

## Two decades of the North Pacific CPR program

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Participants of Workshop 5 at PICES-2019, Victoria, Canada.

### *Early days*

The North Pacific Continuous Plankton Recorder (CPR) Survey is essentially as old as PICES itself. At the very first PICES meeting, held in 1992, a proposal was made by Dr. Tim Parsons to the BIO Committee for a trans-Pacific CPR survey, to be initiated as soon as possible (PICES, 1992). Discussions between PICES scientists and the North Atlantic CPR survey team, run by (then) the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) in the UK, led to a trial tow from Long Beach, California to Alaska in the summer of 1997, behind an oil tanker. The samples were processed, and in 1998 Sonia Batten attended the MONITOR Task Team meeting to present results of this demonstration tow. An Advisory Panel (AP-CPR) was convened under MONITOR to implement a regular CPR survey that would contribute to the PICES 4Cs (Climate Change and Carrying Capacity) program.

### *Establishing the Survey*

In establishing the North Pacific CPR Survey, BIO and MONITOR wished to fill the major gap in high seas plankton sampling/monitoring and provide a link between existing sampling programs in the PICES marginal regions. Open ocean plankton sampling was needed to obtain a better understanding of fisheries dynamics, especially salmonids that spend their early lives in the subarctic gyre ecosystems. Two years of initial funding was obtained and in 2000 and 2001, six monthly CPR tows during spring through summer on the California to Alaska route were undertaken; additionally, a single trans-Pacific transect from the west coast of North America to Asia was conducted. Additional

funding led to three trans-Pacific transects in spring, summer and autumn from 2002 onwards. Increased port security concerns caused the oil tanker company to pull out of the program in 2003, so from 2004 onwards the transect into Alaska began in Juan de Fuca Strait, across the Gulf of Alaska to Cook Inlet, run six times per year from container vessels. Eventually, a funding consortium was set up, administered by PICES, so several agencies could contribute modest amounts in their area of interest (much less than the full costs of acquiring the data) and by the leveraging that this generated, ensured more financial security for the program. Contributors to the consortium over the years have included the North Pacific Research Board, the Exxon Valdez Oil Spill Trustee Council, Fisheries and Oceans Canada, SAHFOS, the Marine Biological Association (UK), PICES, JAMSTEC, Japan Society for the Promotion of Science, Japan Fisheries Research and Education Agency, and Hokkaido University. To all, we offer our sincere appreciation.

As of this year (2019), over 30,000 CPR samples (Fig. 1) have been collected and stored in the archive. One-third of the samples have been microscopically processed giving information on distribution and abundance for over 400 taxa (larger phytoplankton, some microzooplankton and mesozooplankton), and some additional components of the pelagic environment such as pollen and microplastics. Data for selected regions are available through the PICES website at <https://pices.int/projects/tcprstnp/main.aspx>, and all raw data are available on request. Sampling further north into the Arctic was also undertaken in 2018 and 2019 and it is a goal of the Global Alliance of CPR Surveys that this sampling is sustained.

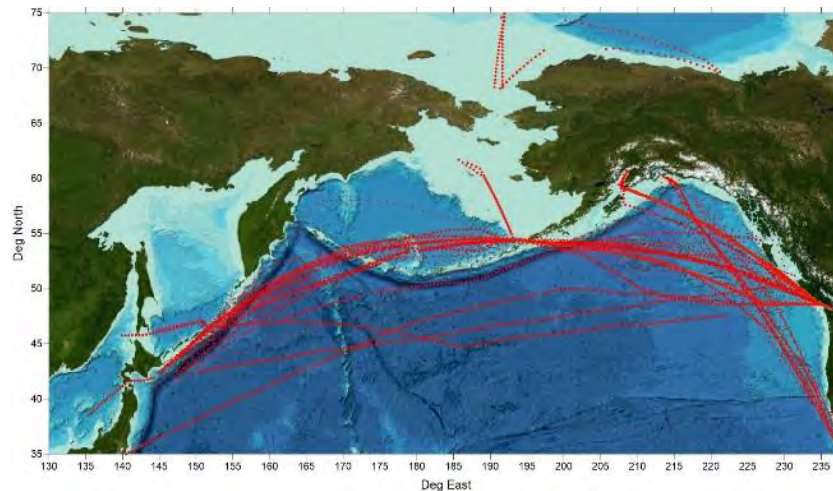


Fig 1. Location of CPR sampling from 2000 to 2019.

### Adding value

In addition to sampling the North Pacific plankton community, we have sought to expand the program and make the most of the sampling platform. Loggers mounted to the CPR (data are available from the [PICES website](#)) now measure ocean conditions including temperature, sometimes salinity and chlorophyll fluorescence. A separately-funded NPRB study added marine bird and mammal observations to the trans-Pacific transects for 5 years (2002–2007) to give simultaneous daytime observations of lower and upper trophic levels from North America to Asia (Sydeman *et al.*, 2010). Molecular techniques have been used to identify genetic variability within a species (Kirby *et al.*, 2007), and to identify organisms not distinguishable during routine sample analysis (such as *Pseudonitzschia* species, Stern *et al.*, 2018). More recently, stable isotopes have been measured in zooplankton specimens taken from samples across the Gulf of Alaska to model patterns of primary and secondary productivity (Espinasse *et al.*, 2019).



Volunteer commercial vessels that tow the CPR in the North Pacific (left and right columns).



### Outputs

Right from the beginning there was a need to include the results from the survey in regional ecosystem status assessments and reports. The Fisheries and Oceans Canada State of the Pacific Ocean annual report was one such venue (*e.g.*, Boldt *et al.*, 2019), as well as NOAA's [Ecosystem Considerations reports](#) for Alaskan waters, and of course the North Pacific Ecosystem Status Reports produced by PICES. Peer-reviewed publications which include Pacific CPR data are many. Some of the more notable ones are included in the reference list at the end of this article.

### Workshop at PICES-2019

As October 2019 marked the completion of the 20<sup>th</sup> year of North Pacific CPR sampling, we felt it was timely to hold a celebratory workshop at the PICES Annual Meeting to look forward as well as review past accomplishments. The workshop began with three introductory talks by the Conveners, covering CPR basics and the history of the North Pacific CPR Survey (Batten), studies that have linked the plankton data with higher trophic levels (Sydeman), and basin-scale studies on PDO-ecosystem variation using data from standard and special surveys conducted in the subarctic



North Pacific (Chiba). Our invited speaker, Pierre Heulouet from the North Atlantic CPR Program, described numerical methods for examining plankton communities with 60 years of data to stimulate ideas. There were then three contributed talks which described i) the use of CPR samples to examine spatial variation in ocean productivity patterns using stable isotopes (B. Hunt), ii) linking zooplankton community structure with large-scale SST and currents data from satellites (B. Hoover), and iii) the recent expansion of CPR transects into the Arctic Ocean including potential areas for future study (Ostle). The session also included one poster looking at western Pacific large copepod dynamics. Workshop presentations gave a thorough overview of many aspects of the Pacific CPR program from all regions, from detailed community data to using the sample archive. Presentations can be accessed via the PICES website at: <https://meetings.pices.int/publications/presentations/PICES-2019>.

Following the presentations there was a 45-minute period of audience discussion on issues reported and priorities for the future. The main points are summarized below:

- There was discussion about finer-scale resolution of the Pacific data since only about 1/3 of the samples are routinely processed. Satellite data can sometimes be used to identify mesoscale processes such as eddies but the sampling resolution of the CPR may miss this. It was pointed out that archived samples can be processed to fill in finer-scale as required for special projects, though there is a limit to how fine a scale CPR data can be used to inform as it is designed for large-scale sampling.
- The issue of microplastics contamination and sampling in CPR samples was discussed. The type of microplastics can be categorized quickly by new technology so that the likely contaminants (fibres) can be eliminated, and there can be a focus on particles whose presence will be due to ocean pollution. It was also mentioned that a time series is necessary to be able to determine when mitigation actions are being successful (as countries try to achieve their sustainability goals) and the CPR offers one of the only possibilities for such a time series.
- There was strong support for continuing to work in the Arctic, especially with the recent declines in sea ice in the northern Bering and Chukchi seas. It was also felt that a north to south transect extending into the transition zone proper would be very useful, for example, Alaska to Hawaii to fill the geographical data gap in lower latitudes.
- There was some discussion on emerging technologies, some of which are being considered alongside the Atlantic CPR program (for example, optical and DNA methods) and the additional sensors that can be attached to the CPR itself (Planktags to record temperature and salinity, CO<sub>2</sub> sensors). The group agreed that having simultaneous physical data was valuable since satellites only see the surface skin and salinity especially would be useful.
- The value of the funding consortium was seen as a major strength in that it gives the survey resiliency if one party withdrew. The importance of having early results, being timely with updates, and getting these updates into regular assessments was also seen as contributing to the success of the survey.

Overall, the survey has achieved the vision of those who sought to bring it to PICES at the very first meeting, recognizing the need for seasonal plankton data in the open ocean and coasts of the PICES region. It has had a successful first 20 years, and is in a good position to contribute to PICES science for years to come.

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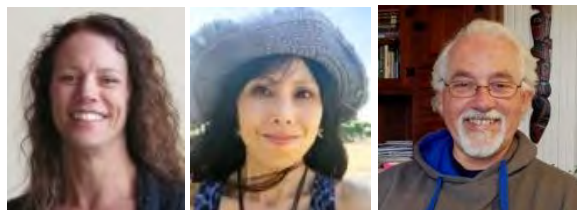
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*Dr. William (Bill) Sydeman (wsydeman@comcast.net) is a veteran ecosystem ecologist and participant in the PICES community. Dr. Sydeman served as the Co-Chair of the Advisory Panel for Marine Birds and Mammals from 2003 to 2010, and remains a member of the group, now classified as a Section. He has worked on the concept of seabirds as ecosystem indicators for decades, and currently conducts a variety of projects on forage nekton (krill and forage fish), seabirds, and marine mammals from the North Pacific to the South Atlantic (Benguela Current) focusing primarily on climate change, winds and upwelling, and ecosystem impacts.*

## PICES calendar of events for 2020

[National Academy of Sciences Workshop – Emerging Technologies to Advance Research and Decisions on the Environmental Health Effects of Microplastics](#) January 27–28, 2020, Washington, DC, USA

[PICES-2020 Spring School – Coastal ocean observatory science](#)  
March 4–8, 2020, Kagoshima, Japan

[International Symposium – Plastics in the Arctic and the Sub-Arctic region](#)  
April 21–23, 2020, Reykjavik, Iceland

[Ocean Past VIII Conference – Historical perspectives on marine ecosystems, fisheries, and futures](#)  
May 10–13, 2020

[MSEAS-2020 – Managing for sustainable use of the Earth's marine and coastal systems](#)  
May 25–29, 2020, Yokohama, Japan

[ESSAS Annual Science Meeting – Linking past and present marine ecosystems to inform future fisheries and aquaculture](#)  
June 1–3, 2020, Sapporo, Japan

[ICES Annual Science Conference 2020](#)  
September 7–10, 2020, Copenhagen, Denmark

[PICES-2020 – How does 30 years of research on changing North Pacific ecosystems inform the UN Decade of Ocean Science for Sustainable Development Goals?](#) October 22–November 1, 2020, Qingdao, China