-years in length, concluding in 2032. Funding for Ms. Batten’s Year 4 and Year 5 will be approved in future Trustee Council meetings for EVOSTC fiscal years 2015 and 2016, respectfully. The EVOSTC Science Panel, Executive Director, Science Coordinator and Public Advisory Committee have consistently recommended Ms. Batten’s project for funding.

Thank you for your interest in the Exxon Valdez Oil Spill restoration program. Please contact us if you have any questions.

Sincerely,

Elise Hsieh
Executive Director

cc:
Sonia Batten
Sir Alister Hardy Foundation for Ocean Science
C/o 4737 Vista View Crescent
Nanaimo, British Columbia, V9V 1N8, Canada
Dear Sir/Madam,

Letter of support for Dr Sonia Batten’s NPRB-LTMP application

The Global Alliance of Continuous Plankton Recorder Surveys (GACS) is a new international programme comprising all the current regions CPR surveys, including the North Pacific survey led by Dr Batten. The general goal of GACS is to understand changes in plankton biodiversity at ocean basin scales through the global alliance. By “understand” we mean characterise, analyse and interpret. GACS has established a database of global CPR observations that will allow us to assess changes in plankton biodiversity at a local or regional level in a global context. GACS produces an annual Marine Ecological Status Report for global plankton biodiversity, as well as other reports and scientific publications for key stakeholders and policy makers. They include national governmental agencies, intergovernmental and international scientific agencies such as IOC-GOOS (UNESCO), PICES, SCAR, SCOR, POGO, SOOS. GACS also aims to be an interface for plankton biodiversity with other global ocean observation programmes.

I note the overall goal of the Long-term Monitoring Program is to support time-series research/long-term monitoring aimed at understanding the current state of the marine ecosystem, attempting to predict future ecosystem states in response to changing ocean conditions, as well as understanding ecosystem variability and subsequent effect on marine resources. The overall goal of the LTMP is very much at the heart of GACS activities. I note the importance of the LTMP in involving multiple trophic levels which is essential to understand the full impact of environmental changes in a marine ecosystem. Plankton are an essential component to study and monitor. They are the foundation of marine pelagic ecosystems, providing the food that drives the system as well as ecosystems service that humans depend on. Climate change impacts are most likely to affect plankton first before cascading through the rest of the marine ecosystems. Changes in plankton have resulted in significant, ecosystem, commercial and societal impacts. The North Pacific CPR Survey is a well established plankton monitoring program, producing an important regular time series on plankton over a very large area of the far northern Pacific. The survey can also be used as a focus and link for other plankton research activities. The CPR data contributes significantly to understanding both local and regional patterns, has become an important member of the PICES community, and subsequently contributes to the bigger picture of plankton change at a global level. GACS fully supports the North Pacific CPR Survey’s application, and hope is successful in gaining NPRB support.

Yours sincerely,

Dr Graham Hosie
Chair, Board of Governance
Global Alliance of CPR Surveys

3 July 2013
5 February 2014

Dear Sir or Madam
North Pacific Research Board

**The North Pacific Continuous Plankton Recorder Survey – Sonia Batten and Alex Bychkov**

This is to confirm that the Sir Alister Hardy Foundation for Ocean Science fully supports the proposal for the North Pacific Continuous Plankton Recorder Survey to the North Pacific Research Board’s Long-term Monitoring Program 2014-2019. SAHFOS continues to provide in-kind support to the Survey.

SAHFOS employs Dr Sonia Batten as the North Pacific CPR Survey Co-ordinator on a permanent contract of employment.

Yours faithfully

[Signature]

Professor Nicholas J P Owens
Director
This letter is to indicate support by the North Pacific Marine Science Organization (PICES) of a pre-proposal on “The North Pacific Continuous Plankton Recorder Survey” submitted for the Long-term Monitoring Program to be funded by the North Pacific Research Board in 2013-2018.

PICES is an intergovernmental scientific organization established by an international convention in 1992 in order to promote and coordinate marine scientific research in the North Pacific and adjacent seas. The current PICES member-countries are Canada, Japan, People’s Republic of China, Republic of Korea, Russian Federation, and the United States of America.

Recognizing the Continuous Plankton Recorder (CPR) as the only long-term biological indicator of global change on the scale of the North Pacific, PICES has endorsed the North Pacific CPR survey in 1999 and, since 2008, manages the funding consortium that supports this regional activity. The survey has entered its 14th year of sampling in 2013, and the time series generated by the survey has contributed greatly to our understanding of biological responses to North Pacific climate change and was an indispensable part of the first two PICES North Pacific Ecosystem Status Reports (2004 and 2010). CPR information has long been a part of the annual State of the Pacific Ocean report produced by Fisheries and Oceans Canada, and has been included, as an ecosystem indicator, in the annual stock assessment report of the North Pacific Fishery Management Council for the last 4 years.

PICES also maintains, under its Technical Committee on Monitoring, a CPR Advisory Panel comprising scientists representing each PICES member country (Dr. Sonia Batten is an ex-officio member of the Panel). The Panel meets annually to contribute advice and oversee the project. Reports from the Panel are available at http://www.pices.int/members/advisory_panels/cpr.aspx.

An adopted consortium approach, under the auspices of PICES (current members of the consortium are: NPROB, Fisheries and Oceans Canada, EVOSTC through its long term monitoring program Gulf Watch Alaska, the Sir Alister Hardy Foundation for Ocean Science, and Japan Society for the Promotion of Science) has been successful, and has significantly reduced the level of support required from each organization. We hope that the North Pacific CPR Survey will be included in NPROB’s Long-term Monitoring Program and look forward to the resulting cooperation.

Yours sincerely,

[Signature]

Thomas Therriault
Science Board Chairman-elect