Report on the Technical Committee on Monitoring

The Technical Committee on Monitoring (hereafter MONITOR) met twice in Yokohama, Japan: 1) 18:00 to 20:00 on Sunday, October 28, 2018 and 2) 14:00 to 18:00 on Wednesday, October 31, 2018. Prior to the meetings, a MONITOR briefing book, containing the draft agenda and information regarding agenda items, was circulated to MONITOR members. The briefing book was updated and recirculated as new information was provided.

MONITOR meeting participants (from left to right) front row: Sung Yong Kim, Sanae Chiba, Sonia Batten, Tetjana Ross, Masakazu Higaki; back row: Hiroto Abe, InSeong Han, Sai-Ichi Saitoh, Vladimir Kulik, Kazuaki Tadokoro, Tae Dong Kim, Jennifer Boldt, Lisa Eisner, Jack Barth, Vyacheslav Lobanov

Sunday, October 28, 2018

AGENDA ITEM 1
Welcome and introductions

MONITOR Chair, Dr. Jennifer Boldt, called the meeting to order, participants introduced themselves, and the agenda was reviewed and adopted (***MONITOR Endnote 1****and* ***MONITOR Endnote 2***).

AGENDA ITEM 2
PICES-2018 information and judges

a. Topic Sessions and Workshops

MONITOR was a sponsor of the following Topic Sessions at PICES-2018:

MONITOR Topic Session (S11) on "*Influence of climate and environmental variability on pelagic and forage species*", Co-Convenors: Matthew Baker (USA), Sei-Ichi Saitoh (Japan) , Mary Hunsicker (USA) Elizabeth (Ebett) Siddon (USA)

b. Judges for the best presentation award (MONITOR members)

MONITOR was tasked by the Science Board Chair to judge the MONITOR-sponsored Topic Session S11.

Best Oral Presentation was awarded to early career scientist, Yanhui Zhu, for the talk titled "*Seasonal dynamics in pelagic fish abundance around Set-net in Kochi prefecture*". Best Poster was awarded to early career scientist, Mitsuhiro Ishino, for the poster titled "*Why the body size of walleye pollock larvae in Funka Bay and the adjacent waters, Hokkaido was large in 2016?*" (see Best Presentations at PICES-2018).

AGENDA ITEM 3
Reports from PICES groups

a. FUTURE SSC

Dr. Lobanov provided an overview of the FUTURE science program, including objectives and recent activities (*e.g.*, synthesis paper).

b. Activities of AP-NPCOOS

An overview AP-NPCOOS activities was provided by Co-Chairs Drs. Kim and Barth.

Membership changes: Mr. Yingze Sun (PR China) stepped down as member.

AP-NPCOOS hosted a summer school in Sidney, British Columbia, that provided a hands-on experience conducting quality control and assurance of data obtained from coastal ocean observing system. There were 28 participants from 14 countries (5 PICES member countries) selected from 104 applications. Included were lectures at the Institute of Ocean Sciences (IOS) and Oceans Network Canada (ONC), sampling cruises on the R/V *Strickland* in Saanich Inlet, analyses of DFO mooring data, ferry trips to Tsawwassen (ferry data sampling), and a visit to the Vancouver Aquarium for an information on microplastics.

MONITOR meeting participants discussed the value of summer schools such as this one. Given that many people could not attend, it was suggested perhaps the course material could be made available online and, in the future, the option of an online class might be worth considering

AP-NPCOOS is planning a 5-day summer school for the fall of 2020, Yokohama National University facility, Japan. This will be co-sponsored with WG 37 and organized by Drs. N. Yoshie, T. Kobari, S. Shimode. They expect approximately 20 students and early career scientists to participate. A full summer school proposal will be submitted to PICES early in 2019.

AP-NPCOOS members are also working on a set of publications focusing on examples of success stories to fulfill regional and national needs via coastal ocean observing system efforts.

AP-NPCOOS proposed a 1-day topic session for PICES-2019 on coastal ocean observing and how to deliver Essential Biological and ecological ocean variables. In addition, the AP proposed a 1-day workshop on bioacoustics as an effective way to measure upper trophic levels given consistent measurement techniques, quality control, and analyses. They also requested 0.5 day for a business meeting at the PICES-2019.

c. Activities of AP-CREAMS

Dr. Lobanov provided a summary of AP-CREAMS. The term of AP-CREAMS ends in 2019, and this will be discussed at their April 2019 workshop, before the inter-sessional Science Board meeting.

Membership changes: Dr. Ryan Rykaczewski is a new member representing USA; Prof. Guebuem Kim is a new member replacing Prof. Kyung-Il Chang (Korea); Prof. Kyung-Ryul Kim stepped down as Co-Chair and member and a suggested replacement is Dr. Jae Hack Lee (current member); a suggested new member is Prof. Sung Huyn Nam (Korea).

AP-CREAMS activities over the past year have included:

1. Meetings:
    a. AP Meeting on May 4–5, 2018, Hangzhou, China
    b. AP Meeting on Oct. 26, 2018 at PICES-2018, Yokohama, Japan
2. Joint Cruises:
    a. Ferry box monitoring between Donghae and Vladivostok
3. Publications:
    a. EAST-II area: "Oceanography of the Yellow and East China Sea" in a PICES Scientific Report series - completed and submitted to MONITOR and POC for review
    b. NPESR3, Region 19 – in preparation; planned finish date: March 1, 2019

The next AP-CREAMS meeting will be held in spring 2020, which will mark 15 years of CREAMS. Towards celebrating 15 years of AP-CREAMS, the AP proposed a workshop for the PICES 2019 titled "*Circulation, biogeochemistry, ecosystem, and fisheries of the western North Pacific marginal seas: Past and future of CREAMS (Circulation Research of East Asian Marginal Seas)*". AP-CREAMS also requested 0.5 day for a business meeting at the PICES-2019.

AP-CREAMS submitted a proposal for a summer school titled "*Ocean turbulence: from observing to research*", planned for August 2019 in Qingdao, China. It is anticipated that 25–30 students and early career scientists will participate.

MONITOR members volunteered to review different sections of the EAST II report. Reviews will be due by December 2018.

Action: reviewers to provide their review on EAST II report to the MONITOR chair by Dec. 17, 2018.

AGENDA ITEM 4
Relations with PICES, international, and national organizations and programs

a.) Pacific Continuous Plankton Recorder (CPR) program and activities of Sir Alister Hardy Foundation for Ocean Science (SAHFOS) and GACS

1. The Continuous Plankton Recorder Survey

In April this year the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) which was responsible for the North Pacific and North Atlantic CPR surveys merged with the Marine Biological Association of the United Kingdom. This was for mainly for practical and economic reasons and essentially there is no fundamental change in major personnel or day-to-day operations. We are now the "CPR Survey at the MBA".

While routine CPR surveys are the core activities, instrumentation and molecular work remain as two key development areas. Using the CPR as a platform for other instrumentation continues to expand, with a new generation of the "Planktag" received this summer (engineered for longer deployments with a bigger battery and more memory) to record conductivity, temperature, ambient light and chlorophyll-a on selected transects. The molecular work enables the CPR samples to be used to assess a wide taxonomic range from viruses, bacteria, protists through the plankton to fish. Techniques for metagenetics, metagenomics and metatranscriptomics will further provide information on function as well as taxonomy.

2. Global Alliance of CPR Surveys (GACS)

The last GACS Annual meeting was in December 2017, with the upcoming meeting in November 2018. All regional surveys are continuing and there were no new surveys added this year. Focus at PICES-2017 was on the recording of microplastics, which surveys do so and how to compare between regions. It is expected that this will continue to be an area for joint study.

3. North Pacific CPR Survey

We are just completing the 19th consecutive year of the North Pacific CPR survey. The figure below shows the location of collected samples with 2018 samples in yellow.

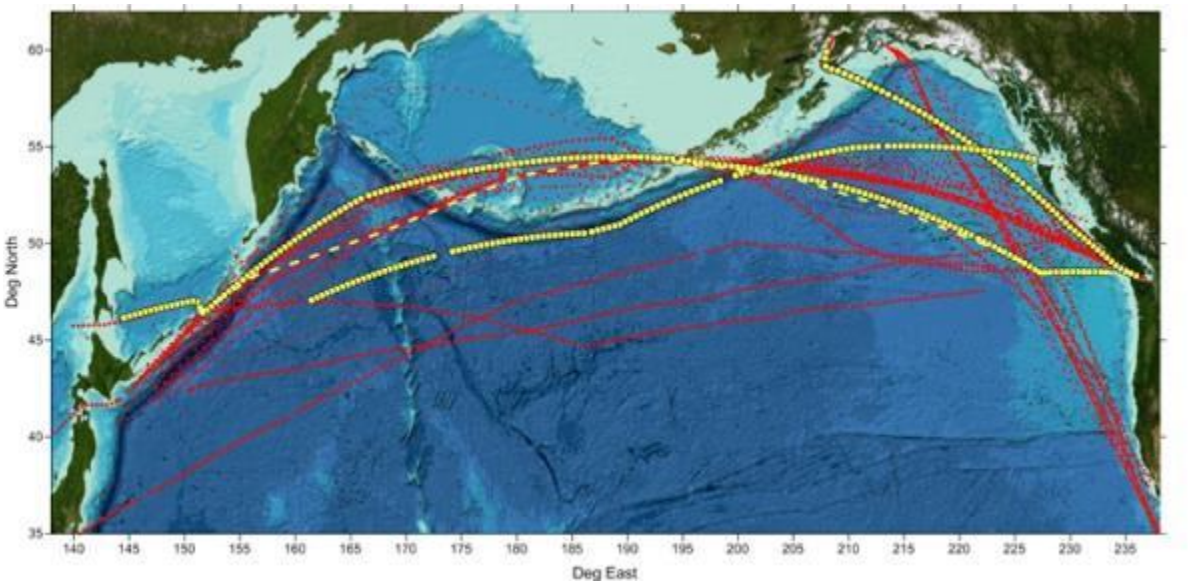


Fig 1. Historical (2000-2017) CPR samples (red) and 2018 transects (yellow). The September trans-Pacific samples have not yet returned so location from log forms is indicated by the dashed line.

2018 has seen the usual mix of highs and lows: A new vessel for the trans-Pacific transect was fitted with a towing point in March and has since carried out three successful west-bound transects (the March transect went south of the Aleutians and the last section failed due to a jammed mechanism). Some routing changes next year will add a logistical challenge but essentially it is working well. Unfortunately, the CPR on the Juan de Fuca to Alaska transect was lost in August, likely it hit something in the water. Although a spare instrument was shipped out to complete the year's sampling in September and October, the samples from August were lost, as well as the CTD that was attached to the CPR.

Dr. Batten met with Dr. Atsushi Yamaguchi from Hokkaido, Japan, in September to discuss the CPR program; he has some interest in the western sample analysis that has been coordinated by Dr. Sanae Chiba to date.

A CPR was towed in the western Arctic from the Canadian DFO ship the *Sir Wilfred Laurier* in summer as a pilot project. Analysis of the samples and exploration of additional opportunities is ongoing.

There were four presentations at PICES-2018 utilising North Pacific CPR data:

- Topic Session (S1) on "*Toward integrated understanding of ecosystem variability in the North Pacific*": oral presentation by Robert Suryan on "*Ecosystem variability and connectivity in the Gulf of Alaska following another major ecosystem perturbation*" co-authored by Stephani Zador, Mandy Lindeberg, Donna Aderhold, Mayumi Arimitsu, John Piatt, John Moran, Janice Straley, Heather Coletti, Dan Monson, Thomas Dean, Russell Hopcroft, Sonia Batten, Seth Danielson, Benjamin Laurel
- Topic Session (S2) on "*Fish production through food web dynamics in the boundary current systems*": oral presentation by Boris Espinasse on "*Defining isoscapes in the Northeast Pacific as an index of ocean productivity*" co-authored by Brian Hunt, Sonia Batten and Evgeny Pakhomov
- Topic Session S11on "Influence of climate and environmental variability on pelagic and forage species": poster presentation by Chris Rooper on "*Linkages between pelagic temperature and zooplankton abundance, and growth and recruitment of Pacific ocean perch in Alaska*" co-authored by Jennifer L. Boldt, Peter-John F. Hulson, and Sonia Batten
- Workshop (W3) on "Development of a systematic approach to data management in PICES"; poster presentation by Sonia Batten on "*Data from the North Pacific Continuous Plankton Recorder Survey*"

To celebrate 20 years of the North Pacific CPR program, a workshop titled "*Celebrating two decades of North Pacific CPR sampling, and future directions*" was proposed for PICES-2019.

4. SCOR WG

Dr. Batten represents PICES as an Associate Member of the SCOR WG on *Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs* (P-Obs). The group has so far met only once, in February 2018 at a kick-off meeting alongside Ocean Sciences Meeting in Portland, Oregon, USA.

The main goal of the WG is to "Identify best practices (technologies and sampling protocols) and technical feasibility to incorporate plankton measurements into global ocean observing platforms (initially GO-SHIP and for expansion into the mooring array of OceanSITES).

The first deliverable has already been met, an article about the WG inviting feedback:
Boss, E., Waite, A., Muller, Karger, F., Yamazaki, H., Wanninkhof, R., Uitz, J., Thomalla, S., Sosik, H., Sloyan, B., Richardson, A., Miloslavich, P., Karstensen, J., Grégori, G., Fennel, K., Claustre, H., Cornejo, M., Berman-Frank, I., Batten, S. and Acinas, S. (2018), Beyond Chlorophyll Fluorescence: The Time is Right to Expand Biological Measurements in Ocean Observing Programs. *Limnology and Oceanography Bulletin*, 27: 89-90. doi:10.1002/lob.10243 (Available at https://aslopubs.onlinelibrary.wiley.com/doi/10.1002/lob.10243)

The group is now reviewing existing technologies and working on drafting manuals which will form another major output. WG P-Obs plans to meet in 2019 in conjunction with OceanObs19.

b.) World Ocean Assessment II

The United Nations Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects, commonly called the 2nd Process of the World Ocean Assessment (WOA II), was launched in 2016 and plans to publish the assessment document in 2020.

The outline structure of WOA II was drafted by the Group of Experts (GoEs), the leaders of writing teams, in January 2018, and approved by the AHWGW in April 2018. The Pool of Experts (PoEs), which will be writers

or reviewers of WOA II, were nominated by each state and intergovernmental organization, including PICES. Among 531 PoEs, 168 are from PICES countries (Canada, 32, China, 30; RoK, 17; Japan, 21; USA, 68), but there are no experts nominated from Russia. The Group of Experts has organized the writing team of each chapter. Dr. Sanae Chiba is a member of the GoEs.

WOA II plans to have a series of regional workshops from August to December 2018 in Palau, Malta, Ukraine, Indonesia, Qatar, Ghana and Ecuador for the writing teams to discuss the contents of the chapters assigned for the respective workshops. Invitation letters to the regional workshops will be sent from UN DOALOS, the Secretariat of WOA II, to all PoEs. Draft chapters will be completed by June 30, 2019

c.) OceanObs19

Dr. Chiba, Program Committee Co-Chair reported that OceanObs19 will be held on September 16–20, 2019 in Honolulu, Hawaii, USA. This is the third of the decadal conference series to galvanize international community to network and develop effective strategies for a sustained, multidisciplinary and integrated ocean observing system. OceanObs99 resulted in an internationally coordinated system for physical climate and ocean carbon observations. OceanObs09 expanded the range of communities working together to undertake more comprehensive and sustained ocean observations and led to the Framework for Ocean Observing. OceanObs19 expands the concept of FOO and particularly focuses on end-user engagement, their needs for ocean observing networks and deliverables.

Community White Papers (CWP) of OceanObs19 will be peer reviewed and published in *Frontiers in Marine Science* prior to the conference. About 130 CWP writing teams are currently working on their drafts toward the due date of October 31, 2018. The detailed conference structure is under development, and a call for poster presentations and registration has opened at the end of September.

AGENDA ITEM 5
Quick overview of information

a.) POMA

MONITOR members were asked to encourage additional nominees for next year's POMA (PICES Ocean Monitoring Service Award). This award aims to recognize organizations, groups and outstanding individuals that have contributed significantly to the advancement of marine science in the North Pacific through long-term ocean monitoring and data management.

Action: Members to encourage and solicit nominees for POMA.

b.) Notes from ISB-2018

MONITOR sponsored a 1.5 day inter-sessional workshop of FiSCAO (the Fifth Meeting of Scientific Experts on Fish Stocks in the Central Arctic Ocean); there was no financial request. See this link for the report.

c.) PICES meeting structure

On June 26, 2018, an email was sent to MONITOR members (by the MONITOR Chair) asking about thoughts on the PICES Annual Meeting schedule. In particular, what are some of the pros and cons of the current schedule for PICES Annual Meetings? For example, some questions to consider:

- Is your expert group getting enough business meeting time at PICES Annual Meetings? *i.e.*, is the duration of business meetings sufficient for AP-CREAMS, AP-NPCOOS, WG-NPESR, and MONITOR?

- Is there enough time to improve collaborations with other organizations?
- Should the PICES Science Board Topic Session (S1) be reduced in length?
- When should the FUTURE mini-symposium take place?

Member feedback indicated that we have enough time for our business meeting and for collaborations with other organizations (unless there are new ones, then we would need to streamline the agenda). Members' thoughts on the length of the S1 session were mixed. Some thought it was adequate in length, and other thought it could be reduced if it interfered with concurrent sessions. In addition, some members commented that there could be improvements to make S1 the 'flagship' session. Members also had mixed feedback on the timing of the FUTURE mini-symposium. Most members thought that holding it between the opening and closing session would be best, to attract the most people. One member thought that the Sunday before the opening session would be better timed. Overall, if PICES wants to highlight its main science program, to get the best attendance, it might be best to convene the mini-symposium during the main meeting.

d.) ICES ASC theme session proposals:

Relevant themes might include:

- Habitat models,
- Ecosystem vulnerability,
- Management strategies in a changing ocean (MONITOR members identified this as relevant to MONITOR activities),
- Aquaculture,
- Energy transfer food webs,
- Adapting changes in environment,
- Trade-offs,
- Ecosystem structure use of traits.

e.) Other:

i. **Action:** Members were asked to submit the following to the MONITOR Chair by October 31, 2018:
   - Any proposals and requests for funding, including travel, publications, *etc*. (*e.g*., summer school);
   - Proposals for new expert groups, with suggested members and recommended co-chairs (if known);
   - Changes in expert group membership.

ii. **Action:** MONITOR members were asked to advertise PICES capacity building events to their member country students and post-docs.

iii. MONITOR Chair and Vice-Chair – election for new Chair and Vice-Chair next year
Action: members to think about being the new Chair or Vice-Chair!!

iv. **Action:** MONITOR members were asked to start reviewing PICES-2019 submitted topic session and workshop proposals

Wednesday, October 31, 2018

AGENDA ITEM 6
Welcome, Introductions, and Sign-in

MONITOR Chair, Dr. Jennifer Boldt, called the meeting to order, participants introduce themselves, and the agenda was reviewed and adopted.

AGENDA ITEM 3d
Reports from PICES groups

d. Activities of WG 35 (NPESR3)

Dr. Peter Chandler, Co-Chair of WG 35, reported on the status of the NPESR3. Lead authors have been writing regional assessments and the assessments are in various states of completion. In some cases, authors have written their assessment based at least partially on environmental time series observations that were submitted to the online system; in other cases, authors proceeded without ETSOs, and others are still waiting for ETSOs to be submitted. The timeline for producing the NPESR3 was updated. Foundation indicators (such as temperature, oxygen, zooplankton, and fisheries-related time series) will be provided to lead authors by December 2018. By January 2019, the first half of the assessments will be submitted to the Editorial Board. The remaining assessments will be submitted by February, 2019. The WG plans to convene a synthesis writing workshop in April or May, 2019 and a draft final report will be submitted by summer 2019 to its parents for review, and presented at PICES-2019.

The WG requests 1 day meeting at PICES-2019.

AGENDA ITEM 7
Proposals for PICES-2019

Members discussed and ranked proposals for PICES-2019 topic sessions, workshops, and inter-sessional workshops. Although, there were many excellent proposals, the ones that were ranked as pertinent to MONITOR and the FUTURE were identified as:
Topic Sessions:

- 2-*Marine heatwaves in the North Pacific: Predictions and impacts in coastal regions*;
- 3-*Coastal ocean modelling in the North Pacific*;
- 6-*Identifying thresholds and potential leading indicators of ecosystem change: the role of ecosystem indicators in ecosystem-based management*;
- 9,11-*Coastal Ocean Observing Systems, Essential Biological Variables, and community-based monitoring*;
- 15-*Integrating economic and social objectives in marine resource management*.

Workshops:

- W1-*Learn to effectively communicate your science*;
- W4-*Circulation, biogeochemistry, ecosystem, and fisheries of the western North Pacific marginal seas: Past and future of CREAMS (Circulation Research of East Asian Marginal Seas)*;
- W5-*Celebrating two decades of North Pacific CPR sampling, and future directions*;
- W8-*PICES contribution to Central Arctic Ocean (CAO) ecosystem assessment (Third)*;
- W9-*Synthesis of bio-acoustics programs for monitoring zooplankton and fisheries in the North Pacific*;
- W14-*Common ecosystem reference points*;
- W16-*Application of machine learning to ecosystem change issues in the North Pacific*.

Intersessional workshops:
- Identifying the existence of thresholds in marine ecosystem driver-response relationships;
- NPESR3 Synthesis Workshop;
- Towards an integrated approach to understanding ecosystem predictability in the North Pacific [formerly W18].

AGENDA ITEM 8
Relations with PICES, international, and national organizations and programs, *continued*

a.) Argo

Dr. Toshio Suga, representing the 2018 POMA Argo Steering Team, provided a summary of the Argo program (***MONITOR Endnote 3***).

Given the value of data provided by Argo floats and given that the new floats provide essential ocean variables, MONITOR members strongly support Argo. wrote a recommendation to PICES:

Recommendation: MONITOR recommends all PICES member countries to support Biogeochemical Argo float efforts in the North Pacific.

The global Argo float program has been very successful in its primary mission to measure changes in the heat content of the ocean under climate change. Argo floats are deployed by PICES member countries and the data from the entire array are used by PICES scientists. Argo float coverage in the North Pacific is predicted to be good for the basic Argo floats, *i.e*., those that measure temperature, salinity and pressure.

A new type of Argo float is now available for routine operation. The "biogeochemical" (BGC) Argo float can measure the following parameters that are important to understanding biogeochemical processes and changes in the ocean. Six core biogeochemical sensors in the BGC-Argo are:
- Oxygen (by fluorescence lifetime)
- Nitrate (by direct UV spectroscopy)
- pH (by Ion Sensitive Field Effect Transistor)
- Chlorophyll (by fluorescence emission)
- Particle abundance (by optical backscatter)
- Downwelling irradiance with wavelength resolution.

In July 2018, IOC/UNESCO formally approved the global implementation of BGC Argo measuring the six BGC parameters. BGC Argo is now at the "regional pilot array" phase and deployed under several research projects. Over 300 BGC Argo floats are operating now. The big hole of the pilot arrays of BGC Argo is in the North Pacific due to lack of a major scientific initiative there.

Because of the importance of measuring and monitoring changes in, among others, dissolved oxygen and pH in the North Pacific, the MONITOR recommends that PICES encourage and support scientific programs in PICES member countries that will deploy BGC Argo floats in the North Pacific.

b.) North East Asian Regional (NEAR-GOOS)

Dr. Masakazu Higaki, Chairman of the IOC/WESTPAC Coordinating Committee for NEAR-GOOS NEAR-GOOS provided recent updates.

The North-East Asian Regional-Global Ocean Observing System (NEAR-GOOS) is the first regional pilot project of GOOS. Initiated in 1996, NEAR-GOOS aimed to facilitate the sharing of oceanographic data in the marginal seas bordered by the partner countries: China, Japan, Korea and Russia. The major achievement of NEAR-GOOS at its first phase features the establishment of a network of real-time and delayed mode databases accessible online free-of-charge, with these databases being operated by designated national agencies. Despite some restrictions on oceanographic data exchange in some member states, NEAR-GOOS archives now contain 59 types of data with total volume of 210 GB (as of June 2018). A challenge for NEAR-GOOS at its second phase (after 2003) was to advance from data management to jointly developing sustained regional integrated ocean observations and delivering enhanced services, for a wide range of users in the region. Currently, NEAR-GOOS has three working groups on data management, products, and ocean forecasting system (OFS). Recent NEAR-GOOS projects include Cross Basin Climate Monitoring Section implemented by Japan and Russia since 2011, enhancement of OFS since 2016, and ferry box monitoring since 2018. The NEAR-GOOS workplan for 2018–2019 includes:

- Continuation of NEAR-GOOS Climate Monitoring Section as a pilot project implemented by JMA (Japan) and POI (Russia) with the aim to understand long-term variability of the water mass structure caused by climate change in the region since 2011;
- Continuation of the development of regional observing capacity through the improvement of the national observing systems as well as communication of operational data when it is possible;
- Enhancement communication with other GOOS Regional Alliances (GRAs) through participation in GRAs teleconferences and GRA Forum;
- Strengthening collaboration with other regional organizations and programs (*e.g*., PICES, PAMS, PACON, *etc*.);
- Organizing the 19th Session for NEAR-GOOS Coordinating Committee from November 13-15, 2018 in Bangkok, Thailand, including the 2nd Technical Meeting of OFS WG.

Action: Drs. Sung Yong Kim and Jack Barth to contact NEAR-GOOS for an update at next year's meeting to increase the awareness of NEAR-GOOS.

c.) Central and Northern California Ocean Observing System (CeNCOOS)

Alex Harper provided a summary of CeNCOOS and SCCOOS activities (***MONITOR Endnote 4***).

d.) U.S. Ocean Observatories Initiative (OOI) and Northwest Association of Networked Ocean Observing Systems (NANOOS)

Dr. Barth provided an overview of the U.S. Ocean Observatories Initiative (OOI) and Northwest Association of Networked Ocean Observing Systems (NANOOS). See *MONITOR Endnote 7* for full presentations.

e.) Alaska Ocean Observing System (AOOS) –Eisner

Dr. Lisa Eisner provided an overview of AOOS activities (***MONITOR Endnote 5***).

f.) GOOS BIO-ECO –Batten/Chiba

The panel will have its next meeting in November. Several publications have resulted from the panel's activities in 2018 which are of relevance to MONITOR:

Bax, N. J., Appeltans, W., Brainard R., Duffy J. E., Dunstan P., Hanich Q., Harden D. H., Hills J., Miloslavich P., Muller-Karger F. E., Simmons S., Aburto-Oropeza O., Batten S., Benedetti-Cecchi L., Checkley D. Chiba S., Fischer A., Andersen G. M., Gunn J., Klein E., Kudela R. M., Marsac F., Obura D., Shin Y.-J.,

Sloyan B., Tanhua T., Wilkin J. (2018) Linking Capacity Development to GOOS Monitoring Networks to Achieve Sustained Ocean Observation. Frontiers in Marine Science, 5 (346) doi: 10.3389/fmars.2018.00346

Chiba, S., Batten, S., Martin, C.S., Ivory, S., Miloslavich, P., and Weatherdon, L.V. (2018) Zooplankton monitoring to contribute towards addressing global biodiversity conservation challenges, Journal of Plankton Research, https://doi.org/10.1093/plankt/fby030

Miloslavich P, Bax NJ, Simmons SE, et al. (2018) Essential ocean variables for global sustained observations of biodiversity and ecosystem changes. Glob. Change Biol. 2018, 24:2416–2433. https://doi.org/10.1111/gcb.14108

In addition, a workshop was convened in June 2018 towards the "Implementation of global, sustained and multidisciplinary observations of plankton communities". A report of this workshop (GOOS Report #230) can be found at http://www.goosocean.org/index.php?option=com_oe&task=viewDocumentRecord&docID=22500

g.) North Pacific Research Board (NPRB) – Baker

Dr. Matthew Baker, Science Director at the North Pacific Research Board (NPRB) provided an update to the PICES MONITOR Committee (***MONITOR Endnote 6***). NPRB supports long-term monitoring (LTM) programs to maintain time series observations, better understand system processes, assess resource trends, and evaluate effectiveness of management actions. NPRB has funded monitoring since its initial awards in 2004, including Bering Sea mooring arrays, the Continuous Plankton Recorder (CPR) surveys, physical and biological observations on the Seward Line, and data maintenance programs with NOAA, Alaska Department of Fish and Game and archival data in Russia. In 2014, the Board determined that funding for LTM projects would be issued in five-year increments and awarded funds to the CPR, Seward Line and a Chukchi Sea Observatory (moored array). Each of these programs is summarized below:

Continuous Plankton Recorder (CPR) Survey

The CPR is a mechanical device towed behind commercial ships to survey the quantity, community composition, and variability of plankton. Commercial ships tow the CPR along their regular routes. Samples are analyzed microscopically and plankton identified and counted, building a database of abundance and diversity. All samples are archived. NPRB is funding continued sampling along two paths through the North Pacific in collaboration with consortium partners: Canadian Department of Fisheries and Oceans, the Exon Valdez Oil Spill Trustee Council, the Sir Alister Hardy Foundation for Ocean Science, and the North Pacific Marine Science Organization. PICES advocated CPRs in 1998. The survey began in 2000. PICES convened a CPR-Advisory Panel meeting each year, reporting to the MONITOR Technical Committee [PIs: R. Hopcroft, K. Kuletz, S. Danielson].

Seward Line Longterm Ecological Research Network

NPRB has supported an initiative to coordinate oceanographic sampling to measure changes in the North Pacific over the past two decades (1998-2018). These cruises monitor physics, chemistry, plankton, marine bird and mammals in cross-shelf habitat of Gulf of Alaska. NPRB funding facilitates the additional assessment of microzooplankton, a critical linkage between phytoplankton and metazooan zooplankton [PIs: Danielson, C. Hauri, R. Hopcroft, A. McDonnell, P. Winsor].

NE Chukchi Sea Moored Ecosystem Observatory

NPRB contributed to the development, launch and maintenance of year-round autonomous collection of physical and biogeochemical data in the northeast Chukchi Sea. This array and related instrumentation provide data that enable analyses of wind, wave, and ice effects on regional oceanography, nutrient cycles, particulate fluxes,

carbon transfer, and Arctic cod and euphausiids dynamics. This information is intended to enable biogeochemical model validation and improve understanding of carbon and shelf-basin exchange.

In May 2018, NPRB reviewed the progress of the three projects and decided to renew funding, committing $2M over five years. The Board expressed great satisfaction with the progress of the projects and noted that the National Science Foundation designation of the Seward Line as a Long-Term Ecological Research Site represents a significant recognition of the value of this dataset.

h.) Ecosystem Study on the Sub-Arctic and Arctic Seas (ESSAS) –Saitoh

Dr. Saitoh provided a summary of ESSAS activities.
He pointed out the Belmont Forum CRA "Arctic Observing and Research for Sustainability". Japan, the US, and Norway submitted a proposal entitled "Resilience and adaptive capacity of Arctic marine systems under a changing climate RACArctic", with lead investigators: Sei-ich Saitoh, Ken Drinkwater, and Franz Mueter. This was one of ten programs accepted. A synthesis grant would run from mid- 2015 to mid-2018. The goal of the project is to review and synthesize results from national programs in the three member countries (Japan, USA, Norway) to assess the resilience and adaptive capacity of these arctic marine systems in a changing climate, from both a natural and social science perspective. The objective are to: i) review and synthesize the potential for changes in the physical and chemical oceanography under future climate using state-of-the-art models; and ii) review and synthesize what is known about potential changes at the bottom of the food web.

The third RACArctic meeting was held at Institute of Marine Research in Tromso, Norway, from 6-8 March 2018. The meeting was attended by 14 participants from Japan, US, and Norway and was primarily focused on rigorous discussion as to the contents and structure of the peer-reviewed publications, which are being prepared as one of the main outputs of this 3-year project.

In 2018, an ESSAS Annual Science Meeting was convened in Fairbanks, Alaska, USA, June 11–14, 2018. The meeting was on the "Use of Satellite Oceanography to Explore Ecosystem Dynamics in Subarctic and Arctic Regions".

Four sessions included:

Session 1: Novel applications of remote sensing in Subarctic and Arctic marine ecosystems
Chairs: Sei-Ichi Saitoh, Hajo Eicken, Takafumi Hirata

Session 2: Integrated Ecosystem Assessments in the Subarctic and Arctic
Chairs: Alan Haynie, Libby Logerwell, Benjamin Planque

Session 3: Biology, ecology and paleoecology of Arctic gadids
Co-chairs: Franz Mueter, Benjamin Laurel, Caroline Bouchard, John Nelson, Brenda Norcross, Haakon Hop

Session 4: General topics relevant to ESSAS
Workshop: Ocean Acidification and other climate stressors in high-latitude systems
Co-chairs: Samuel Rastrick, Kumiko Azetsu-Scott

An ESSAS SSC meeting was held on June 15, 2018 and the main outcomes included:

- Ken Drinkwater and Sei-Ichi Saitoh stepped down Co-Chairs and remain as ex-chairs
- Benjamin Planque (IMR) and Naomi Harada (JAMSTEC) became new Co-Chairs
- Caroline Bouchard (Denmark) and Toru Hirawake (Hokkaido University) became new members

Upcoming meetings include:

1. Integrated Marine Biosphere Research project (IMBeR) Open Science Conference; Future Oceans2: ocean sustainability for the benefit of society: understanding, challenges, and solutions, Le Quartz Congress Centre in Brest, France, June 17-21, 2019 (with workshops June 15-16, 2019). There will be an ESSAS Session titled "Arctic marine ecosystems in a changing climate" and an ESSAS Workshop titles "Bioenergetics and survival trajectories of Arctic fish in response to environmental stressors". Abstract submission and registration is now open until December 1, 2018.
2. 2020 ESSAS Annual Science Meeting, Sapporo, Hokkaido, Japan, June 12-15, 2020.

It was also noted that the ESSAS website is in the process of being moved to Hokkaido University. http://essas.arc.hokudai.ac.jp/

i.) Others

i. Arctic Council

Request for support from Libby Logerwell:

"I would like to ask the MONITOR committee to consider a request for PICES to support an International Conference on the Ecosystem Approach (EA) to management in Arctic ecosystems.

This conference is going to be organized by a planning group lead by myself and Hein Rune Skjoldal as co-chairs of the Ecosystem Approach Expert Group of the Protection of the Arctic Marine Ecosystem (PAME), a working group of the Arctic Council. This conference is also relevant to the work of the PICES/ICES/PAME Working Group on Integrated Ecosystem Assessment of the Central Arctic Ocean (WGICA), of which Sei-Ichi Saitoh is a co-chair.

The Prospectus for the Conference is attached.

We are asking PICES to provide support for the Conference in two ways:
1. Provide a PICES member for the planning group
2. Provide funding for an invited speaker or Early Career Scientist

Looking forward to seeing you in Yokohama!

Libby

_____

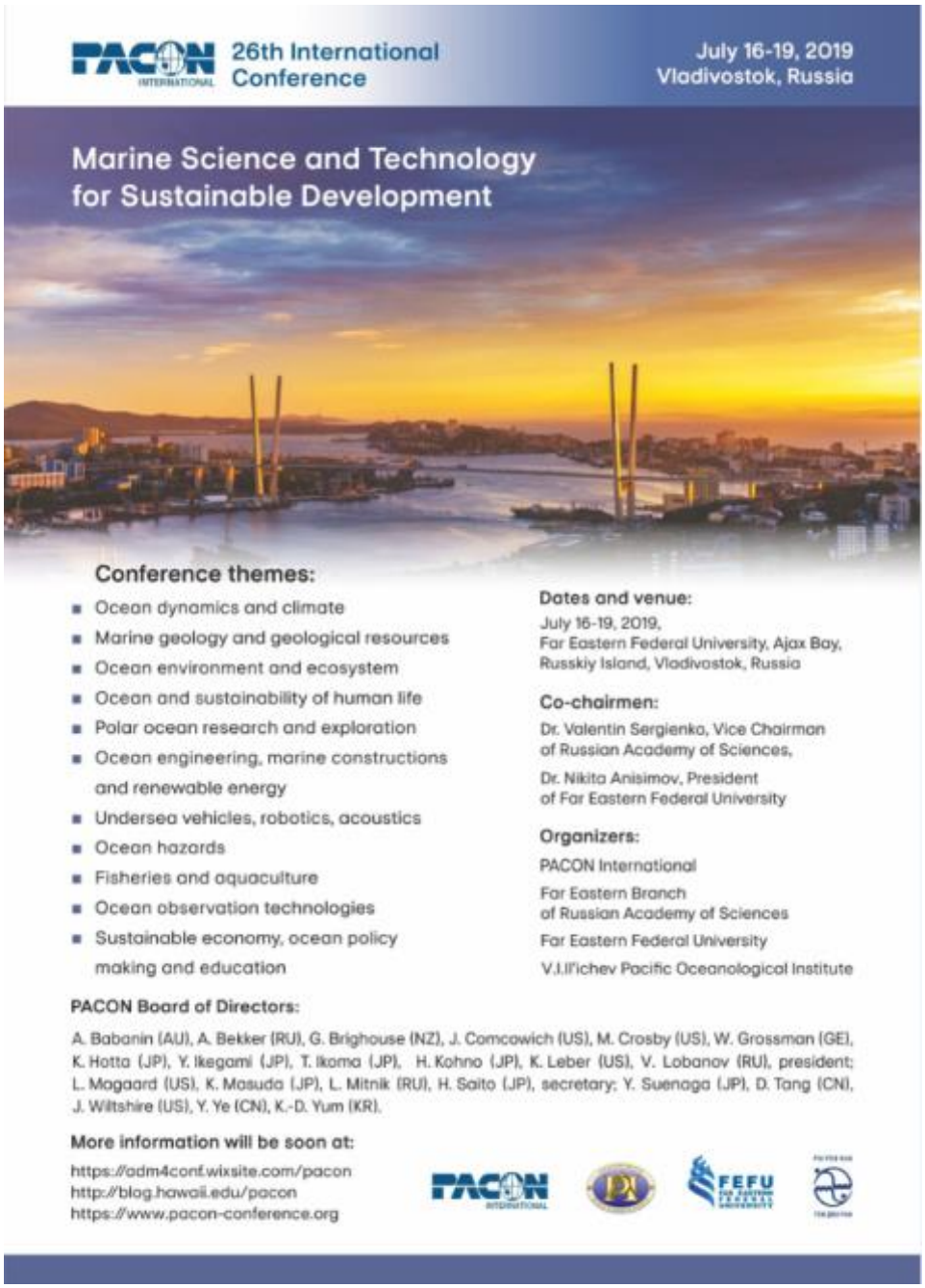
Elizabeth Logerwell, PhD.
Alaska Fisheries Science Center
7600 Sand Point Way NE
Seattle, WA 98115
phone: 206-526-4231

Action: MONITOR supports this request.

ii. PACON (Pacific congress of science and technology) Conference

Dr. Lobanov described this conference (see below) and noted the need for increase linkages between Russia and other nations. He requested from PICES co-sponsorship, support for advertising and organizing sessions, and travel support for early career scientists.

Action: MONITOR supports this request.



AGENDA ITEM 9
National reports

MONITOR members provided their reports on national monitoring. See ***MONITOR Endnote 7*** for national reports.

AGENDA ITEM 10
Other business

a. MONITOR members were asked to consider being a liaison between PICES and the International Quiet Ocean Experiment (IQOE).
b. MONITOR members supported a proposed new working group on shipping – given that ocean noise has been identified as a GOOS EOV (essential ocean variable).
c. MONITOR members also supported the proposed new Study Group on an Integrated Ecosystem Assessment (IEA) of the Northern Bering-Chukchi Seas.
d. MONITOR members supported a request for PICES support for the International Conference on the Ecosystem Approach (EA) to management in Arctic ecosystems, May/June 2019, Bergen, Norway.

MONITOR Endnote 1

MONITOR participation list

Members

Jack Barth (USA)
Sonia Batten (SAHFOS *ex officio*)
Jennifer Boldt (Canada, Chair)
Sanae Chiba (Japan, Vice-Chair)
Lisa Eisner (USA)
In-Seong Han (Korea)
Sung Yong Kim (Korea)
Vladimir Kulik (Russia)
Vyacheslav Lobanov (Russia)
Tetjana Ross (Canada)
Sei-Ichi Saitoh (Japan)
Kazuaki Tadokoro (Japan)

Members unable to attend

China: Jilong Li, Zhifeng Zhang, Xianyong Zhao
Korea: Hee Yoon Park

Observers

Hiroto Abe (Japan; Oct. 28 and 31)
Chuanxi Xing (China; Oct. 28)
Matthew Baker (NPRB; Oct. 31)
Jennifer Fisher (USA; Oct. 31)
Alex Harper (CeNCOOS; Oct. 31)
Masa Kazu Higaki (NEAR-GOOS; Oct. 31)
Tae Dong Kim (Korea; Oct. 31)
Toshio Suga (Argo; Oct. 31)

MONITOR Endnote 2

MONITOR meeting agenda

October 28, 2018, 18:00-20:00

1. Welcome, introductions, and sign-in
2. PICES-2018 information and judges
3. Reports from PICES groups (presenters, please reserve time for questions):
   a. Report from FUTURE SSC (Lobanov)
   b. Activities of AP-NPCOOS (Barth and Kim)
   c. Activities of AP-CREAMS (Lobanov)
4. Relations with PICES, international, and national organizations and programs
   a. Status of Pacific Continuous Plankton Recorder (CPR) program and activities of Sir Alister Hardy Foundation for Ocean Science (SAHFOS) and GACS (Batten)
   b. SCOR WG (P-Obs) (Batten)
   c. World Ocean Assessment II (WOA II) (Chiba)
   d. OceanObs'19 (Chiba)
5. Quick overview of information regarding:
   - PICES meeting structure
   - POMA
   - Notes from ISB-2018
   - ICES ASC theme session proposals (*we will try to do this via email*)
   - MONITOR Chair – election for new chair next year
   - Please start reviewing PICES 2019 submitted topic session and workshop proposals

October 31, 2018, 14:00-18:00

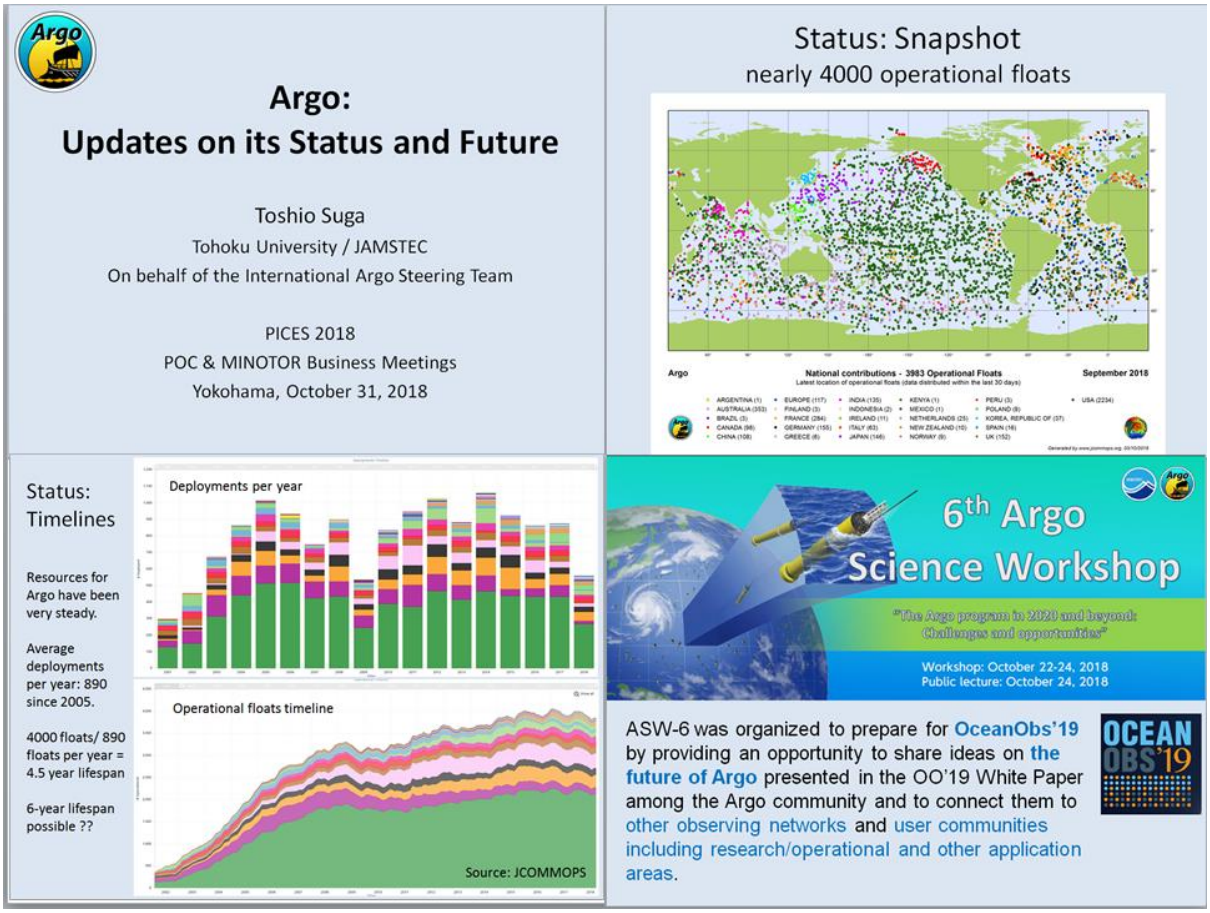
6. Welcome, introductions, and sign-in

3d. Activities of SG-NPESR (Chandler)

7. Proposals for PICES-2019
8. Relations with PICES, international, and national organizations and programs *continued*
   a. Argo – Suga
   b. North East Asian Regional (NEAR-GOOS) – Higaki/Lobanov
   c. Central and Northern California Ocean Observing System (CeNCOOS) – Harper
   d. U.S. Ocean Observatories Initiative (OOI) and Northwest Association of Networked Ocean Observing Systems (NANOOS) – Barth
   e. Alaska Ocean Observing System (AOOS) – Eisner
   f. GOOS BIO-ECO – Batten/Chiba
   g. North Pacific Research Board (NPRB) – Baker
   h. Ecosystem Study on the Sub-Arctic and Arctic Seas (ESSAS) –Saitoh
   i. Others:
      - International Conference on the Ecosystem Approach (EA) to management in Arctic ecosystems
      - Pacific congress of science and technology
9. National reports – Written and Oral
   - Canada (Boldt, Ross)
   - China (Zhao, Zhang)
   - Japan (Chiba, Saitoh, Tadokoro)
   - Korea (Han, Kim, Park)
   - Russia (Kulik, Lobanov)
   - USA (Barth, Eisner)
10. Other business

MONITOR Endnote 3

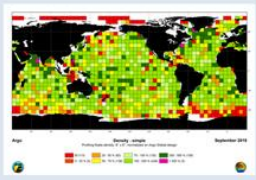
Dr. Toshio Suga, representing the 2018 POMA winning Argo Steering Team, provided a summary of the Argo program.



Plans for evolution, growth, and technical advances

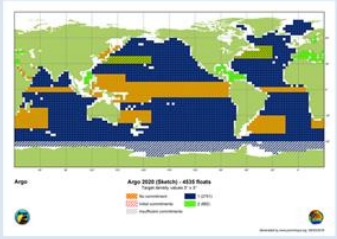
Scientific need and autonomous technology advances intersect.

- "Original" Argo left important regions with sampling gaps or insufficient coverage:
  1. High latitude/Seasonal Ice Zones
  2. Marginal seas
  3. Equatorial oceans
  4. Western boundary regions
- The deep ocean below 2000 m Core Argo depth contains critical components of ocean circulation and ocean/climate variability. These are accessible with a new generation of 4000 m and 6000 m profiling floats (Deep Argo).
- Autonomous sensors have been developed for biogeochemical parameters to address key climate problems including oceanic uptake of carbon, ocean acidification, and deoxygenation (BGC Argo).



The Argo Steering Team has discussed for many years the needed spatial enhancements for Core Argo. These were recognized but not included in Argo's original design because:

- Floats in marginal seas had unacceptable grounding rates prior to Iridium.
- Floats in the seasonal ice zone of the Southern Ocean had unacceptable failure rates prior to algorithms for ice avoidance.
- Pilot arrays and statistical analyses of early Argo coverage were needed to inform the design of equatorial and western boundary region arrays (still work in progress).

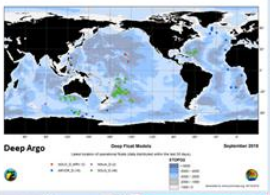


A recent JCOMMOPS map indicates regions requiring standard or enhanced Argo coverage.

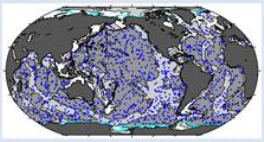
Most enhancements do not yet have committed support.

Deep Argo: Sampling from the sea surface to the bottom

Deep Argo today ~ 70 floats



Deep Argo tomorrow



The Deep Argo design (Johnson *et al.*, 2015) 1228 Deep Argo floats at 5°x5° resolution

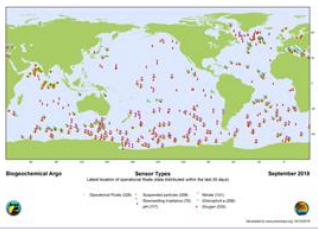
Left to right: 4000 m Deep Ninja and Deep Arvor; 6000 m Deep SOLO

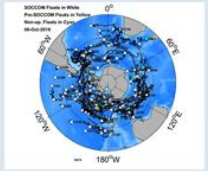
BGC Argo: Biogeochemical cycles in the global ocean

Right: The three main models of BGC-Argo floats presently in use: A. Navis, B. APEX, and C. PROVOR.

IOC/UNESCO formally approved early this year the global implementation of BGC Argo: Oxygen, Nitrate, pH, Chl., particle abundance, downwelling irradiance.

BGC Argo today

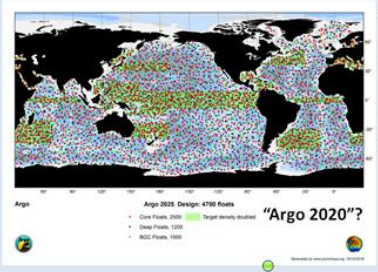




SOCCOM: A BGC Argo regional pilot array with over 100 floats

A vision for Argo in the 2020's and beyond

One array
Global in extent - full depth - multidisciplinary



Why 1 Argo rather than 3?

- Shared platforms
- Shared logistics and resources
- Shared science
- Shared data management system
- Shared EEZ protocols
- Strong synergies (e.g. Deep Argo floats provide Core Argo reference data)

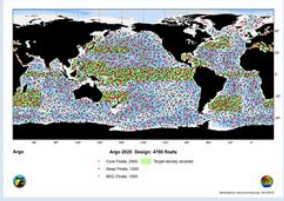
"Argo2020" and beyond: Argo will continue to evolve

3 categories of profiling floats

Experimental measurements (made outside of Argo)	Regional pilot arrays	Global deployment
Turbulence/mixing (CWP)	BGC Argo	"Original" Argo
Acoustic rain gauge	Deep Argo	
Electromagnetic velocity		
???????		

Experimental measurements:

- Demonstrate scientific value and technical readiness (lifetime, accuracy, stability, energy use)
- Deploy in small numbers
- Develop plans for transition to regional pilot arrays, and eventually global
- New measurement parameters – AST to examine consistency with IOC guidelines for drift into EEZs



How do we build greater support and awareness?

Renew or initiate 'Argo2020' outreach to our operational users:

- Seasonal to Subseasonal prediction centres
- OceanPredict
- developing coupled NWP teams
- Decadal prediction community (Deep)
- BGC reanalysis /prediction efforts (BGC)
- Water quality

Reach out to new research users

- fisheries sciences
- ecosystem sciences
- Deep ocean physics/chemistry/biology

We need increased engagement of PICES!

MONITOR Endnote 4

Central and Northern California Ocean Observing System (CeNCOOS)

CeNCOOS:
Expanding biological, ecological, and biogeochemical observing capacity in Central and Northern California

The Central and Northern California Ocean Observing System (CeNCOOS) leads the integration of coastal ocean observing capabilities to inform decision-making and promote economic, environmental, and social benefits in the region. Core observing system improvements include hardening the region's 26 High Frequency radars, continuously operating two autonomous gilder lines, maintaining a network of 15 water quality and meteorological shore stations, and integrating data from regional wave buoys and oceanographic moorings. CeNCOOS also supports modelling efforts to create integrated views of ocean conditions. New observing initiatives include the expansion of harmful algal bloom and ocean acidification observing, seagrass extant and restoration monitoring, and nutrient sensor integration. CeNCOOS is promoting the development of a regionally coordinated biological ocean observation system. Biological and ecological observing activities support a prepared and productive nation empowered to predict and manage the impacts of harmful algal blooms (HABs), hypoxia, acidification and temperature anomalies on marine biodiversity and animal movement. In the nearterm, CeNCOOS is investing in improved integration and dissemination biological information with the goal of reducing duplication of effort and to provide users with streamlined access to biology and ecosystems observational information. This streamlining effort includes improving access to imagery and data from remotely operated vehicle (ROV) surveys in California waters in the CeNCOOS Portal and the development of datastream systems protocols for EyeRIS, a newly developed underwater light-field (plenoptic) camera.

SCCOOS:

How Ocean Observations Work for You: A Perspective from the U.S. IOOS Regional Association Serving Southern California

Clarissa Anderson, SCCOOS Executive Director

Figure 1. Southern California Coastal Ocean Observing System (SCCOOS) represents the Southern California for the U.S. Integrated Ocean Observing System (IOOS®).

The regional observing systems work to collect, integrate and deliver coastal and ocean observations in order to improve safety, enhance the economy and protect the environment. The primary goal of the Southern California Coastal Ocean Observing System (SCCOOS) is to provide observations and products to a diverse stakeholder community of managers and planners, operational decision makers, scientists, and the general public. As the regional observing system for Southern California, SCCOOS, has developed the capability to support short-term decision-making and long-term assessment by implementing and leveraging biological, chemical, and physical observations and models, many of which are available in near real-time. SCCOOS priorities and objectives are aligned with the seven societal goals as outlined in the IOOS Summit Report.

The focus themes, as designated by IOOS, highlight these priorities and are designed to improve safety, enhance the economy, and protect our environment.

- Coastal Hazards: to provide accurate, validated inundation models and information with the long-term goal of improving coastal safety.
- Ecosystems and Climate: to monitor ocean climate trends and environmental change in the Southern California Bight by collecting physical, chemical, and biological data.
- Marine Operations: to advance integrated, customized products that are critical for safe and efficient navigation, search and rescue, and oil spill response.
- Water Quality: to provide monitoring, tracking, and prediction tools for harmful algal blooms, outfall and storm water plumes, and surf zone contaminants.

SCCOOS operates and maintains a variety of technologies, observations, products, and projects to meet our user needs. Recent advances include increased ocean acidification monitoring, developing the harmful algal bloom products for stakeholders, applying Darwin Core standards to biological observations for compatibility with global databases, such as the Ocean Biogeographic Information System (OBIS), and a full redesign of the SCCOOS website.

Ocean Acidification Monitoring

As part of a West Coast-wide ocean acidification (OA) project funded by IOOS and the NOAA Ocean Acidification Program, SCCOOS has added OA and hypoxia monitoring to their ongoing observations. As part of this project and in collaboration with the Todd Martz at Scripps Institution of Oceanography, SCCOOS maintains a "Burkeolator" at Carlsbad Aquafarm that reports alkalinity, pCO2, total CO_2, aragonite saturation (omega), salinity, and water temperature. In demonstration of a technology transition, a low-cost pCO_2 sensor, the "ACDC" from Sunburst Sensors, is also being evaluated at Carlsbad Aquafarm. The ACDC is being operated alongside a SeapHOx unit measuring pH, temperature, and salinity. The calibrated SeapHOx pH data are combined with salinity-derived alkalinity to generate a continuous pCO_2 value for comparison with the ACDC system. The next stage is deployment of the generation 2 ACDC sensor and transfer of the generation 1 ACDC to the Catalina Sea Ranch NOMAD buoy in summer 2019.

Record Temperatures

Southern California has been experiencing anomalously warm waters since the 2014-2016 Pacific Warm Anomaly marine heat wave event. On August 1st, ocean temperatures hit a record high of 78.8°F at the Ellen Browning Scripps Memorial Pier in San Diego. Researchers from Scripps Institution of Oceanography have been measuring seawater temperature near the pier since 1916 as part of the Manual Shore Station program. Data collected from SCCOOS Automated Shore Stations, Coastal Data Information Program (CDIP) wave buoys, and spray gliders all hit record high sea temperatures in August and are telling a similar story. We are currently in ENSO-neutral conditions, but NOAA Oceanic El Niño Index (ONI) projections suggest there is a 70%-75% chance of an El Niño onset during the Northern Hemisphere 2018-2019 winter.

California HAB Bulletin

In collaboration with statewide stakeholders and with the Central and Northern California Ocean Observing System (CeNCOOS), SCCOOS has recently produced the California Harmful Algal Bloom (HAB) Bulletin that synthesizes model output, near real-time observations, and public health alerts to provide a more complete picture of the regional variability in harmful algal blooms. The purpose of this *experimental* product is to give the public and resource managers a quick outlook of recent toxic (marine) algal blooms in coastal California from models and aggregate data sets.

Entering Biological Datasets to ERDDAP

SCCOOS received IOOS directed funding in honor of the passing of Dr. Matthew Howard to make biological datasets Darwin Core-compliant, serving them on an Environmental Research Division Data Access Program (ERDDAP) server, with plans for eventual ingest by the OBIS database.

SCCOOS website redesign

The SCCOOS website has been redesigned to better communicate the SCCOOS mission, provide user friendly products and tools, direct users to data access portals, and highlight the latest news. Ocean observations are categorized based on Global Ocean Observing System (GOOS) Essential Ocean Variables (EOVs), and SCCOOS technologies are organized based on funding parameters and lists the observations each technology measures.

MONITOR Endnote 5

Dr. Lisa Eisner provided an overview of AOOS activities.

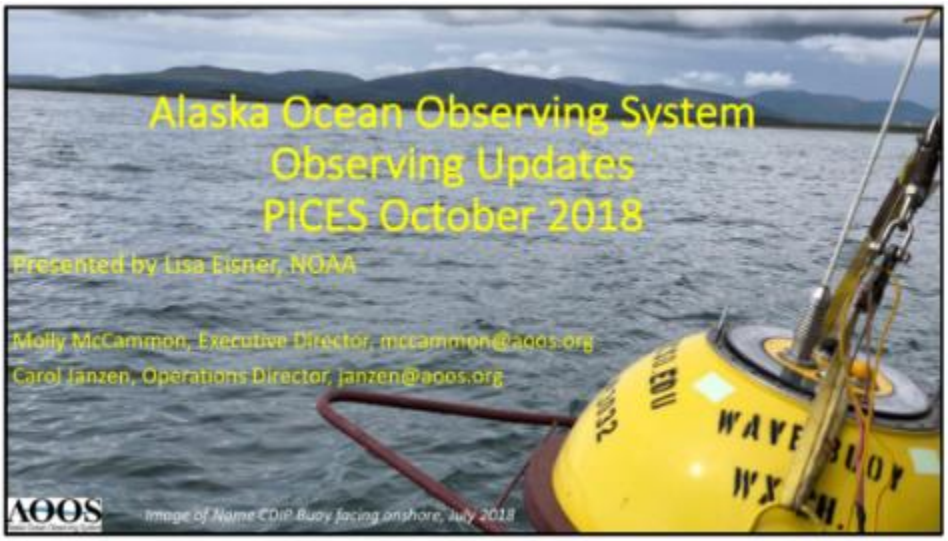
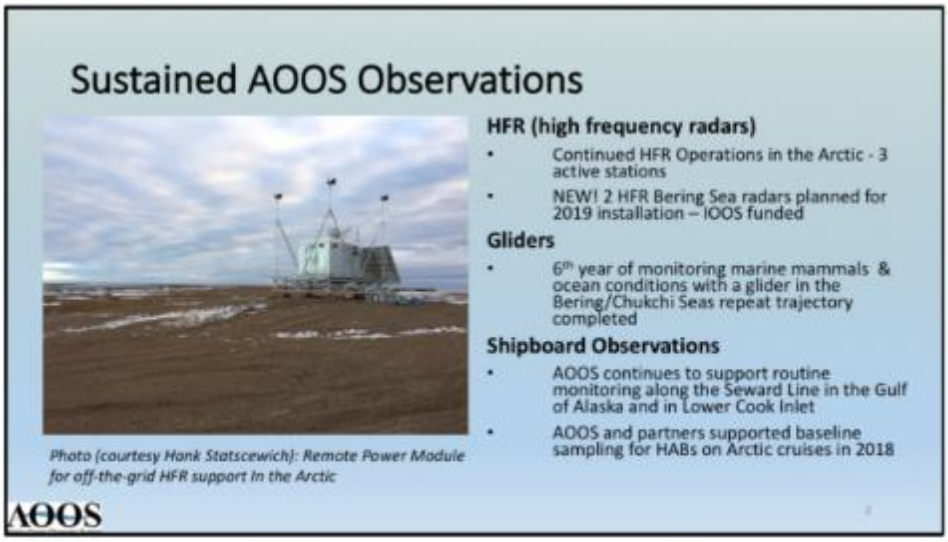


Image of Nome CDIP Buoy facing onshore, July 2018



AOOS continues to support ongoing observing activities throughout Alaska.

Sustained AOOS Observations

Moorings

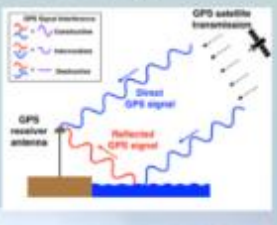
- Chukchi Sea Ecosystem Moored Observatory: Successfully turned around - Year 4
- NEW! Gulf of Alaska Ecosystem Mooring array to be installed 2019
- CDIP Wave Buoy in Lower Cook Inlet remains operational
- NEW! CDIP Wave Buoy installed for open water season off Port of Nome, July 2018
- Ice Detection Buoy – IDB - (2017) successfully recovered in 2018 and will provide year-round water column information during the freeze-up to breakup cycle.
- Next IDB deployment planned for 2019.

Photo: CDIP Buoy arrival in Nome, Alaska July 7, 2018 courtesy of the NOAA Ship Fairweather.

New Technologies: Real-Time Water Level Observing Using GPS Reflectometry

- AOOS and the NWS are now moving towards operational installations of land-based, GPS or Global Navigation Satellite System (GNSS) reflectometry water level measurements at select remote locations
- The method uses reflected satellite GPS signals to determine height of reflecting water surface relative to stable GPS antenna of fixed local height

1. 2018 - first full-time operational trial completed 1 year in Seward, AK
   - This station was relocated for further trials on a sloping low-tide beach in Homer
2. 2018 - permanent operational installation was completed in May 2018 in Stebbins, St. Michael (western AK) with partners UNAVCO



AOOS

Image: Courtesy of ASTRA, LLC.

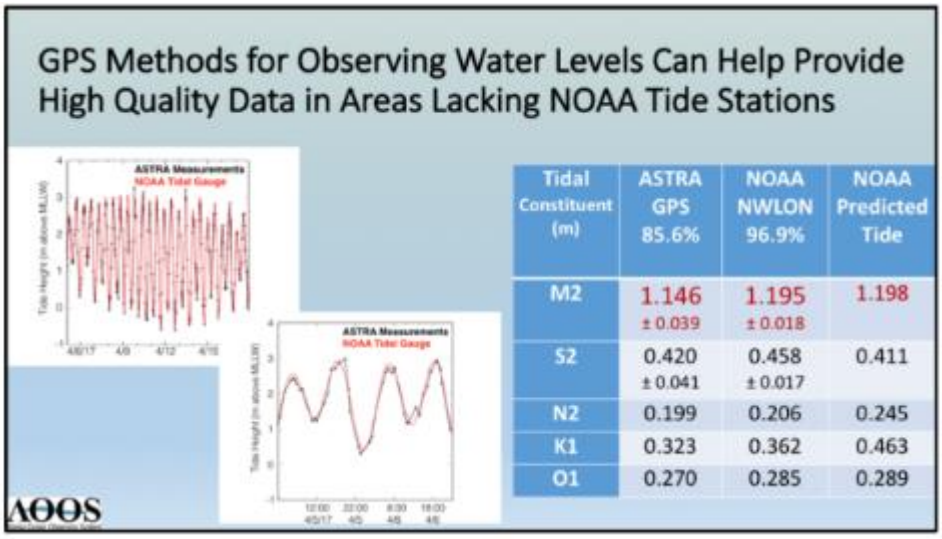
AOOS is working closely with the NOAA National Weather Service to expand water level measurements to fill gaps in in-situ observations. The goal is to increase water level observations, in particular, along the remote coastlines of western Alaska and the Arctic.

GPS Reflectometry is proving to be a successful method for making water levels. Premise behind reflectometry are simple.
An antenna is installed on land, which enables this technology to work year round.

Variations in water level are recorded as changes in the position of the antenna relative to the reflecting water surface.

The GPS signal traverses two paths from a satellite to the antenna, where the first is a direct path, and the second path is a reflected path from the antenna off the water surface.

Though GPS receivers cannot decipher the two paths, the interference between the signals is used to determine the reflecting surface height relative to the antenna height.



Tidal Constituent (m)	ASTRA GPS 85.6%	NOAA NWLON 96.9%	NOAA Predicted Tide
M2	1.146 ± 0.039	1.195 ± 0.018	1.198
S2	0.420 ± 0.041	0.458 ± 0.017	0.411
N2	0.199	0.206	0.245
K1	0.323	0.362	0.463
O1	0.270	0.285	0.289

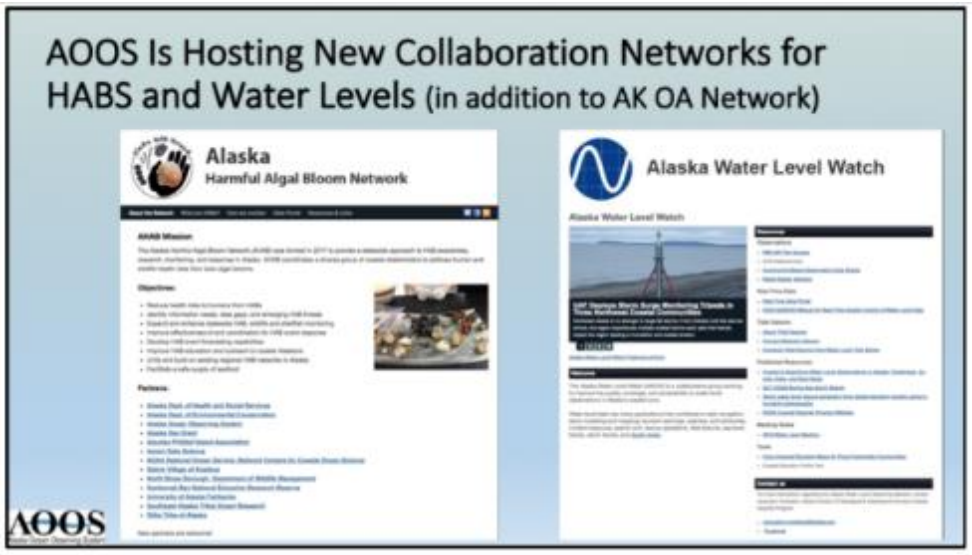
Top plot shows a time series of the NOAA NWLON water level data in red and the GPS data for a period of 2 weeks early in the deployment.
Lower plot shows two days to illustrate agreement between NOAA tide station and the GPS stations. NWLON and GPS stations were 2.5 km apart.

Harmonic analysis based on 92 days Hourly interpolated data from ASTRA and Hourly subsampled NWLON data

- GPS M2 tide was estimated within 5-6 cm of the NWLON computed M2 Amplitudes, within < 4%!
- The other constituents agree to < 5 cm.
- Phases were within 1 degree
- NOAA NWLON data are Tier A in terms of quality, accuracy and redundancy.
- NOAA Tier B data requirement is 11-30 cm, so results are excellent for alternative water level methods at this level.

A few things to note:

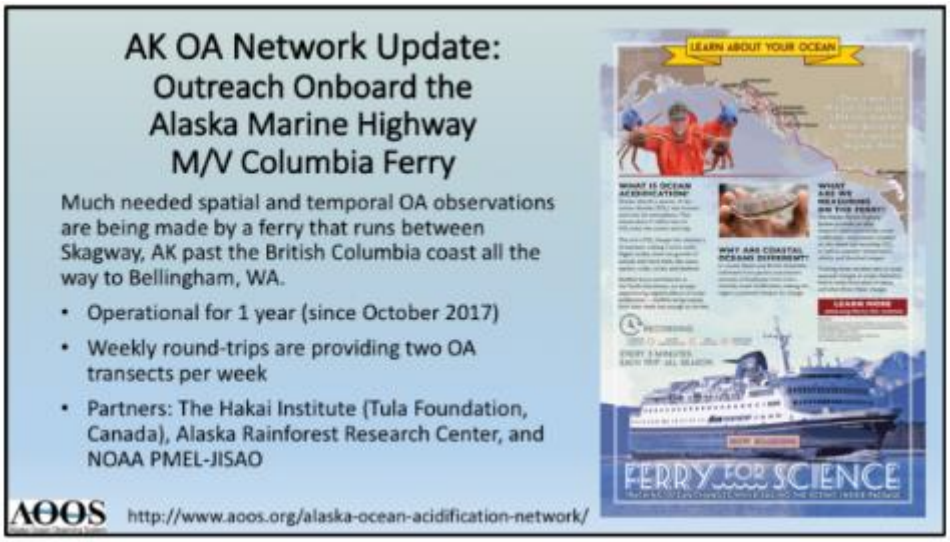
- NWLON Data are from a stilling well, which acts as a low-pass filter for high frequency noise in the water level.
- The GPS signal is raw direct reflected water level, and is not low pass-filtered in any way here.
- The GPS data are not evenly spaced in time, whereas the NWLON data plot was generated from 6 minute data.
- GPS signals are typically occurring in bursts...and the average sample frequency of these bursts us typically < 3 hours.



AOOS is hosting two new collaborations for sharing and promoting HABS and Water Level observing in Alaska.

Network Webpages are now available on the AOOS website. The webpages share information about the state of affairs regarding HABS and Water Levels in the region, ongoing activities and initiatives, monitoring, results, and contact information.

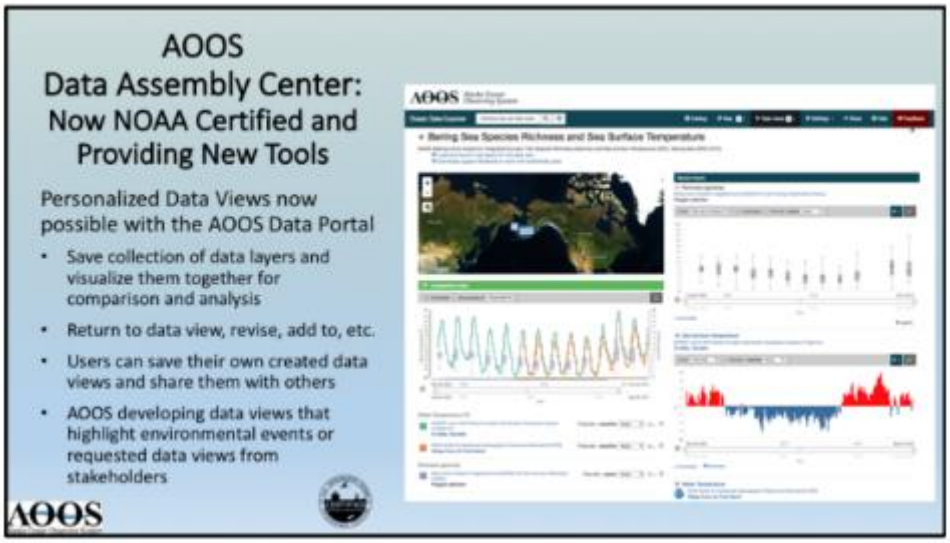
AOOS continues to lead and support the Alaska OA Network.



This poster was developed and installed on the M/V Columbia in time for the spring/summer and fall sailing season. Over 2 million travel to Alaska each summer, and many come via the AK Marine HWY Ferry system.

Ferry update from Wiley Evans

In early August, Wiley Evans of the Hakai Institute is aboard the M/V Columbia ferry. As of August, the ferry has made over 145,000 measurements of seawater carbon dioxide content, dissolved oxygen, temperature, and salinity. When not keeping tabs on the instrumentation, Wiley is also giving public talks to ferry passengers.



Regional Information Coordination Entities (RICEs) are NOAA certified to ensure that the data collected and distributed by the RICE are managed according to the best practices, as identified by NOAA.

AOOS was certified the RICE for the Alaska North Pacific and Arctic region in summer of 2017.

AOOS is updating it's website in 2018-19, and is now offering new tools on it's data portals that allow users to create data profiles called Data Views. These are still in development and we are accepting feedback for users.

AOOS is also creating Data Views for events (storms), projects, and commonly searched data queries based on stakeholder feedback.

AOOS Continues to participate in many national and international marine science initiatives and consortiums.

MONITOR Endnote 6

Dr. Matthew Bake provided an overview of North Pacific Research Board (NPRB) activities:

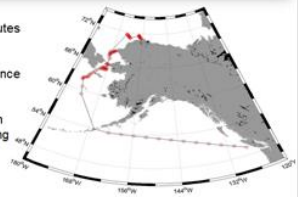
Overview

Summary of interesting results

Commercial ships tow the CPR along their regular routes

Samples are analysed microscopically and plankton identified and counted, building a database of abundance and diversity. All samples are archived.

PICES advocated CPRs in 1998. The survey began in 2000. PICES convened a CPR-Advisory Panel meeting each year, reporting to the MONITOR Technical Committee.



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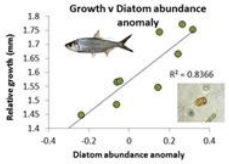
Overview

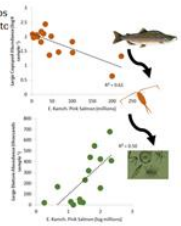
24 peer-reviewed publications to date. Recent highlights are contrasted here, one showing bottom up forcing, the other top-down control:

1. Time series of PWS herring scale measurements shows first year growth is correlated with diatom abundance



Plankton indices explain interannual variability in Prince William Sound herring first year growth. (2016). Batten, S.D., Moffitt, S., Pegau, W.S., and Campbell, R. *Fisheries Oceanography*, 25, 420-432.

2. Opposing relationships between summer plankton abundance and eastern Kamchatka Pink salmon (2000-2014), indicating trophic cascade.



Pink Salmon induce a trophic cascade in plankton populations in the southern Bering Sea and around the Aleutian Islands. (2018). Batten, S.D., Ruggerone, G.T. and Ortiz, I. *Fisheries Oceanography*.

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Seward Line

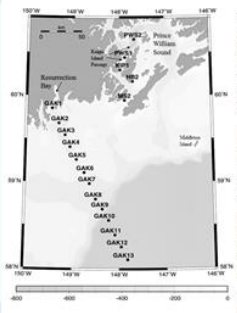
Oceanographic sampling to measure changes in the North Pacific (1998-2018)

Monitors physics, chemistry, plankton, marine bird and mammals in cross-shelf habitat of Gulf of Alaska

NPRB funding facilitates the additional assessment of microzooplankton, a critical linkage between phytoplankton and metazooan zooplankton.

PIs: R. Hopcroft, K. Kuletz, S. Danielson

Seward Line



Seward Line integrated in all major Gulf programs over the past decade (i.e. GOA-IERP, Gulf Watch)

It has provided infrastructure for ocean acidification studies

In 2018 supplying larval fish collections to NOAA and NOAA's Ecosystem Considerations reports in future cycles

Mid-shelf mooring will begin providing real-time meteorological and oceanographic data

NSF LTER site designation: additional lines, summer cruises, new parameters, process studies.

PIs: R. Hopcroft, K. Kuletz, S. Danielson

Chukchi Ecosystem Mooring

S. Danielson, C. Hauri, R. Hopcroft, A. McDonnell, P. Winsor

33 m below the surface
Floatation:
10 viny floats
Acoustic Doppler Current Profiler:
Current speed & direction
Significant wave height & direction
Laser In-Situ Scattering Transmissometer:
Particle size spectra & volume concentration
Optical transmission
Acoustic Zooplankton and Fish Profiler:
Target strength
Volume backscatter
Ice draft
SeaCat datalogger:
Pressure, Temperature, Salinity
Chlorophyll Fluorescence
Photosynthetically Available Radiation

Seafloor + 8 m
Floatation:
3 viny floats

Seafloor + 6 m
Recording Current Meter:
Current speed & direction
Pressure, Temperature, Salinity
Turbidity

Seafloor + 4 m
MicroCat datalogger:
Pressure, Temperature, Salinity
Acoustic Releases:
2 Push-Off Release Transponders

Seafloor
Anchor:
Railroad wheel at 50 m depth

Year-round autonomous collection of physical and biogeochemical data

Enable analyses of wind, wave, and ice effects on regional oceanography, nutrient cycles, particulate fluxes, carbon transfer, and Arctic cod and euphausiids dynamics

Intended to enable biogeochemical model validation and improve understanding of carbon and shelf-basin exchange.

Chukchi Ecosystem Mooring

S. Danielson, C. Hauri, R. Hopcroft, A. McDonnell, P. Winsor

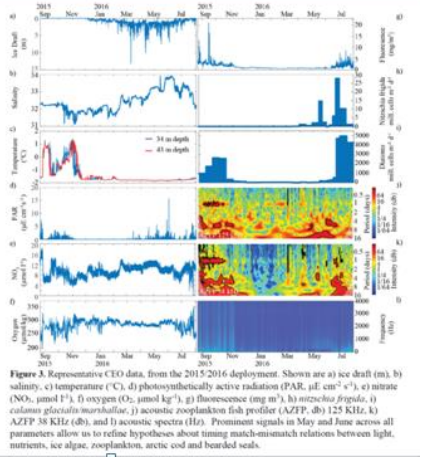


Figure 3. Representative CEO data, from the 2015/2016 deployment. Shown are a) ice draft (m), b) salinity, c) temperature (°C), d) photosynthetically active radiation (PAR, µE cm^{-2} s^{-1}), e) nitrate (NO_3, µmol l^{-1}), f) oxygen (O_2, µmol kg^{-1}), g) fluorescence (mg m^3), h) *nitzschia frigida*, i) *calanus glacialis/marshallae*, j) acoustic zooplankton fish profiler (AZFP, db) 125 KHz, k) AZFP 38 KHz (db), and l) acoustic spectra (Hz). Prominent signals in May and June across all parameters allow us to refine hypotheses about timing match-mismatch relations between light, nutrients, ice algae, zooplankton, arctic cod and bearded seals.

MONITOR Endnote 7

Country Reports for 2018

Canada

I. Highlights from 2017

Fisheries and Oceans Canada (DFO), Pacific Region, conducts annual reviews of physical, chemical and biological conditions in the ocean, to develop a picture of how the ocean is changing and to help provide advance identification of important changes which may potentially impact human uses, activities, and benefits from the ocean. The report from 2018 (for conditions in 2017) is available at: http://waves-vagues.dfo-mpo.gc.ca/Library/40717914.pdf.

Highlights below are taken from this report:

- Ocean temperatures observed in 2017 show that the warm conditions associated with the marine heat wave of 2015-2016, known as the "Blob", have diminished to near normal levels (Figures 1 and 2). La Niña conditions in the equatorial Pacific contributed to these cooler temperatures.

Figure 1. Map of areas reported on in the State of the Ocean report, including Line P, and Ocean Station Papa. Source: Chandler *et al*. (2018).

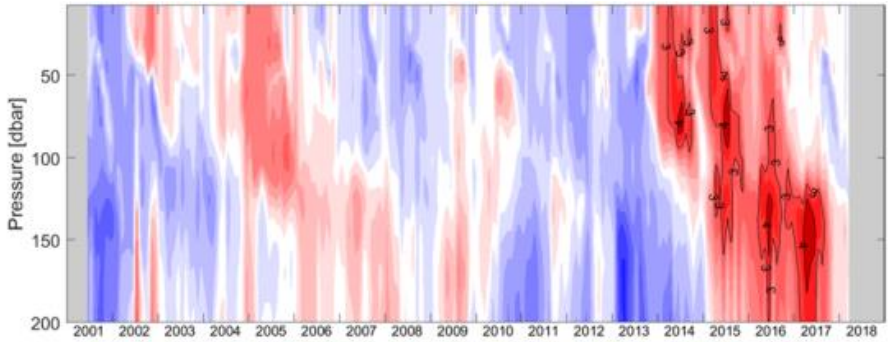


Figure 2. False colour plot of temperature anomalies relative to the 1956–2012 seasonally-corrected mean and standard deviation (from the Line P time series), as observed by Argo floats near Station Papa (P26: 50° N, 145° W); red – above average, blue – below average with darker colours corresponding to larger anomalies. The black lines highlight regions with anomalies that are 3 and 4 standard deviations above the mean. Source: Ross and Robert (2018).

- Physical oceanographic processes associated with the marine heat wave, including increased stratification, have reverted to more normal conditions that may favour primary production and fish growth; although upwelling intensity was average to late in 2017 (Figure 3, Hourston and Thompson 2018). The phytoplankton community composition also showed a return to a more normal distribution.

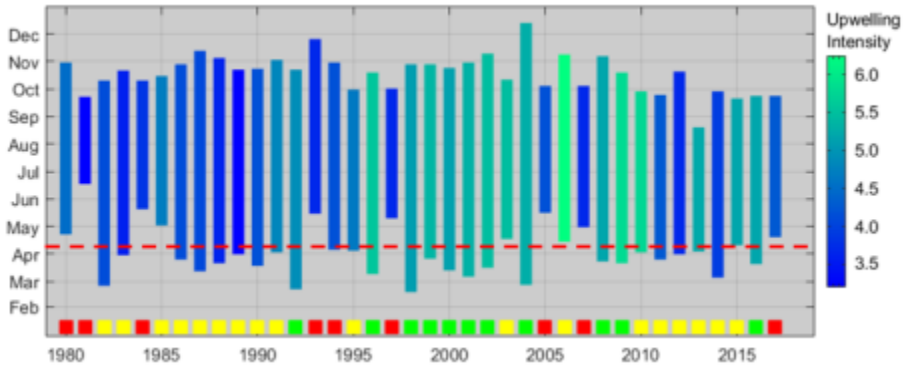


Figure 3. The upwelling index for the west coast of British Columbia. The length of the bar corresponds to the duration of the upwelling season, coloured by the intensity of the upwelling. The dashed red line indicates the average start to the upwelling season. The squares along the x-axis represent the relative annual productivity based on the start date and intensity of the upwelling (green, yellow, red indicates favourable, neutral, and unfavourable productivity conditions). Data source: NOAA/OAR/ESRL/Physical Sciences Division – University of Colorado at Boulder. Figure source: Hourston and Thompson (2018).

- The zooplankton surveys off Vancouver Island (Figure 4) revealed fewer subarctic and boreal copepods that are favourable for fish growth, as well as higher abundances of southern copepods (Figure 5). Also remarkable numbers of pyrosomes (Figure 6) and salps were observed along the entire B.C. coast. The pyrosomes had both negative (clogged fishing gear) and positive (integrated into the food web) impacts.

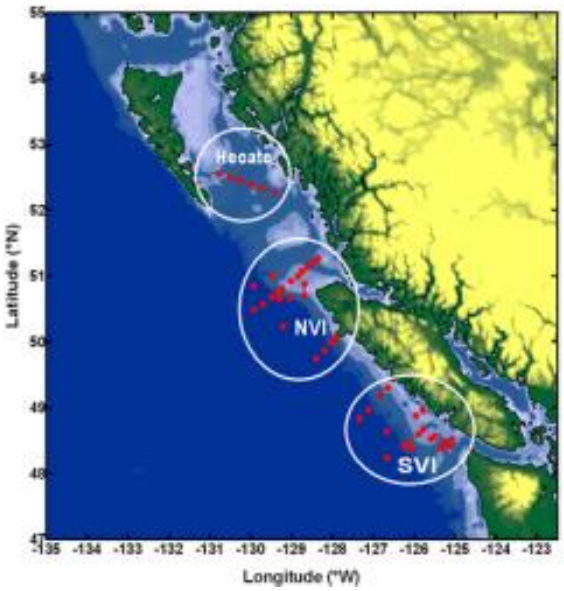


Figure 4. Zooplankton time series sampling locations (red dots) in B.C. marine waters. Data are averaged for samples within each area; the SVI and NVI regions are further classified into shelf and offshore subregions. Source: Galbraith and Young (2018).

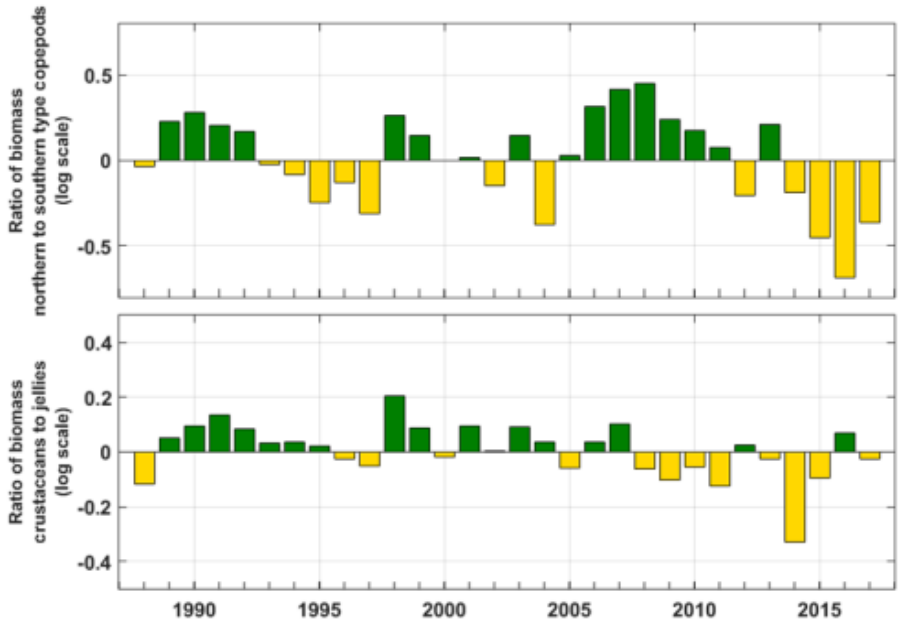


Figure 5. The 1988-2017 time series of yearly averaged anomalies of zooplankton biomass off southern Vancouver Island. (Top) the ratio of northern to southern species of copepods; (Bottom) the ratio of crustaceans to jellies. Green – fish food favourable, amber - less favourable fish food conditions. Source: Galbraith and Young (2018).

Figure 6. Pyrosomes were present in BC waters in 2017 and 2018.

- Multi-species small-mesh bottom trawl surveys conducted annually in May off the west coast of Vancouver Island (Figure 7) indicate pink shrimp biomass in 2017 continued to decline from the peak in 2014, with anomalies now below the climatological mean (Figure 8).

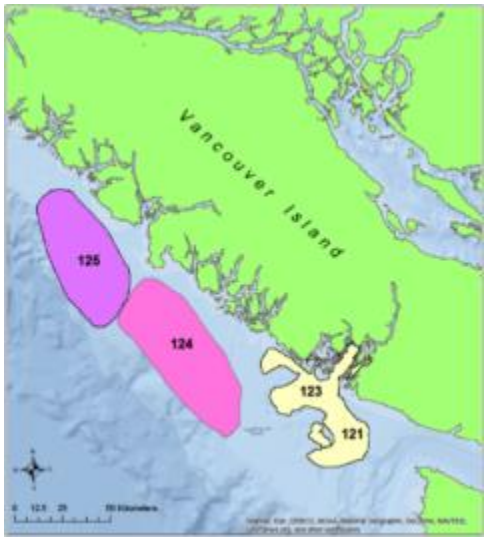


Figure 7. Map showing the three main shrimp (*Pandalus jordani*) fishing grounds and survey areas off Vancouver Island for the WCVI small-mesh multi-species bottom trawl surveys. Source: Perry *et al*. (2018)

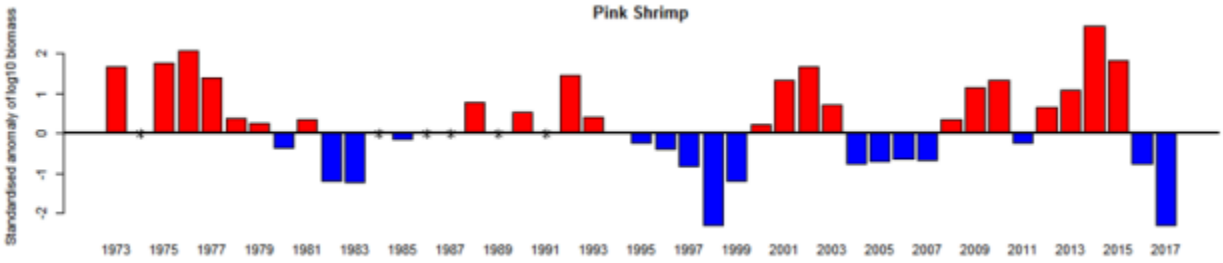


Figure 8. Standardised (by the standard deviation) anomalies of log10 species biomass for pink shrimp in the WCVI small-mesh multi-species bottom trawl surveys. Climatology period is 1981-2010. Source: Perry *et al*. (2018).

- In 2017, the spring spawning biomass of Pacific Herring (Figure 9) showed near historic high levels in the Strait of Georgia, but low levels off Haida Gwaii (Figure 10). The biomass increased on the Central Coast, decreased on the west coast of Vancouver Island, and remained similar to 2016 in the Prince Rupert District (Figure 10).

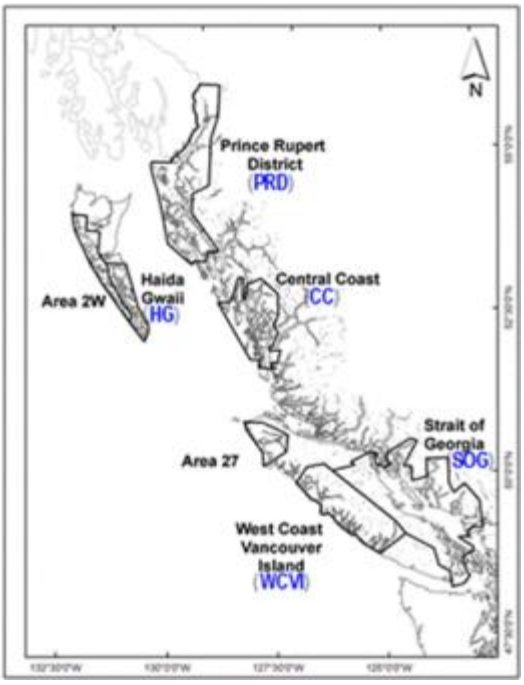


Figure 9. Location of the five major (Strait of Georgia, West Coast of Vancouver Island, Prince Rupert, Haida Gwaii, and Central Coast) as well as two minor (Area 2W, and Area 27) Pacific Herring stocks in BC. Source: Cleary *et al*. (2018).

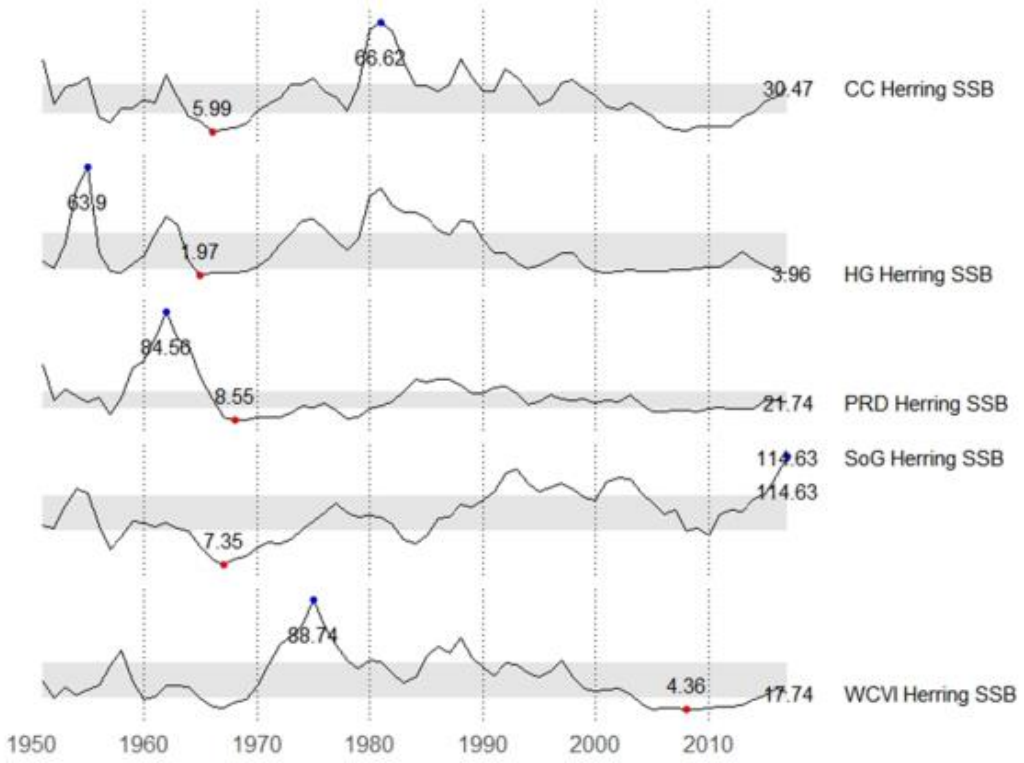


Figure 10. Herring spawning biomass in five major stock areas of B.C: Central Coast (CC), Haida Gwaii (HG), Prince Rupert District (PRD), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI), 1951–2017. Minimum (red), maximum (blue) values are shown with circles and values, values for 2017 are shown, and the shaded ribbons encompass the 25% to 75% quartiles. Source: Cleary *et al*. (2018).

- Record wet spring conditions in southern British Columbia with abundant snow early in the season followed by heavy rains and rapid snowmelt in late spring contributed to a higher than average Fraser River discharge in June that was observed as negative surface salinity anomalies in the Strait of Georgia.
- Based on satellite imagery and in situ measurements, the 2017 Strait of Georgia spring bloom had close to average start timing, was short in duration and moderate in magnitude relative to historical records. It started in mid-March in the central Strait, and mid-April in the northern Strait.
- With the exception of 2015 the Fraser River Eulachon spawning stock biomass index has been at low levels since 2004.
- There was a coast-wide synchronous decline of Sockeye Salmon indicator stock returns in 2017 (Figure 11). The warm ocean conditions in 2015–2016 were unfavourable for the survival of B.C.'s central and south coast salmon.

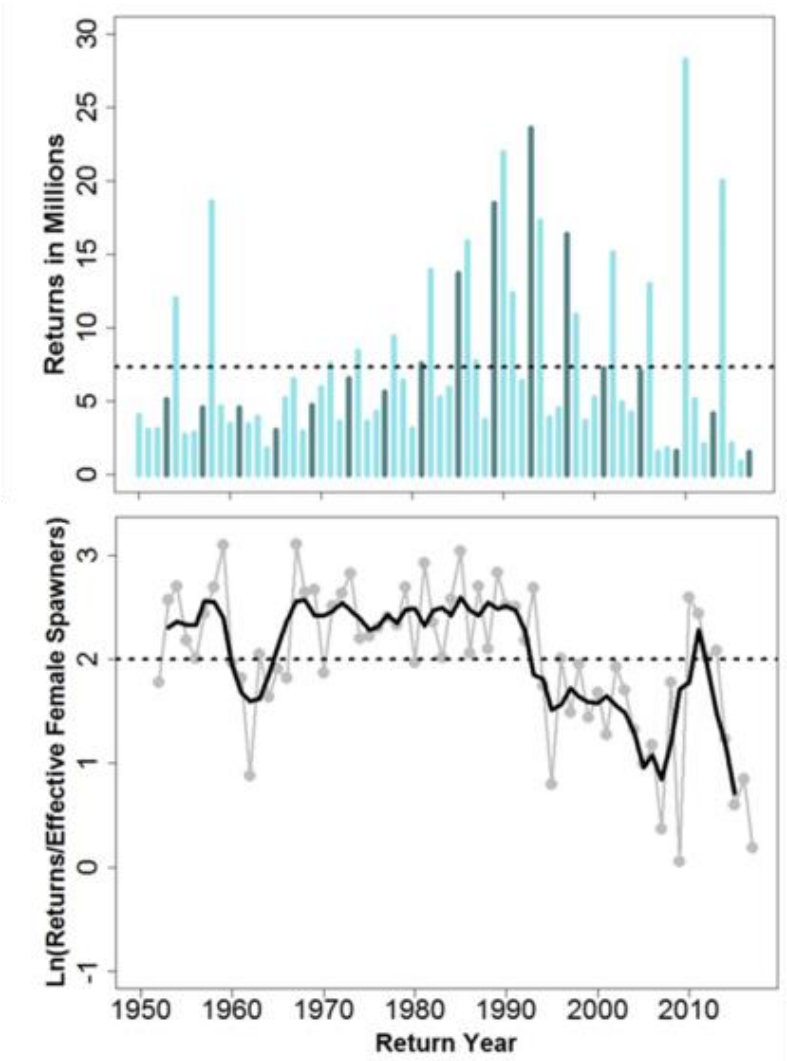


Figure 11. Top panel: Total Fraser Sockeye annual returns (dark blue vertical bars for the 2017 cycle and light blue vertical bars for the three other cycles). Recent returns from 2012 to 2017 are preliminary, and 2017 (the last data point) is an in-season estimate only. Bottom panel: Total Fraser Sockeye productivity (loge (returns/total spawner)) is presented up to the 2017 return year. The grey dots and lines represent annual productivity estimates and the black line represents the smoothed four year running average. For both figures, the dashed line is the time series average. Source: Grant *et al*. (2018).

II. Observational programs

A. Monitoring by research vessel surveys (physical/chemical/biological/fisheries oceanography)

Ongoing:

1. Line P: continuing at 3 surveys/year (February, May/June, August/September), starting in the 1950s (Figure 1). The main goal is to determine ocean conditions and water property changes in the open NE Pacific. Areas of emphasis: hydrography, biogeochemistry, plankton dynamics (http://www.pac.dfo-mpo.gc.ca/science/oceans/data-donnees/line-p/index-eng.html). It is run by DFO/IOS, but there is extensive participation by university and international scientists for specialised water chemistry sampling related to dissolved organic carbon, pH, trace gases, etc. Sampling is conducted during both day and night. Types of sampling include CTD profiles, Niskin bottles, and plankton tows using a Bongo and a multinet. Physical measurements include temperature, salinity, phytoplankton fluorescence and many chemical analyses (*e.g.*, oxygen, nutrients).
2. NE Pacific continental margin: continuing at ~4 surveys per year, covering outer coast of Vancouver Island and parts of Queen Charlotte Sound/Hecate Strait. Areas of emphasis: time series of zooplankton and hydrography (nutrients, O_2, T, S, pH), and their links to climate variability and trends (Figure 4). The La Perouse plankton survey is carried out twice per year in May-June and September, 1979-present. Sampling occurs off the WCVI (shelf and offshore) during the day and night. Sampling includes hydrographic, acoustic, zooplankton (Bongo and multinet and acoustics), CTD, and water samples.
3. Strait of Georgia (Figure 1): continuing at 4 surveys per year, with intensified sampling in 2010 and 2011. Areas of emphasis: hydrography and circulation, nutrients, phytoplankton, vertical flux of organic matter & contaminants.
4. Strait of Georgia zooplankton survey (is funded by, and is part of, the Canada/US Marine Survival of Salmon in the Salish Sea study: see https://www.psf.ca/what-we-do/salish-sea-marine-survival-initiative). The main survey goal of this survey is to determine the species composition, spatial and temporal trends in zooplankton in the Canadian waters of the Salish Sea, for understanding interannual variability in salmon survival. It began in 2015 and is expected to continue for 1–5 additional years. This survey occurs twice per month during February to October in the Strait of Georgia mostly during daytime, but with some nighttime operations. Sampling includes surface water samples, net tows (Bongo, ring net), CTD for temperature, salinity, and phytoplankton fluorescence.
5. British Columbia central coast near Calvert Island (Figure 12). Since 2012, year-round daily to monthly CTD and sensor (fluorescence, turbidity, photosynthetically available radiation, oxygen) profiles are collected at 65 stations located in Rivers Inlet, Fitz Hugh Sound, Kwakshua Channel, Hakai Pass, and Queen Charlotte Sound. At five of these stations, Niskin bottles collect water to measure nutrients, particulate organic matter (for isotopes and fatty acids), particulate organic phosphate, CO_2, $DO^{13}C$, dissolved inorganic carbon, chlorophyll, HPLC, phytoplankton composition, viral and bacterial abundance, and zooplankton (biomass, composition, fatty acids and isotopes). Areas of emphasis include ocean climate, ocean acidification, marine food webs, watershed to oceans, and salmon.
6. Discovery Islands near Quadra Island (Figure 12). Since 2014, year-round weekly to monthly CTD and sensor (fluorescence, turbidity, photosynthetically available radiation, oxygen) profiles are collected at 30 stations located in Sutil Channel, Okisolla Channel, Hoskyn Channel, Calm Channel and Bute Inlet. At three of these stations, Niskin bottles collect water to measure nutrients, particulate organic matter (for isotopes and fatty acids), particulate organic phosphate, CO_2, $DO^{13}C$, dissolved inorganic carbon, chlorophyll, HPLC, phytoplankton composition, viral and bacterial abundance, and zooplankton (biomass, composition, fatty acids and isotopes). Areas of emphasis include ocean climate, ocean acidification, marine food webs, watershed to oceans, and salmon.

B. Ecosystem process surveys (including some surveys used for species stock assessments)

1. Small mesh multi-species survey (Figure 7): The main goal is to estimate abundance and trends of shrimp and other species (*e.g.*, eulachon). Areas and years of the survey are WCVI 1973–present, Queen Charlotte Sound (QCS; 1998–2014). The survey is conducted annually in May 5 for WCVI, and the future of the QCS survey is unknown. This is a trawl survey conducted during daytime with a small mesh bottom trawl. All species captured are recorded and quantified, and a sub-set of species sampled for biological traits (*e.g.*, length, weight, age). Also, temperature at depth is recorded. Results for the WCVI survey are reported annually in the DFO State of the Pacific Ocean reports (http://www.pac.dfo-mpo.gc.ca/science/oceans/reports-rapports/state-ocean-etat/index-eng.html)
2. Juvenile and adult Pacific salmon marine surveys: multiple surveys annually; Strait of Georgia (1997–present); west coast Vancouver Island (1998–present), Queen Charlotte Sound (1998–present); Central and Northern British Columbia (1998–2012); zooplankton and oceanographic data.
3. La Perouse pelagic ecosystem survey: annual (biennial after 2015); daytime acoustic-trawl survey; west coast Vancouver Island (2012–2015; presence data for 1982–2011); zooplankton, oceanographic data. Discontinued.
4. Juvenile herring and nearshore pelagic survey: annual; Strait of Georgia (1992–present) and Central British Columbia (1992–2011); zooplankton and oceanographic data.
5. Night time pelagic species and Pacific sardine survey: annual night-time trawl survey (biennial after 2014); west coast of Vancouver Island (2006–2014); zooplankton, oceanographic data, daytime acoustic data, and marine mammal and seabird observations. Integrated into the Integrated pelagic ecosystem survey (see below).
6. Integrated pelagic ecosystem survey: annual (2017–present) day/night trawl survey; north and west coast of Vancouver Island; zooplankton, oceanographic data, daytime acoustic data collection.

C. Fishery-independent stock assessment and species at risk surveys

These are fishery-independent surveys carried out either annually or at regular intervals for a number of harvested species (hake, multispecies groundfish, invertebrates) or species-at-risk. Increasing use of acoustics and underwater video, and increasing effort to collect and incorporate environmental information. Main surveys include:

1. Groundfish bottom trawl surveys: biennial; in even numbered years west coast of Vancouver Island (2004 – present), and west coast Haida Gwaii (2006 – Present), in odd numbered years Hecate Strait (1984-present) and Queen Charlotte Sound (2003 – Present); oceanographic and oxygen data.
2. Pacific hake acoustic survey: biennial (was triennial); west coast North America, Southern California to Dixon Entrance (1977–present).
3. Other fish surveys: Pacific halibut (longline), sablefish (longline), lingcod (dive), rockfish (video), etc.
4. Salmon abundance (freshwater): estimates of adult salmon leaving and juvenile salmon arriving at the ocean are obtained annually in many rivers.
5. Dungeness crab trap survey: The goal is to index crab population. Survey times: 1988 –present; May and October; semi-annual. Area: Strait of Georgia. Samples collected in daytime. This is a trap survey that uses crab traps. All species captured are recorded and quantified, and all crabs are sampled.
6. Green sea urchin dive survey: The goal is to estimate population abundance; Survey times are 2008 – present for southeast Vancouver Island and 1995 to present for northeast Vancouver Island; during September; surveys are biennial and conducted during the daytime. This is a dive survey. All species observed on transect recorded, and green urchins are sampled.
7. Marine mammal surveys: throughout British Columbia
8. Seal Island Intertidal clam survey: The goal is to estimate population abundance. Survey times are 1940–present, spring/summer, conducted on a triennial basis in the Strait of Georgia during the daytime at low

tide. This is a beach survey, where transects are sampled using quadrates and clam rakes for butter clams.

9. Inshore shrimp assessment surveys: The goal is to estimate shrimp abundance and trends. Survey times are: 1998–present during spring/summer/fall, conducted annually until 2012, and are now biennial surveys in the Strait of Georgia, Knight Inlet, and Chatham Sound during daytime. This is a trawl survey that uses a small mesh bottom trawl (with excluder). All species captured are recorded and quantified, and shrimp sampled for length and weight.
10. Prawn survey: The goal of this survey is to index spawning population. Survey times are 1985-present, November and February, on a semi-annual basis in Howe Sound during the daytime. Prawn traps are used and all species captured are recorded and quantified; spot prawns are sampled for length and weight.
11. Species at Risk monitoring surveys for Northern Abalone: The main goal is to monitor abalone populations relative to recovery targets. Surveys have various start dates, some as early as 1978-present; conducted during May on a five year rotation in the Central Coast and south coast during daytime. This is a dive survey and all species observed on transects are recorded, and abalone are measured *in-situ*.
12. Species at Risk monitoring surveys for Olympia Oyster: The goal is to estimate and monitor abundance and trends. Survey times are 2009–present, during spring/summer on a 5-year rotation in the Strait of Georgia and WCVI during daytime at low tide. This is a beach survey using quadrats. All species are counted in quadrats.
13. Sea cucumber surveys: The goal is to provide biomass estimates. Survey times are 1997–present. Month of sampling is area dependent (Feb-Sep) on 4-year+ intervals, coast-wide. This is a dive survey in which the following species are sampled: *Parastichopus californicus* (sometimes *Cucumaria miniata* and *C. pallida*).

D. Aquatic invasive species surveys

1. Aquatic Invasive Species intertidal monitoring surveys: annual surveys with shifting geographic focus to eventually provide baseline information coastwide (2006–present).
2. Aquatic Invasive Species European Green Crab trap surveys: annual surveys with shifting geographic focus, annual monitoring of Pipestem Inlet, Barkley Sound, tagging and depletion studies (2006–present).

E. Habitat and offshore area of interest surveys

1. Offshore areas of interest:
   a) 2015 – SGaan Kinghlas - Bowie Seamount Marine Protected Area (SK-B MPA) - Survey to collect Visual and Oceanographic data around SGaan Kinghlas Seamount Marine Protected Area (SK-B MPA).
   b) 2016 – Survey of Endeavour Hydrothermal Vents Marine Protected Area (MPA)
   c) 2017 – Survey of the Offshore Area of Interest (AOI) (Figure 13). This was the first survey into the Area of interest that was focused on collecting visual data on seamounts in this area. This survey was able to confirm the height and location of 7 seamounts in the AOI with 5 of them new to science because they were projected from models. This survey collected over 70 hours of videos from 4 seamounts and collected Oceanographic and eDNa samples around each of these seamounts http://dfo-mpo.gc.ca/science/atsea-enmer/missions/2017/offshoreaoi-sihauturiere-eng.html
   d) 2018 – Survey to SGaan Kinghlas - Bowie Seamount Marine Protected Area (SK-B MPA) and to the offshore AOI – This survey was a partnership between Haida Nation, Fisheries and Oceans Canada, Oceana Canada, and Ocean Networks Canada and was able to completed high resolution multibeam maps of 5 seamount and collect data on seamounts heights from 13 seamounts of which 6 were new to science. The survey focused on collection of visual survey data on 6 seamounts and collected voucher specimens along with eDNA samples at each of these 6 seamounts. http://dfo-

mpo.gc.ca/science/atsea-enmer/missions/2018/seamounts-sousmarins-eng.html

2. Epibenthic animals and oxygen:
   a) Saanich Inlet ROV transect: annual survey; 2006-present; one standard transect; Patricia Bay, Saanich Inlet; data collected includes dissolved oxygen, video. Goal is to compare hypoxia-induced shifts in the epibenthic animal distributions over time.
3. Glass sponge reef assessment and monitoring surveys:
   a) 2012, 2013, 2016: Three Remotely Operated Vehicle (ROV) surveys to develop assessment and monitoring methods for 19 glass sponge reefs in the Salish Sea (Strait of Georgia and Howe Sound). This work supported two initiatives to establish fishing closures to protect the reefs in the Strait of Georgia and Howe Sound under the Sensitive Benthic Area Policy; these closures apply to all bottom-contact fisheries and as such qualify as Other Effective Area Based Conservation Measures, contributing to the achievement of Canada's commitment to marine conservation targets under the United Nations Convention on Biological Diversity. Data collected include video (approx. 150 hours) and still imagery, as well as temperature and salinity 1 m above bottom along line transects.
   b) 2015 and 2017: Two Remotely Operated Vehicle (ROV) surveys to map and study glass sponge reefs within the Hecate Strait and Queen Charlotte Sound Hecate Strait MPA. Targeted research to (1) better understand, in situ, sensitivity of glass sponges to suspended sediment, (2) to collect macrofauna samples for isotope analysis to construct reef food webs, and (3) to ground truth sponge cover in areas with different acoustic signature. Data is used for monitoring indicator development. 2017 survey was done in collaboration with researchers from the University of Alberta: http://www.dfo-mpo.gc.ca/science/atsea-enmer/missions/2017/hecate-eng.html
   c) 2017: Remotely Operated Vehicle (ROV) survey to ground truth a recently discovered large glass sponge reef in Chatham Sound. Data collected include video and still imagery, as well as temperature and salinity 1 m above bottom along line transects. http://www.dfo-mpo.gc.ca/science/atsea-enmer/missions/2017/chathamsound-eng.html

F. Argo profiling drifters

Canada has been very active in this successful international program. Since the start of the program, Canada has deployed many floats (see http://www.argo.ucsd.edu/).

G. North Pacific Continuous Plankton Recorder

Canada has contributed financial support since 2008 for the North Pacific CPR program plus hosts a local sorting center (at IOS), and collaborates with project lead Sonia Batten on some of the analyses and publications (see http://pices.int/projects/tcprsotnp/).

H. Ocean observatory networks (Ocean Networks Canada)

The 'inland seas' component has operational undersea cabled observatory nodes and coastal radar (VENUS network) in the Strait of Georgia (since 2008) and in Saanich Inlet (since 2006). The installation of sensor platforms on ferries on three routes between Vancouver and Vancouver Island was completed in 2015. An ocean glider program, initiated in 2014, provides additional mobile observing capacity for coastal waters. Five community-based cabled observatories are currently operating in coastal locations, one on Vancouver Island, three on the British Columbia mainland, and another in the Canadian Arctic at Cambridge Bay, Nunavut. Additional community-based cabled observatories are being installed at four coastal British Columbia sites, with completion expected in late 2019. A growing network of HF radar installations and Automatic Information System receivers in the Strait of Georgia and on the northern coast of British Columbia provides real-time information on surface ocean conditions and vessel traffic.

The 'offshore' cabled network (NEPTUNE) is a part of a broader US/Canada northeast Pacific observing system. The Canadian component (installed 2009) consists of a fully operational, 812 km elliptical undersea cabled observatory loop extending from southern Vancouver Island across the continental shelf and slope to the Endeavour Segment of the Juan de Fuca Ridge. The observing system at the Endeavour node underwent expansion in 2017-2018. Autonomous oceanographic moorings (since 2012) in the Salish Sea provide continuity between the VENUS and NEPTUNE observing systems.

ONC's Oceans 2.0 data system also archives and delivers ocean data partner observing systems in Atlantic Canada and the eastern Arctic. Beginning in early 2019, ONC will be hosting the Pacific node of the Canadian Integrated Ocean Observing System.

For more information see http://www.oceannetworks.ca/.

I. British Columbia Shore Station Oceanographic Program

The British Columbia Shore Station Oceanographic Program (often referred to as the BC lighthouse data) began in 1914. Sea surface temperatures and salinities have been monitored daily at lighthouses on the west coast of Canada. Observations are logged and forwarded monthly to the Institute of Ocean Sciences where they are quality controlled and archived (http://www.pac.dfo-mpo.gc.ca/science/oceans/data-donnees/lighthouses-phares/index-eng.html).

J. Hakai Institute autonomous instrumentation

Fixed autonomous stations include (Figure 12):

- Burke-o-later (BoL) for determining T, S, pCO_2 and TCO_2 in Hyacinthe Bay, near Quadra Island since 2015;
- Multiple temperature sensors at fixed nearshore locations throughout the central coast near Calvert Island since 2015;
- A MApCO_2 buoy near Calvert Island that measures S, T, surface seawater and atmospheric pCO_2, and meteorological data since 2018;
- A cabled observatory called the Limpet has measured T, S, and oxygen at the seafloor in Hyacinthe Bay off Quadra Island since 2015;
- A string of moored temperature and salinity sensors has collected T data every 10 minutes in 10 meter intervals since 2017;
- The Alaska Marine Highway System M/V Columbia has collected T, S, O, and seawater and atmospheric pCO_2 since 2017.

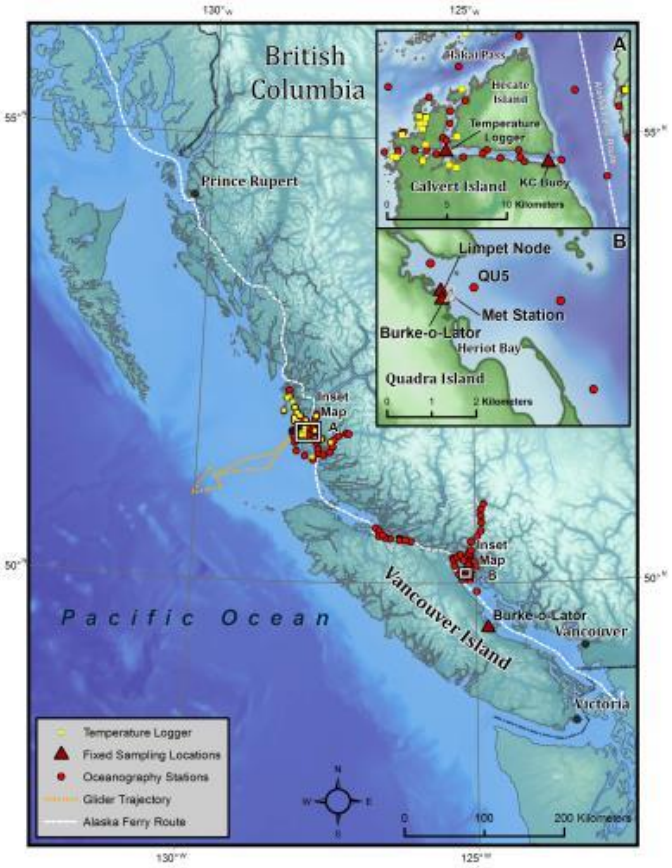


Figure 12. Locations where the Hakai Institute collects ocean data in British Columbia. Hydrographic stations (red circles) are where physical, biological and chemical measurements are made at bi-weekly to monthly frequencies. High frequency data from fixed sampling locations (red triangles) and temperature loggers (yellow circles) are output every 5 minutes. Instrumentation on board the Alaska Marine Highway System (AMHS) M/V Columbia measures surface parameters while underway every 2.5 minutes along weekly ~1000 nm transits between Bellingham, Washington (48.75°N) and Skagway, Alaska (59.64°N).

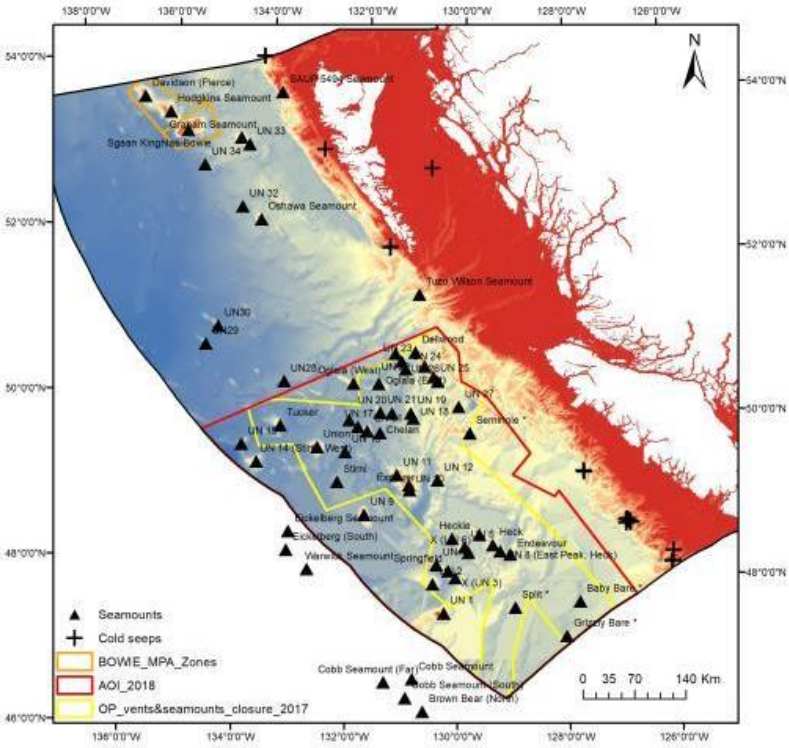


Figure 13. 2017 Survey of the Offshore Area of Interest (AOI). Source: Tammy Norgard (DFO).

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Japan

I-1. Highlight of 2018: JAMSTEC has launched a marine plastic research project (by Sanae Chiba, RCGC JAMSTEC

1-1. Deep-sea Debris Database

Global Oceanographic Data Center (GODAC) launched the Deep-sea Debris Database in 2017, which collate photos and video footages of sea floor debris observed during more than 5000 deep-sea dives by JAMSTEC's ROVs and submersibles since 1982 (Fig. 1). An article published using the database information depicts the proliferation of single-use plastics even the deepest part of the ocean, over 10,000 m deep in the Mariana trench (Chiba *et al*. 2018, Marine Policy 96: 204-212, https://doi.org/10.1016/j.marpol.2018.03.022). The database is being regularly update as new footages are added.

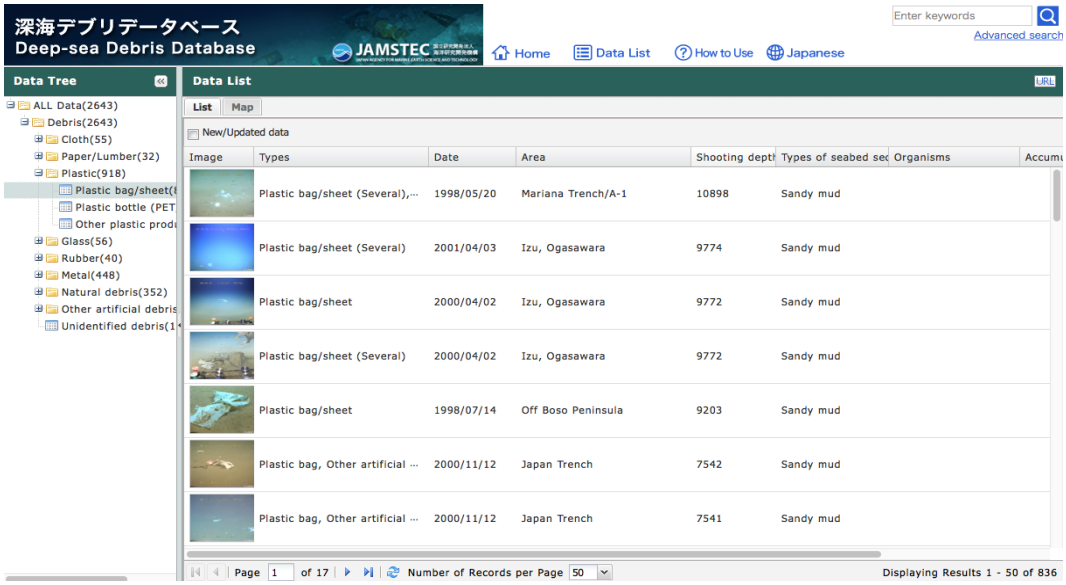


Fig. 1 Deep-sea Debris Database, showing plastic bag distribution in the greatest depth.

1-2. Microplastic Monitoring

A new project to develop an innovative method for microplastic monitoring was launched in September 2018 (~FY2022). Aiming for the establishment of a cost-effective, standardized measurement system of smaller microplastics (<100 μm), the oceanic distribution of which is largely unknown, this project applies a hyperspectral camera technique coupled with machine learning on the image analysis. The system will be designed to be attached to the sea-water intake system of various ships, thus enabling it to analyze microplastic distribution at a large scale.

I-2. Update on Conventional Observation Programs of Research Center for Global Change

RCGC (Research and Developmental Center for Global Change) is in charge of a variety of ocean observation programs. Conventional monitoring projects as shown below are succeeded and under operation by RCGC. As yet, these projects are mainly limited to physical, chemical and atmospheric observation.

2-1. Argo JAMSTEC

http://www.jamstec.go.jp/ARGO/argo_web/argo/?lang=en

The Pacific Argo Regional Center (PARC) has been established as a joint collaboration between the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the International Pacific Research Center (IPRC) at the University of Hawaii, and the Commonwealth Scientific and Industrial Research Organization (CSIRO). PARC is taking on the responsibility to validate all float data in the Pacific through rigorous scrutiny and to derive regional products based on these floats.

The global data point map of temperature and salinity was updated (data up to Sept. 2018). The map of gridded mixed layer depth with its related parameters (MILA GPV: MIxed Layer data set of Argo, Grid Point Value) was updated (data up to Sept. 2018; Fig. 2). Download and visualization services of Argo gridded dataset "MOAA GPV" and "MILA GPV" have started from JAMSTEC GODAC data site.

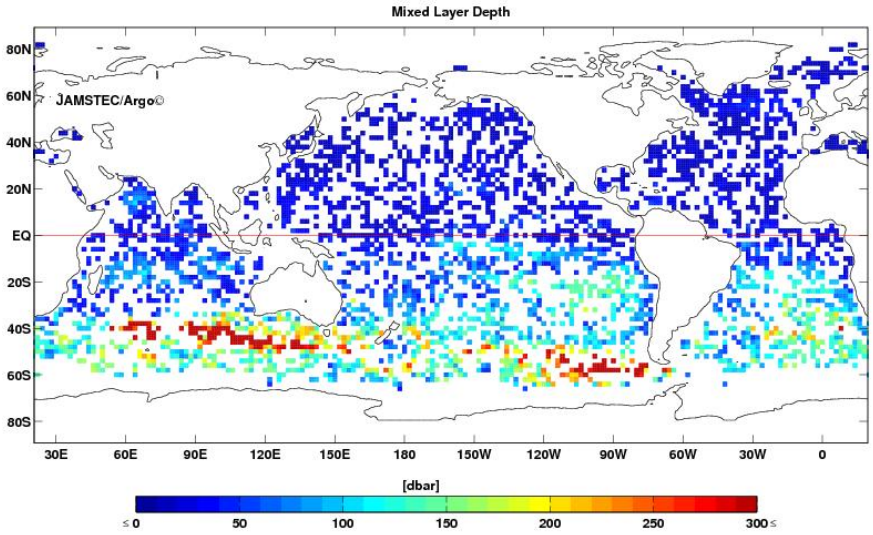


Fig. 2 Mixed Layer properties (depth definition : $\Delta\sigma\theta$= 0.125km/m^3 & ΔT = 0.5°C) August 2018.

2-2. Deep NINJA: Deep ocean observation by deep-sea float

http://www.jamstec.go.jp/ARGO/deepninja/

JAMSTEC has deployed 26 Deep NINJA floats in collaboration with Tsurumi-Seiki Co., Ltd, primarily in the Southern Ocean up to Sept. 2018. As of July 25, 2014, a Deep NINJA float (S/N 6) deployed off the Adélie Coast of Antarctica measured deep profiles under sea ice throughout an Antarctic winter and continued to observe seasonal changes of the deep/bottom waters for more than one year. In 2016, three Deep NINJAs were deployed in the Western Indian Ocean and subtropical North Pacific. In 2017, one and two floats were deployed in the South Pacific/Southern Ocean and North Pacific, respectively (Fig. 3).

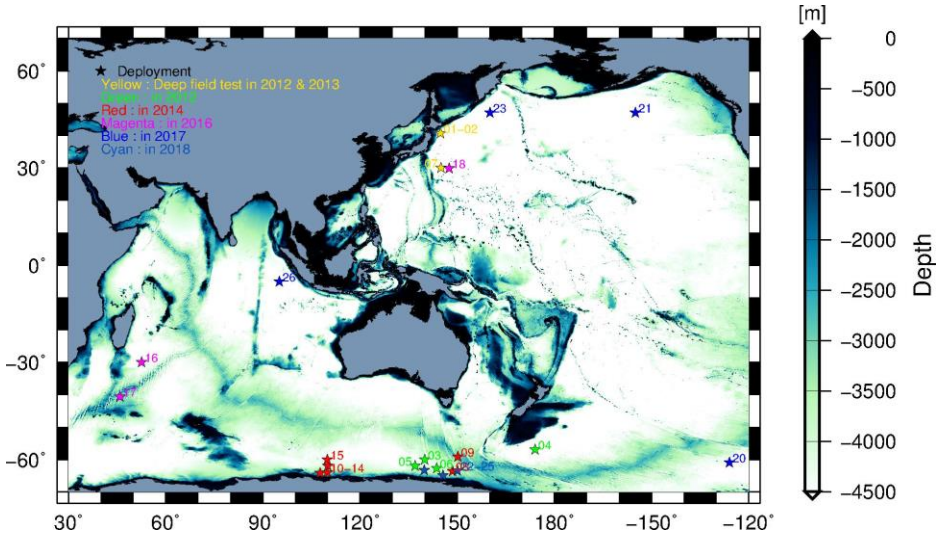


Fig. 3 Deployment map of Deep NINJA floats.

2-3. TRITON Project

http://www.jamstec.go.jp/jamstec/TRITON/real_time/

TRITON (TRIangle Trans-Ocean buoy Network) is a mooring array of ocean buoys designed to obtain real-time air-sea data in the equatorial western Pacific and eastern Indian Ocean for improved detection, understanding and prediction of El Niño and La Niña.

2-4. IOMICS Project:

http://www.jamstec.go.jp/iorgc/iomics/

IOMICS (Indian Ocean Moored buoy network Initiative for Climate Studies) uses a new type of moored buoy which observes sea surface heat flux components and ocean temperature and salinity in the upper layer to understand the mechanism of the Indian Ocean's variation and its importance for global climate system under a cooperative framework among surrounding countries.

2-5. Post-WOCE Hydrography

http://www.jamstec.go.jp/iorgc/ocorp/data/post-woce.html

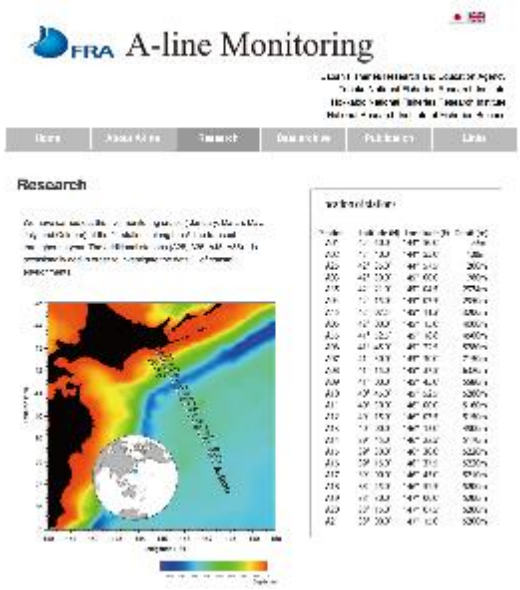
Repeat hydrography is carried out along the WOCE (World Ocean Circulation Experiment) observation lines. It encompasses observations of chemical tracers, total alkalinity, pH, Ω, and nutrients to accurately quantify influences of global warming and ocean acidification on marine ecosystems, as well as to depict changes of the ocean heat content and the distribution of substances in seawater.

II. Report from Fisheries Research Agency (FRA) (by Kazuaki Tadokoro, Tohoku National Fisheries Research Institute)

1. Observation at monitoring lines

A-Line

Tohoku and Hokkaido National Fisheries Research Institutes have carried out oceanographic monitoring from 1987 to the present at the A-line transect in the Oyashio and Kuroshio-Oyashio transition waters. In recent years, observations have been carried out in January, March, May, July, and October. Observations include CTD, water sampling by Niskin bottles, Norpac nets, and Bongo nets. Five cruises were carried out in 2018. The oceanographic data are open and available from the A-line website. Published data are from 1990 to 2016 for CTD and from 1990 to 2013 for other types of data.



A-line monitoring website

O-Line

The National Fisheries Research Institute has carried out monitoring from 1999 to the present at the O-line transect (138°W, 27°N to 34.30°N) in the Kuroshio waters. The observations are carried out in January, March, May, August, and October. Observations include CTD, water sampling by Niskin bottles, and Norpac net. Five cruises were carried out in 2018.

CK-line

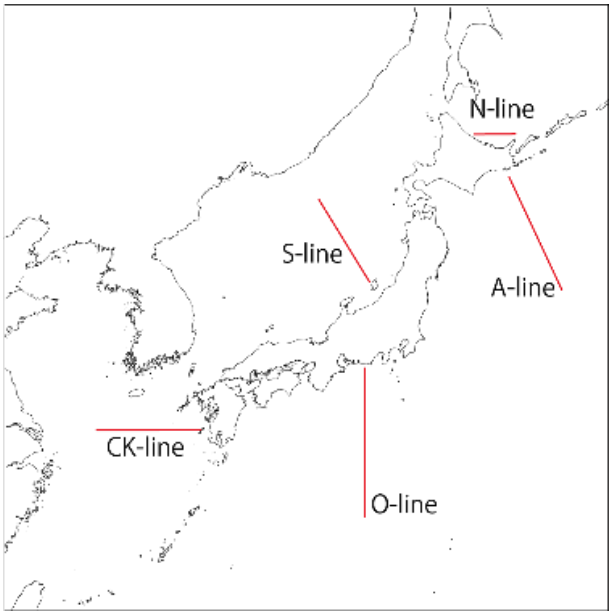
Seikai Fisheries Research Institute have carried out the monitoring from 2002 to present at a transect CK-line in the East China Sea. The observations were carried out in February, March, June, July, and October. Observations include CTD, water sampling by Niskin bottles, and Norpac net. Five cruises were carried out in 2018.

S-line

The Japan Sea National Fisheries Research Institute has carried out monitoring from 2016 to the present in the Sea of Japan. Observations are carried out in February, April, June, and September. Observations include CTD, water sampling by Niskin bottles, and Norpac net. Five cruises were carried out in 2018.

N-line

The Hokkaido National Fisheries Research Institute has carried out monitoring from 2000 to the present in the Sea of Okhotsk. The observations are carried out in May and September. Observations include CTD, water sampling by Niskin bottles, and Norpac net. Five cruises were carried out in 2018. See the N-line website.



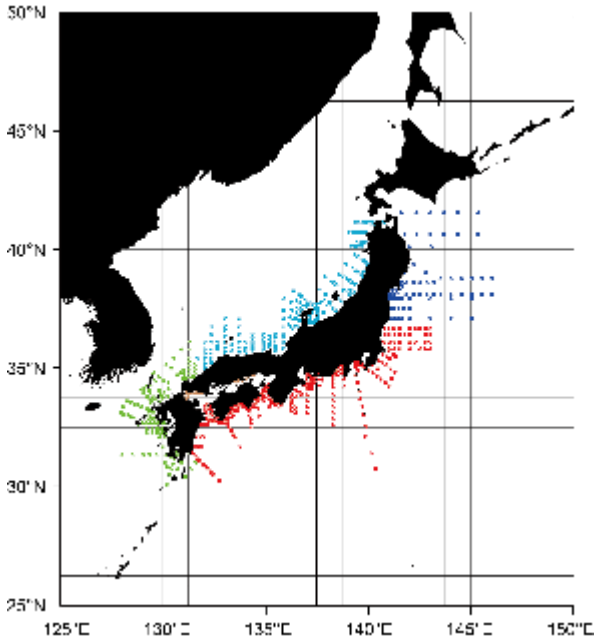
Monitoring lines of FRA

2. Meta genomic and HPLC sample collecting

To understand the biodiversity and biomass of plankton around Japan, FRA has collected metagenomic samples of mesozooplankton and phytoplankton at monitoring lines (A-line, O-line, CK-line, S-line, N-line). Mesozooplankton samples are collected by NORPAC net (mouth diameter: 45cm, mesh size: 0.1mm). Phytoplankton are collected by nuclerpore membrane filter (pore size: 0.2 μm, and 3 μm) and GF/F filters. We are also collecting the HPLC samples for the CHEMTAX analysis. The samples were collected by GF/F filter.

3. Monitoring of stock assessment project commissioned by Fisheries Agency of Japan

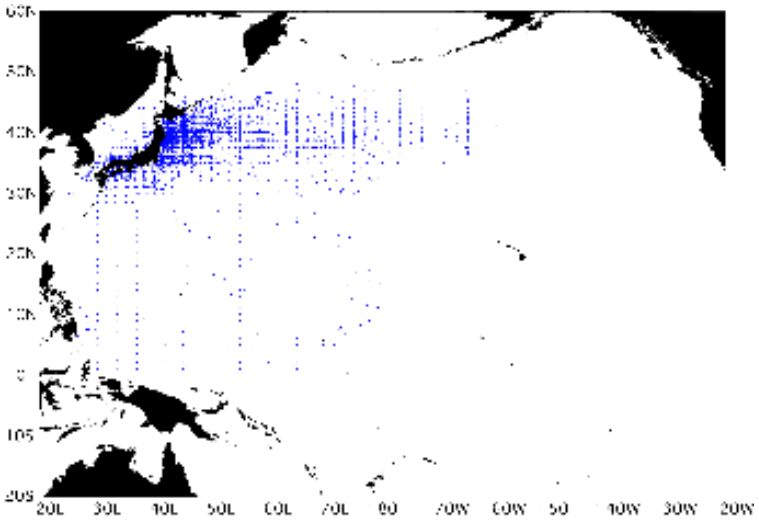
Observations have been carried out at 760 stations in the waters around Japan, except Okinawa and Hokkaido, since 1972. The frequency of the observation is monthly except with the stations in the Sea of Japan. In the Sea of Japan, observations are carried out during spring and autumn. Annual sampling number is about 7000. The prefectural fisheries institutes mainly carry out the monitoring. Observation items are CTD and Norpac net. CTD and abundance of egg, larvae, juvenile pelagic fish data are archived in the database of the FRESCO (Fisheries Resource Conservation) system managed by JAFIC (Japan Fisheries Information Service Center).



Observation stations for monitoring during the stock assessment project

4. Zooplankton sample collection

The Tohoku National Fisheries Research Institute has been collecting zooplankton samples from 1951 to the present (see http://tnfri.fra.affrc.go.jp/seika/plankton/hyohon_home.html). The total number of samples is more than 155,000 at present (October 1, 2018). The samples are preserved by 5% buffered formaldehyde. The sampling area is mainly in the waters around Japan. However, the samples have also been collected in the western North Pacific, central North Pacific, and Peruvian waters. Samples are collected by FRA, prefectural fisheries institutes, Japan Meteorological Agency, and university. The inventory of the sample is archived to the closed database.



Sampling locations of zooplankton

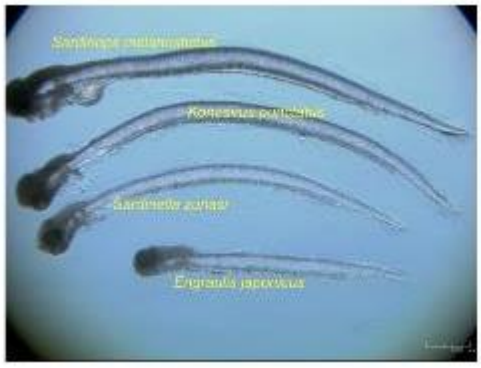
5. Zooplankton photo, sketch, and genomic information library

To analyze zooplankton to species level we have started to collect genomic information (COI, 18S, *etc*.) of mesozooplankton around Japan. We are also collecting morphological information (photos and sketches) of mesozooplankton at the same time. Up to the present, we collected samples and photos from 3 cruises (western north Pacific subtropical waters, western north Pacific tropical waters, Kuroshio-Oyashio Transition waters). This program is collaboration with SCOR Working Group 157 (MetaZooGene).

Mesozooplankton

6. Fish eggs, larvae, juvenile sample collection

The National Fisheries Institute started to collect fish egg, larvae and juvenile samples starting in 2015. The samples were mainly collected during the stock assessment project commissioned by the Fisheries Agency of Japan.



Fish larvae specimen samples

7. Fish specimens sample collection

The Seikai National Fisheries Research Institute has a total number of about 32,000 samples. They are mainly preserved by isopropyl alcohol. DNA samples have also been collected from a part of the samples.

Location, collection building and specimens of fish samples

III. Report from Hokkaido University (by Sei-Ichi Saitoh, Arctic Research Center, Jun Nishioka, Institute of Low Temperature Science and Toru Hirawake, Faculty of Fisheries Sciences, Hokkaido University)

Hokkaido University has conducted two oceanographic field campaigns for a new Japanese Arctic Research program, Arctic Challenge for Sustainability (ArCS), in sub-Arctic and Arctic waters in 2018. The first one was a research cruise by the R/V *Professor Multanovskiy* in the North Pacific and western Bering Sea and second was a research cruise by the T/S *Oshoro-maru* in northern Bering Sea and southern Chukchi Sea.

1. R/V Professor Multanovskiy cruise

To understand the Arctic system, the sub-polar marginal seas are key sites. The western area of the Bering Sea (Anadyr Bay), is considered to have a strong influence on physical and biogeochemical processes in the Arctic Ocean although there are limited data in this area. Therefore, it is important to investigate the role that the Bering Sea plays in linking the Arctic Ocean systems.

An expedition was carried out under the joint research program between Japan and Russia, through the ArCS and OMIX (Ocean Mixing Processes) projects, by Hokkaido University, The University of Tokyo and Far Eastern Regional Hydrometeorological Research Institute (FERHRI). The R/V *Professor Multanovskiy*, which belongs to FERHRI, conveyed the investigators (25 Japanese and 6 Russian scientists). The vessel departed from Otaru, Japan on July 23 at 11:00 am and returned to Otaru on September 14. This research cruise was 54 days at sea, with no call at a port (Figure 1). Dr. Jun Nishioka was chief scientist of the cruise.

Water sampling was conducted to measure biogeochemical parameters to improve our understanding of the dynamics of nutrients, dissolved and particulate matter, and phytoplankton and zooplankton. We also measured parameters related to the physical and hydrological processes that play critical roles in biogeochemical cycling in this region. During the cruise, we conducted CTD water sampling casts, mooring studies, piston coring, zooplankton net sampling, and underway monitoring.

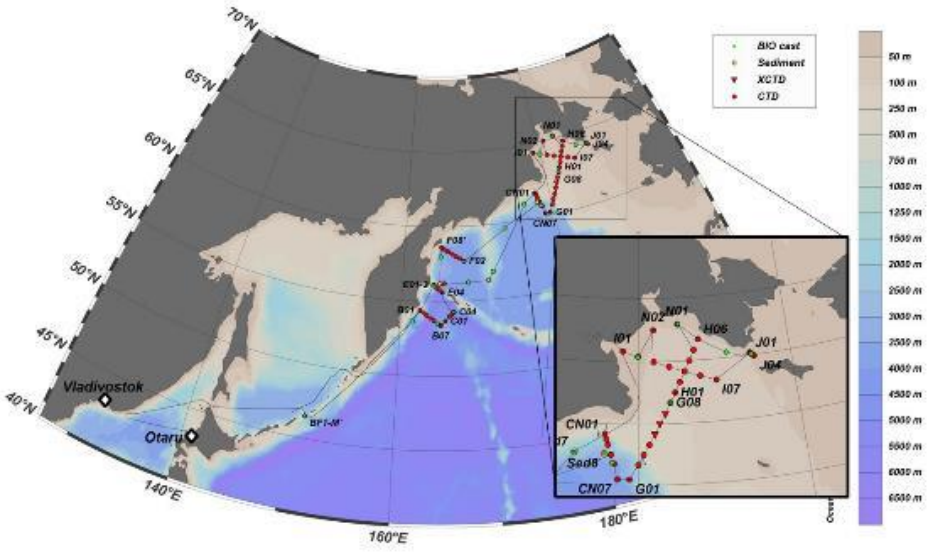
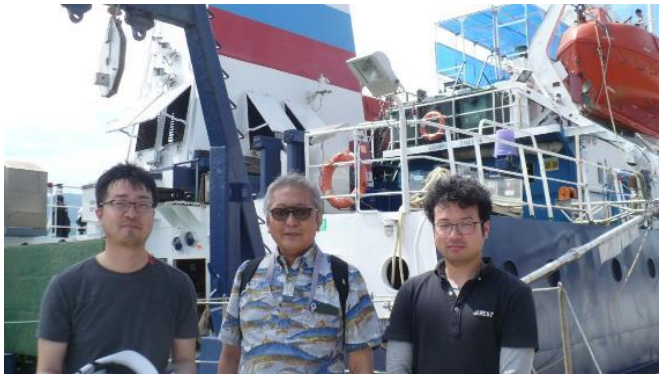


Fig. 1 Observation stations (expanded area is the ArCS project target region)

R/V *Professor Multanovskiy*



Some of the participants of the R/V *Professor Multanovskiy* cruise

2. T/S Oshoro-maru cruise

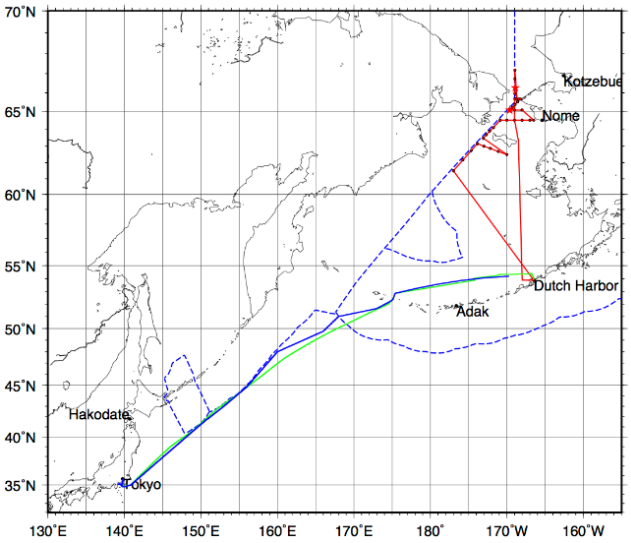
The 56th cruise of the T/S *Oshoro Maru* in the northern Bering and southern Chukchi seas in 2018 was partly supported by the ArCS project. In this cruise, oceanographic surveys, sampling and experiments regarding marine biology and moorings were carried out. We will try to elucidate the nutrient supply mechanism that maintains high biological production in this region, and evaluate the impact of changes in particle flux on the physiology, ecology and production of zooplankton, benthos and fish. The transportation, accumulation and sources of contaminants in Arctic marine biology will also be examined. Furthermore, education of undergraduate and graduate students through the Arctic research is an important objective of this cruise. Some of the students will definitely become scientists or leaders who will contribute to the Arctic environment and sustainability of the marine resources in the polar oceans.

A preliminary report was published which covered the investigators, instruments, and methods of observation items carried out. The observation items include CTD, water sampling, biological and chemical analyses of the water, sediment sampling, fish larvae collection, plankton collection. We also successfully operated kite and sled trawls, and bio-optical measurements for satellite oceanography. Sea bird and mammal sighting surveys were also conducted from the compass bridge. Data will be published in Data Record of Oceanographic Observations and Exploratory Fishing, and database of the ArCS project.

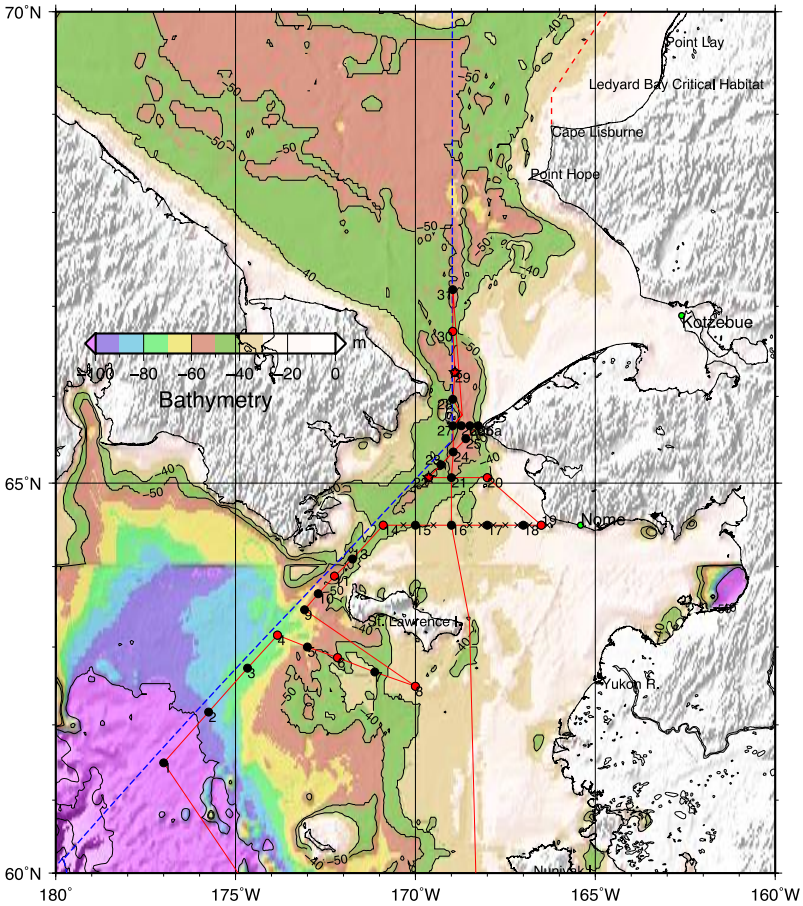
The Chief Scientist was Toru Hirawake (Faculty of Fisheries Sciences, Hokkaido University), and the schedule and ports of call are as follows:

June 14, 2018	Departure from Tokyo port
June 14–June 26	Observations of Leg-1
June 26–June 29	UNISEA dock in Dutch Harbor
June 29–July 15	Observations of Leg-2
July 15–July16	City dock in Dutch Harbor
July 16–July 27	Observation of Leg-3
July 27–July 31	Observation for Leg-3
July 31	Departure from Tokyo port
August 2	Arrival at Hakodate port

Group photo during the 56th cruise of the T/S *Oshoro Maru*



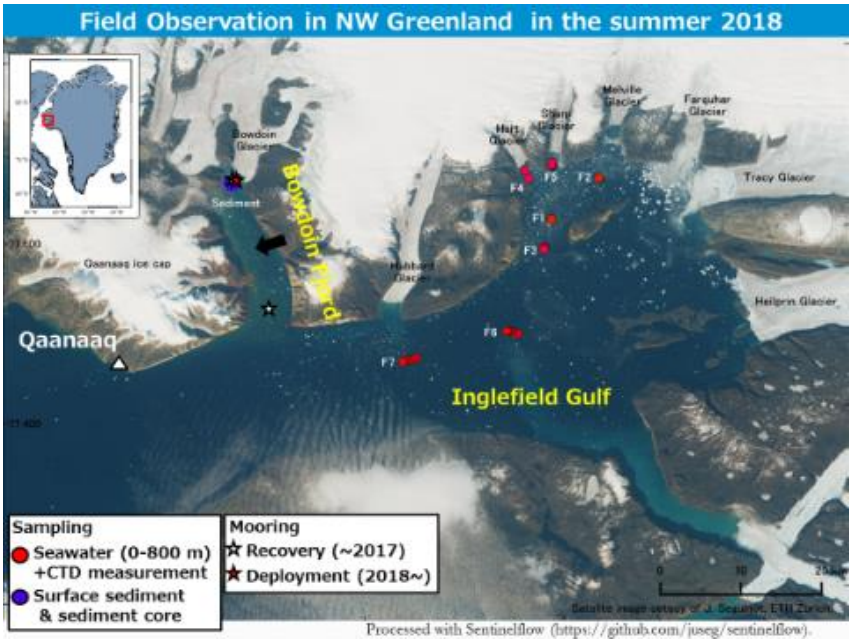
Track lines and sampling stations of the T/S *Oshoro Maru* cruise.
Green, red and blue solid lines show track lines for Leg-1, 2 and 3.



Map of sampling stations during Leg-2. Black and red circle shows routine and biological stations, respectively. Cross shows XCTD station.

3. Ice sheet/glacier–ocean interaction in Greenland

Through the ArCS project, we carried out coastal observations in Greenland.



Observation stations and mooring stations in Inglefield Gulf.

Korea

I. Report from NIFS (National Institute of Fisheries Science)

1. Abnormal water temperature in the Korean waters

During winter and summer in 2018, abnormal water temperature were observed in the Korea waters. During winter, SSTA (Sea Surface Temperature Anomaly) was about –2 to about –3℃ in the coastal area of Korea. During this time, the economic loss from mass mortality at aquaculture farms due to extreme low water temperatures was about 10M$. On the other hand, SSTA was about 2~5℃ in the coastal and offshore area of Korea during July and August in 2018. Economic loss from mass mortality due to extreme high water temperatures was estimated 80~90M$. In recent years, these abnormal water temperatures have frequently occurred in Korea waters. The reasons for extreme high water temperature could be caused by heat waves related to North Pacific High, no passing typhoons, and the strength of Tsushima Warm Current.

2. Wave-glider survey around the coastal upwelling area

NIFS operated a wave-glider to understand the oceanic conditions caused by coastal upwelling along the eastern coast of Korea for 30 days in June and July, 2018. A wave-glider was attached with temperature, salinity, Chl-*a*, wind speed/direction sensors and ADCP (Acoustic Doppler Current Profiler). From these results, NIFS was able to analyze the physical, biogeochemical and atmosphere features related with coastal upwelling in detail.

3. Real-time Information System for Aquaculture around the Korean coastal area

In order to extend available real-time water temperature information to alert aquaculture farms, a Real-time Information System for Aquaculture (RISA) was added by NIFS to the real-time water temperature data of 44 wave height buoys maintained by KMA (Korea Meteorological Administration). With this NIFS-KMA connection, RISA is able to provide real-time water temperature information from 98 stations to correspond with fisheries disasters.

II. Report from KMA (Korea Meteorological Agency)

KMA maintains on-going monitoring programs of wave buoys, and atmospheric condition at meteorological stations. In particular, buoy-mounted cameras have been tested to monitor the ocean conditions, with images at 16 buoys and 9 lighthouse stations.

III. Report from KAIST (Korea Advanced Institute of Science and Technology)

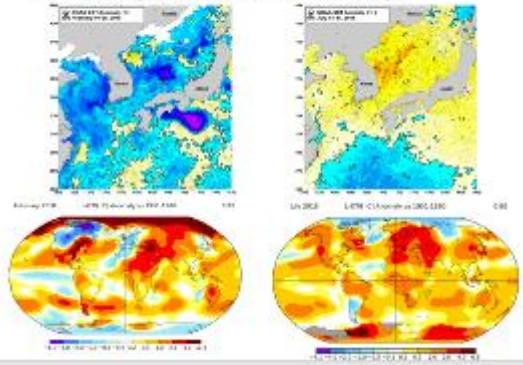
1. Coastal Ocean Observing System in Korea

KAIST is responsible for COOS (Coastal Ocean Observing System). COOS generally consists of an observing system by satellites, buoys, gliders Argo float, tide gauges, HF radars, marine platforms and other *in-situ* coastal observations. This system can be used for rescue, coastal environmental accidents, fisheries, coastal disasters and other various coastal problems.

1

Anomalous water temperature in the Korea Waters

- Anmalous water temperature (SSTA) about 2~3 °C lower in winter and higher in summer than climatology



2

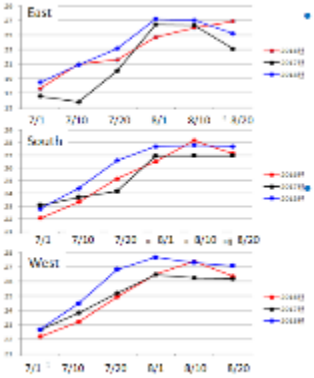
Mass mortality by anomalous water temperature

- **Economic loss** by anomalous water temperature on aquaculture was about **18M$** in 2018.

<Low and high water temperature warning by NIFS>

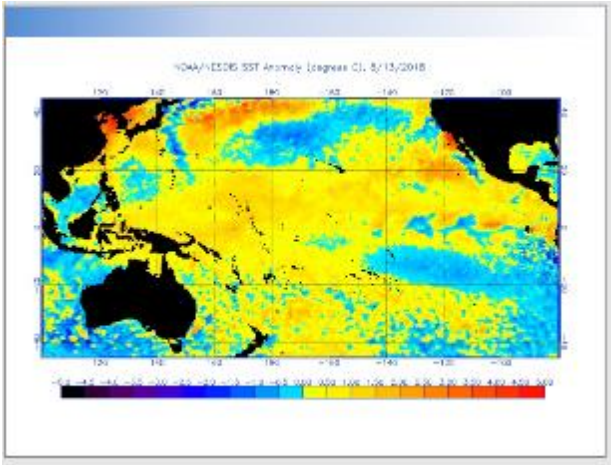
3

Warming tendency during recent three years



- The warm water temperature phenomena during summer 2018 appear early compared with similar phenomena during last two years (2016, 2017).
- Does the warm-water temperature phenomenon appear early and stay around Korea?

4

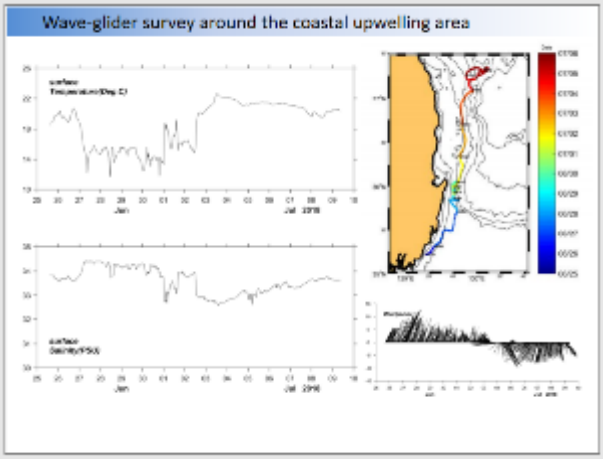


5

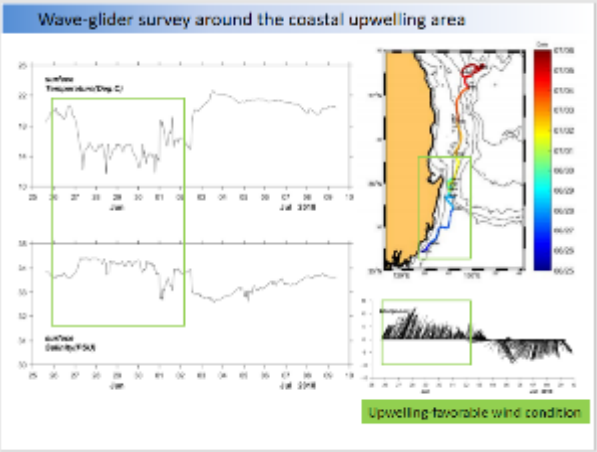
Wave-glider survey around the coastal upwelling area

- Period : June and July of 2018
- Goals: 1) To understand the ecological features by the development of coastal upwelling and 2) the spatio-temporal variations of coastal upwelling along the coast
- Parameters : Temperature, salinity, currents, waves, atmospheric conditions

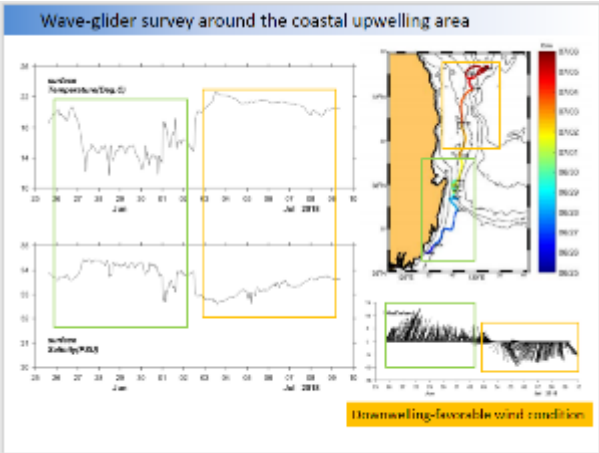
6


Wave-glider survey around the coastal upwelling area

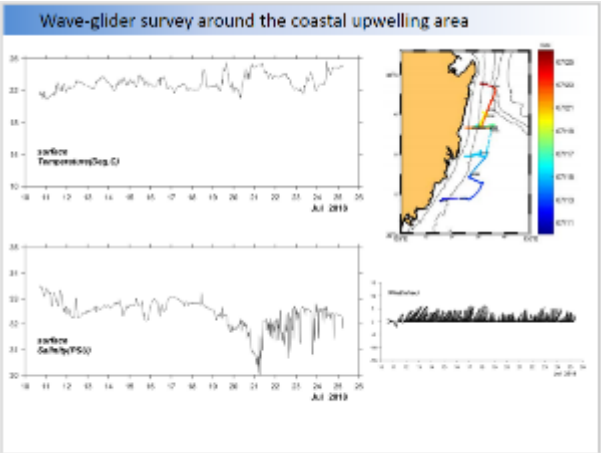
7


Wave-glider survey around the coastal upwelling area
Upwelling-favorable wind condition

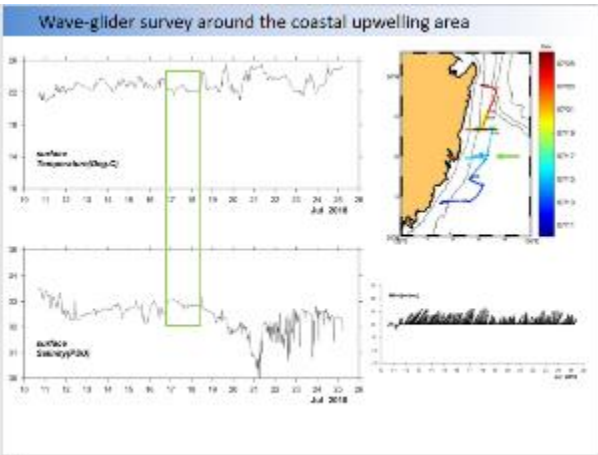
8


Wave-glider survey around the coastal upwelling area
Downwelling-favorable wind condition

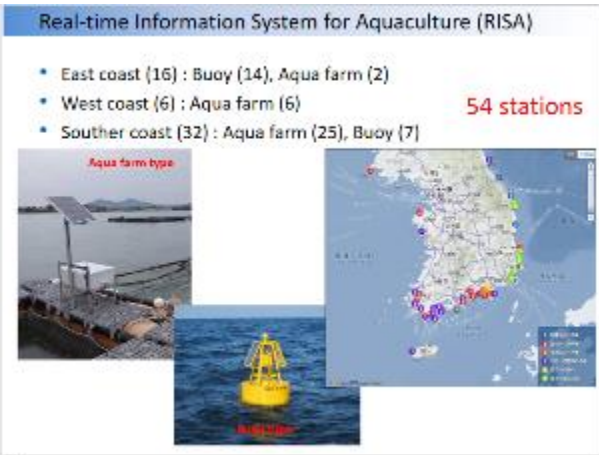
9


Wave-glider survey around the coastal upwelling area

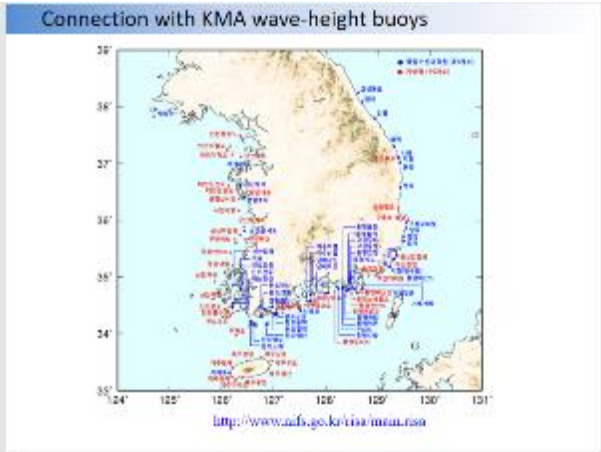
10

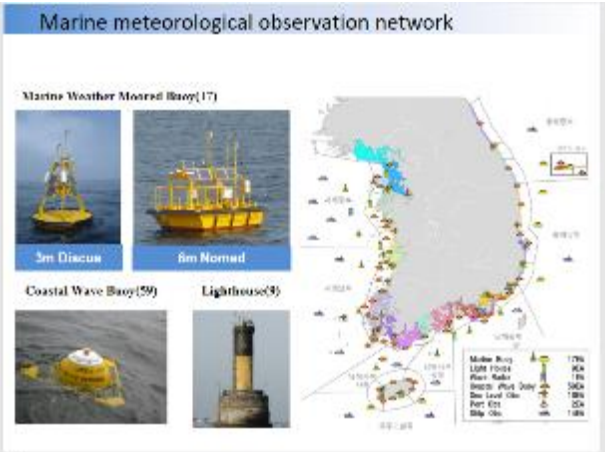

Wave-glider survey around the coastal upwelling area

11


Real-time Information System for Aquaculture (RISA)
East coast (16) : Buoy (14), Aqua farm (2)
West coast (6) : Aqua farm (6)
Souther coast (32) : Aqua farm (25), Buoy (7)
54 stations
Aqua farm type

12


Connection with KMA wave-height buoys
http://www.nafs.go.kr/risa/main.nsa
13


Marine meteorological observation network
Marine Weather Moored Buoy(17)
3m Discus
6m Nomad
Coastal Wave Buoy(59)
Lighthouse(9)
14


Buoy mounted camera
✓ Capture ocean conditions of waves, fog, and precipitation, etc) with images
✓ Sampling interval: 1 hour
✓ To be installed in December at
16 buoys (BuoyCamera) and
9 Light House AWS(MarineCamera)
16

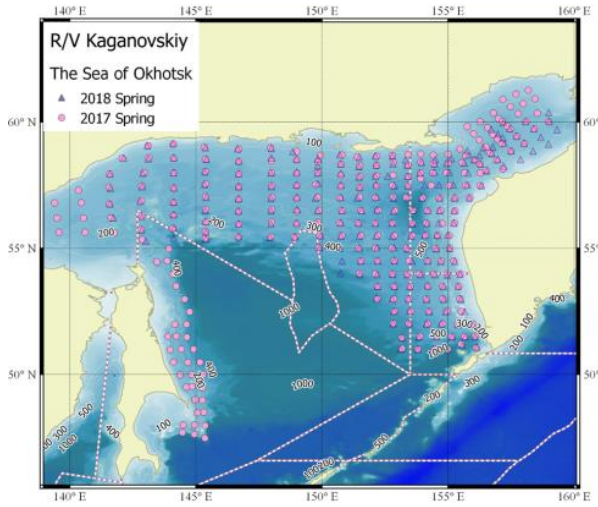
Russia

I. Information stored in the PostgreSQL server hosted by TINRO-Center in 2017–2018 (by I.V. Volvenko)

TINRO-Center conducts fishery-independent surveys in all Far Eastern Seas and the Northwestern part of the Pacific Ocean. The information from trawls and CTD stations has been stored in the Laboratory "Regional Data Center" for 43 years (Volvenko, 2015). The laboratory was renamed in 2018 to "Laboratory for Fishing Statistics and Databases". Employees at TINRO-Center can organize their datasets as they wish, but they are obliged to share copies with Laboratory for Fishing Statistics and Databases if the data is gathered in the expeditions organized by TINRO-Center. Thus, we prepare and store the data in the PostgreSQL database for the usage by authorized users.

TINRO-Center dispatched the R/V *Professor Kaganovskiy* (hereinafter referred to as the R/V *Kaganovskiy* for brevity) to the Sea of Okhotsk as usual (Figure 1) to estimate the status of the stock of walleye pollock in spring and the abundance of all other species caught by trawls. Two hundred and sixty-nine midwater trawlings were made from April 11, 2017to May 30, 2017 and 220 midwater trawlings were made from April 15, 2018 to May 26, 2018.

Forty-three midwater trawlings were conducted by the same research vessel from March 27, 2017 to April 4, 2017 and 30 trawlings were conducted from April 6, 2018 to April 11, 2018. All of them were conducted mainly to estimate walleye pollock stock above the shelf of the southern Kuril Islands as usual (**Error! Reference source not found.**).



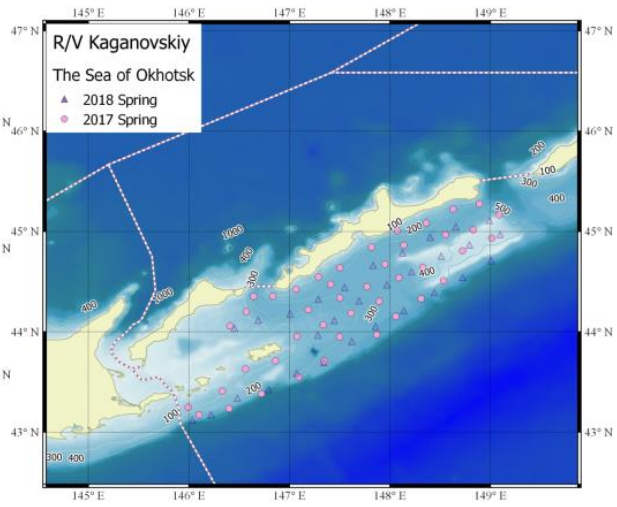


Figure 1 (left) and Figure 2 (right)

As usual, the R/V *TINRO* conducted bottom trawlings close to Western Kamchatka in summer (mostly June) along the coast down to 560 m depth (from June 22, 2017 to August 3, 2017; 259 trawlings) and from the coast down to 211 m depth (from May 28, 2018 to July 3, 2018; 220 trawlings), but this year it started in spring from deeper locations (from April 14, 2018; 171 trawlings). The maximum depth of bottom trawling was 972 m (Figure 2).

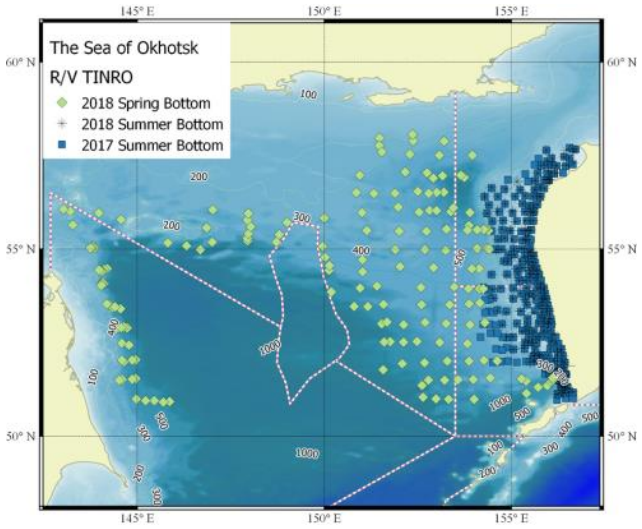


Figure 2

The upper pelagial layer of the Sea of Okhotsk is usually studied in fall to count juvenile salmon mainly, *e.g.*, the R/V *Kaganovskiy* made 84 trawlings from October 11, 2017 to November 15, 2017, but this year another research vessel – the *Dmitriy Peskov* made 29 trawlings earlier: from July 12, 2018 to July 27, 2018 (Figure 4). The adults of salmon (mature and immature) are the main targets to estimate abundance of during scientific surveys in summer in the offshore waters of the Northwestern part of the Pacific Ocean. The R/V *Kaganovskiy* conducted 77 trawlings from June 1, 2017 to July 4, 2017 and 88 trawlings from May 31, 2018 to July 7, 2018. The R/V *TINRO* conducted 72 trawlings from August 8, 2017 to September 8, 2017, having multiple targets, and 47 trawlings in the waters east off Kamchatka from September 14, 2017 to September 30, 2017 for salmon research (Figure 4).

In the Bering Sea, the R/V *Buhoro* made 255 bottom trawlings down to 374 m depth from June 7, 2017 to August 11, 2017 (Figure 5).

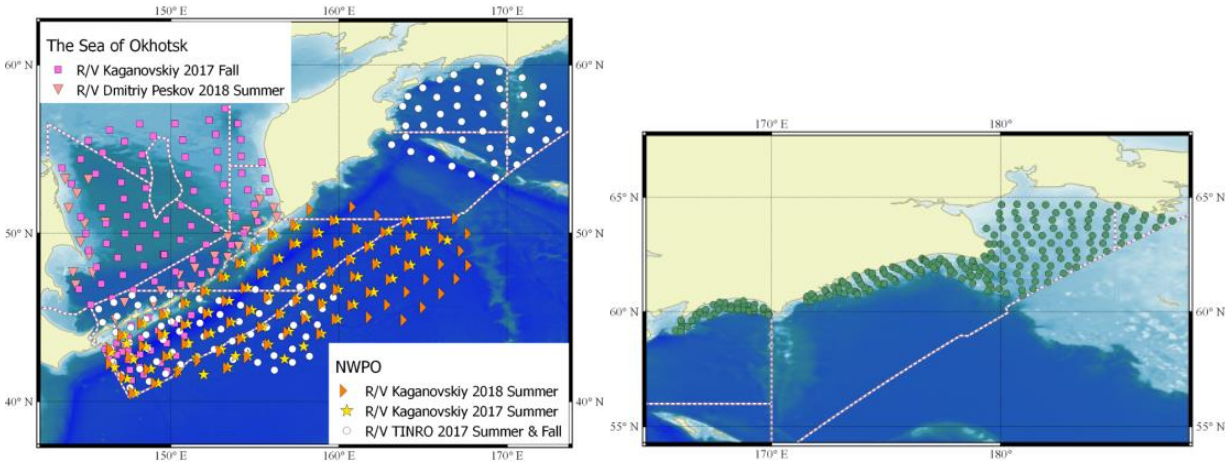


Figure 3 (left) and Figure 5 (right)

Traditional bottom surveys in Region 19, Peter the Great Bay, took place with the R/V *398* conducting 57 bottom trawlings from August 1, 2017 to September 9, 2017 and the R/V *Buhoro* conducting 224 bottom trawlings from April 20, 2018 to June 17, 2018 (Figure 4).

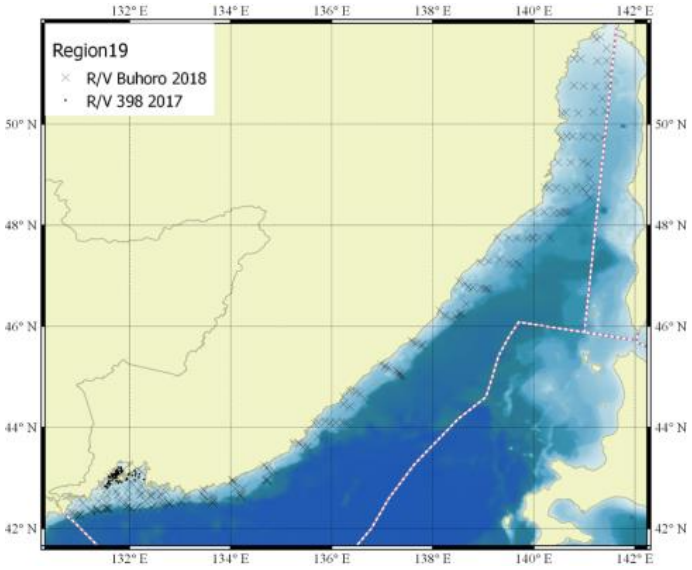


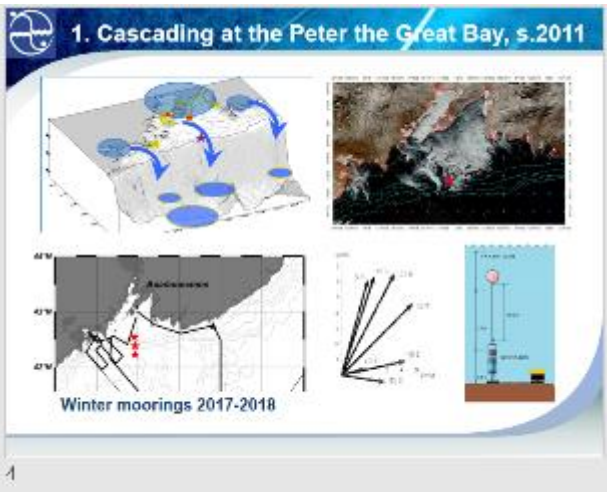
Figure 4

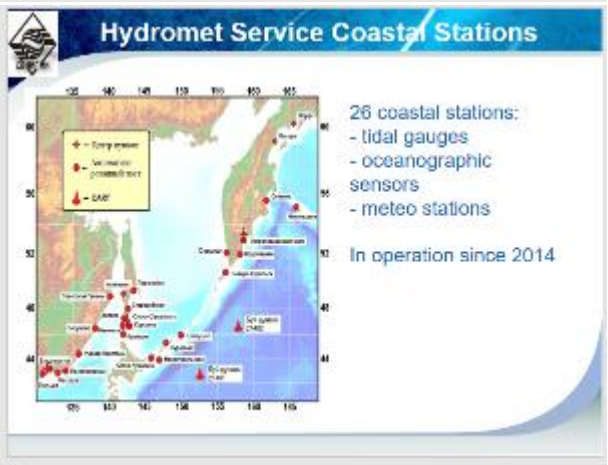
There are some other expeditions still in the process of conducting or checking. A full list of expeditions, conducted in 2018, will be available in 2019 only.

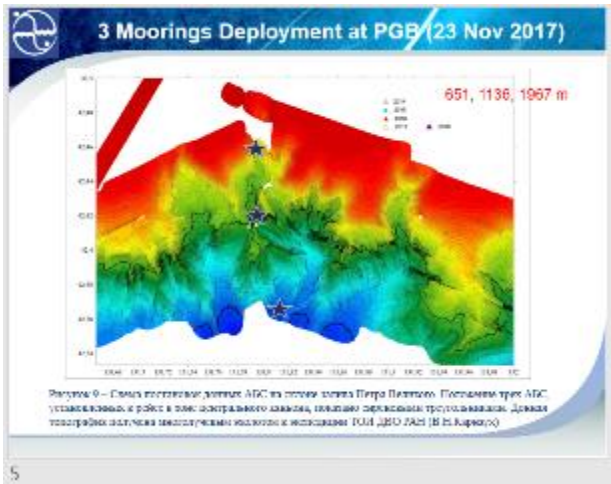
Reference

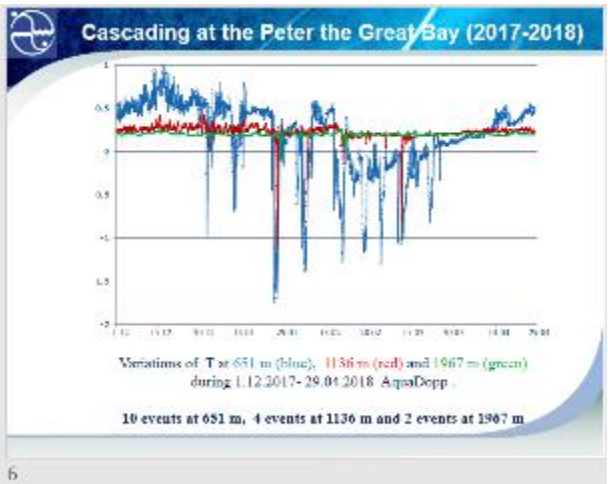
Volvenko, I. V. (2015). The Role of the Regional Data Center (RDC) of the Pacific Research Fisheries Center (TINRO-Center) in North Pacific Ecosystem and Fisheries Research. *International Journal of Engineering Research & Science*, 1 (November 2015), 47–54.

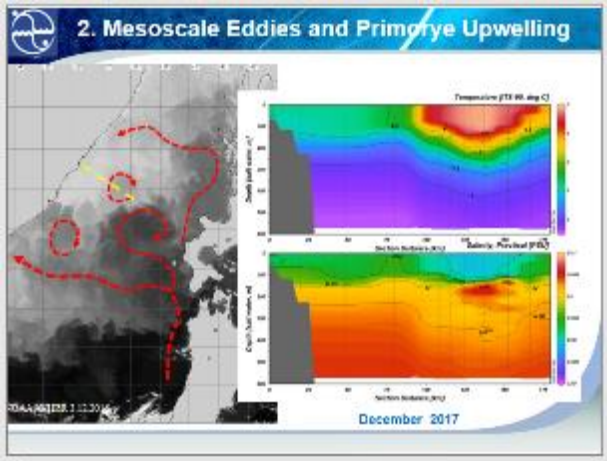
Recent monitoring activities in Russia by POI (by Vyacheslav Lobanov, V.I. Il'ichev Pacific Oceanological Institute, Far Eastern Branch, Russian Academy of Sciences)



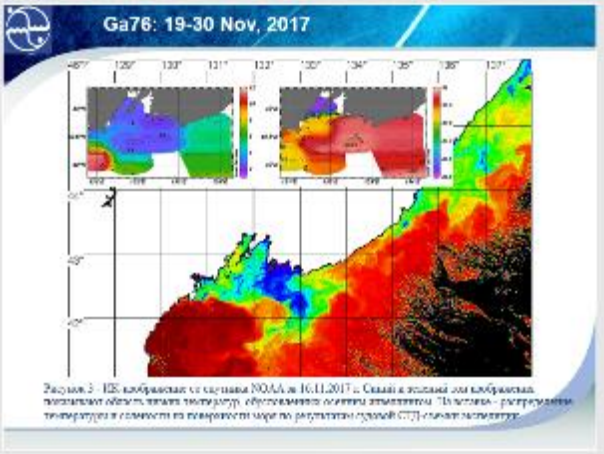




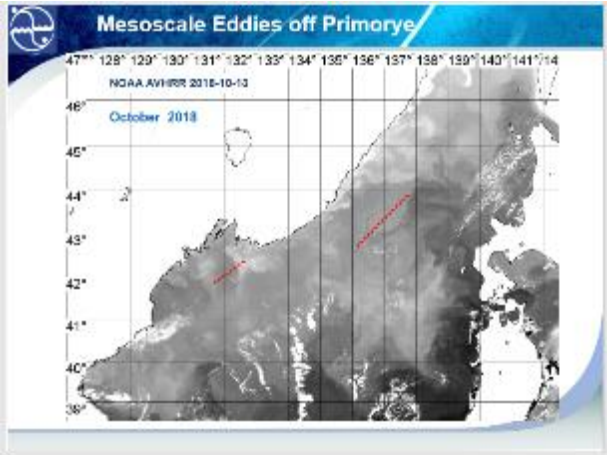



2. Mesoscale Eddies and Primorye Upwelling
December 2017

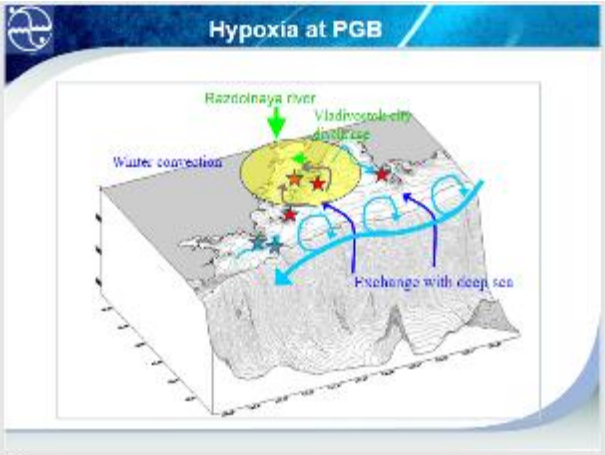
7


Ga76: 19-30 Nov, 2017

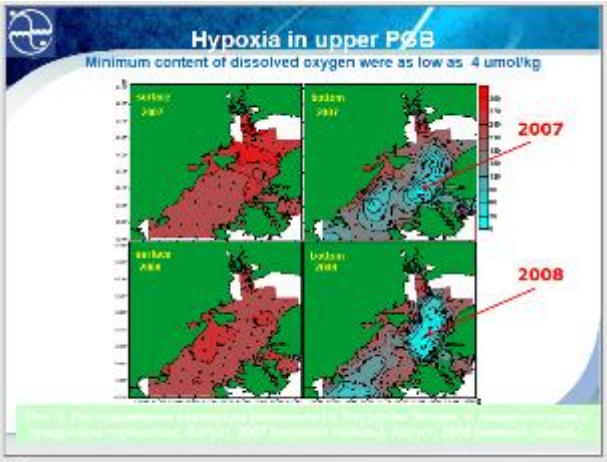
8


Mesoscale Eddies off Primorye
NOAA AVHRR 2018-10-13
October 2018

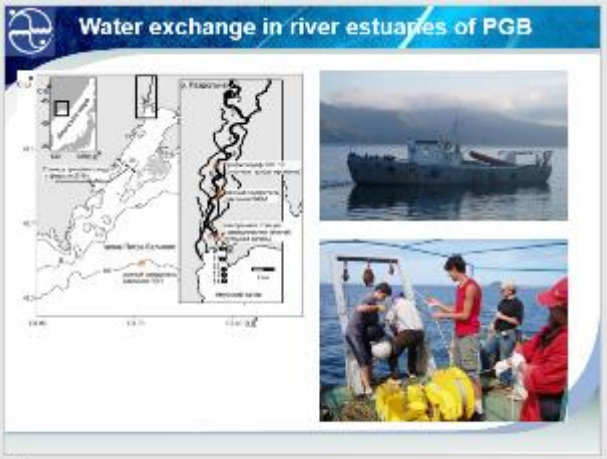
9


Hypoxia at PGB
Razdolnaya river
Vladivostok city discharge
Water convection
Exchange with deep sea

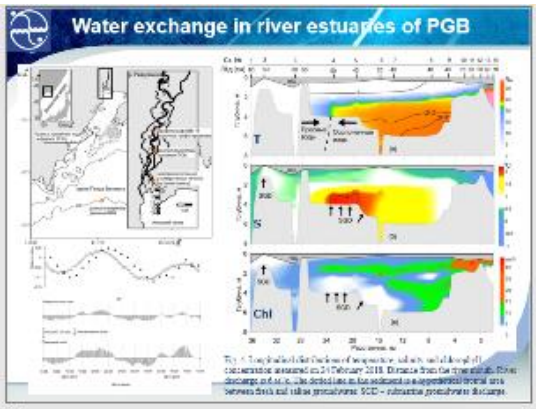
10


Hypoxia in upper PGB
Minimum content of dissolved oxygen were as low as 4 umol/kg
2007
2008

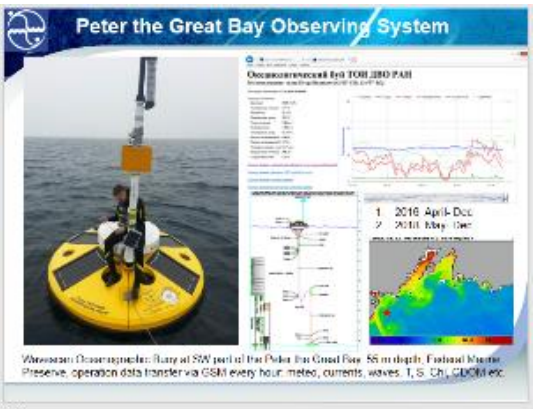
11


Water exchange in river estuaries of PGB

12



13



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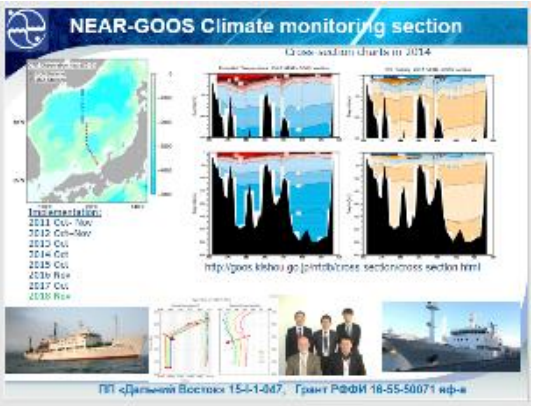

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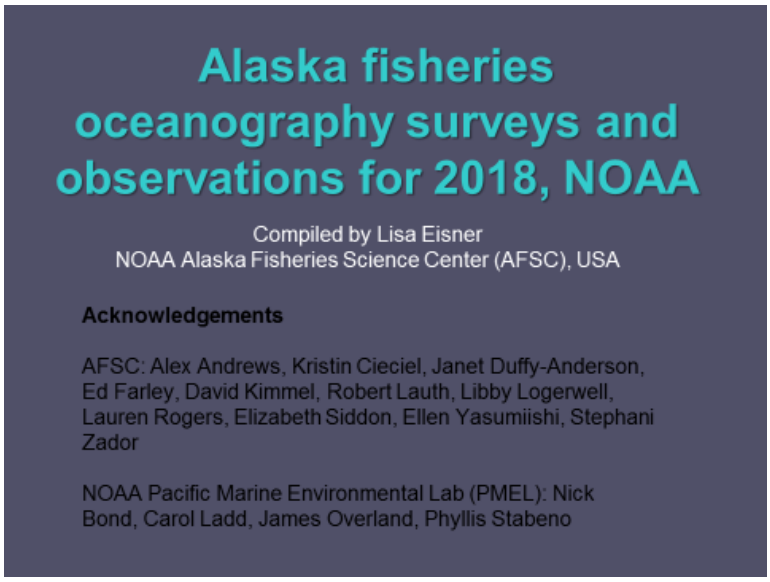
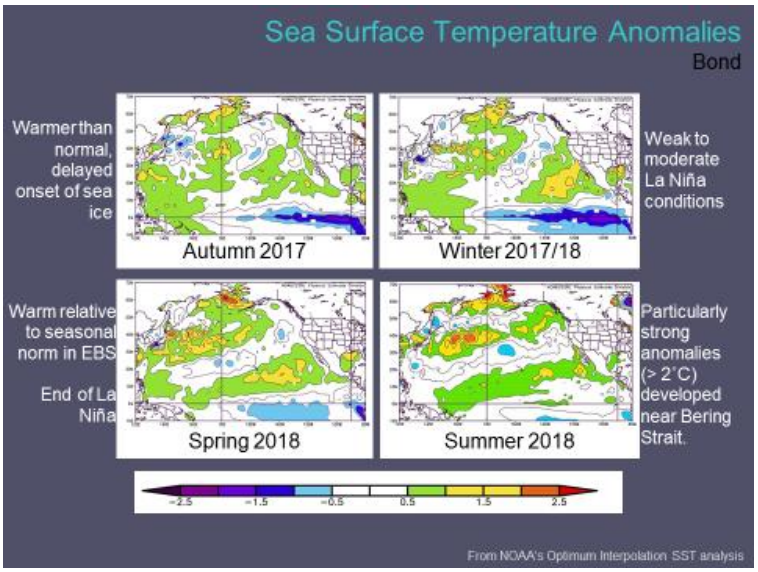
USA

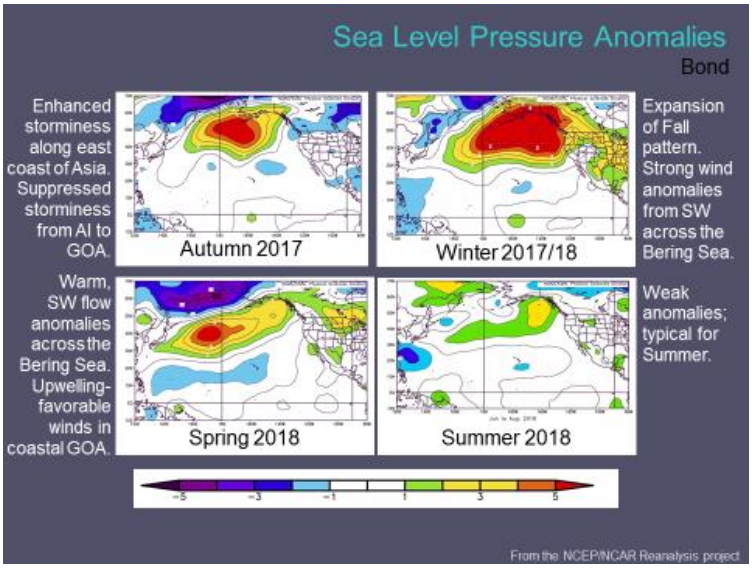
US country report for Alaska (primarily NOAA surveys and observations) for 2018

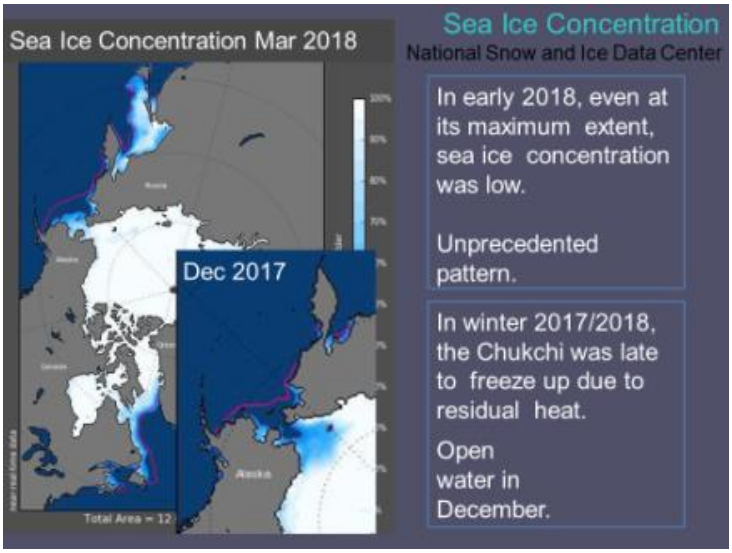
The Bering Sea is emphasized, since the majority of surveys were conducted in this region in 2018. NOAA Alaska Fisheries Science Center (AFSC) focuses more effort on the Bering Sea in even years and the Gulf of Alaska in odd years.

Slides kindly provided by Stephani Zador and Elizabeth Siddon (climate), Lauren Rodgers and Ellen Yasumishii (RPA) and Bob Lauth (Bottom Trawl) from presentations at NPFMC Groundfish Plan Team meeting September 19, 2018 in Seattle, WA.

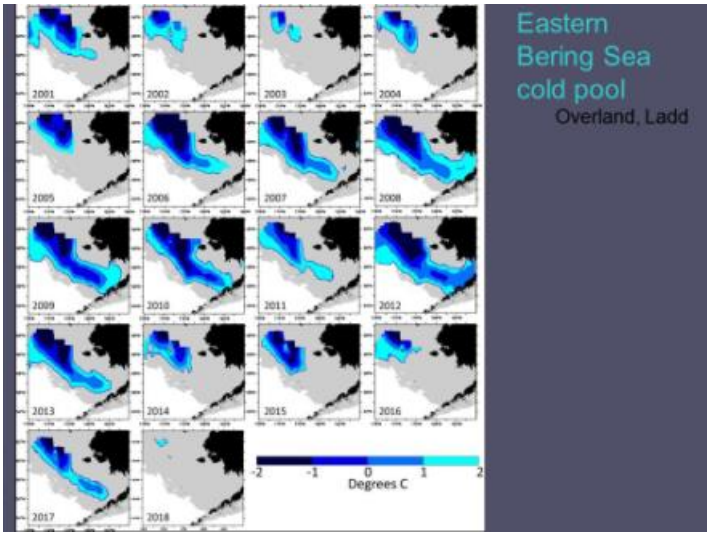



Sea Surface Temperature Anomalies
Bond
Warmer than normal, delayed onset of sea ice
Autumn 2017
Winter 2017/18
Weak to moderate La Niña conditions
Warm relative to seasonal norm in EBS
End of La Niña
Spring 2018
Summer 2018
Particularly strong anomalies (> 2˚C) developed near Bering Strait.
−2.5 −1.5 −0.5 0.5 1.5 2.5
From NOAA's Optimum Interpolation SST analysis

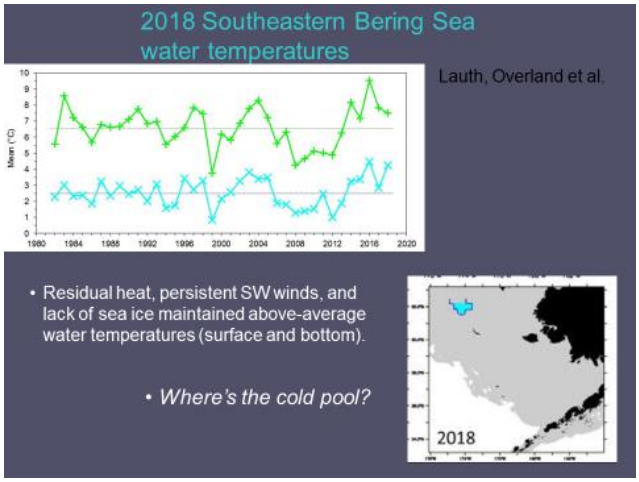

Sea Level Pressure Anomalies
Bond
Enhanced storminess along east coast of Asia. Suppressed storminess from AI to GOA.
Autumn 2017
Winter 2017/18
Expansion of Fall pattern. Strong wind anomalies from SW across the Bering Sea.
Warm, SW flow anomalies across the Bering Sea. Upwelling-favorable winds in coastal GOA.
Spring 2018
Summer 2018
Weak anomalies; typical for Summer.
−5 −3 −1 1 3 5
From the NCEP/NCAR Reanalysis project

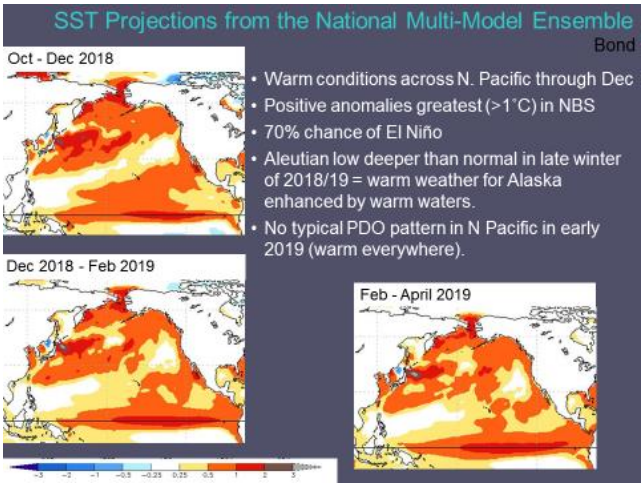

Sea Ice Concentration Mar 2018
Sea Ice Concentration
National Snow and Ice Data Center
Dec 2017
In early 2018, even at its maximum extent, sea ice concentration was low.
Unprecedented pattern.
In winter 2017/2018, the Chukchi was late to freeze up due to residual heat.
Open water in December.

Cold pool observations from temperature measurements on summer AFSC bottom trawl surveys, June to mid-August.

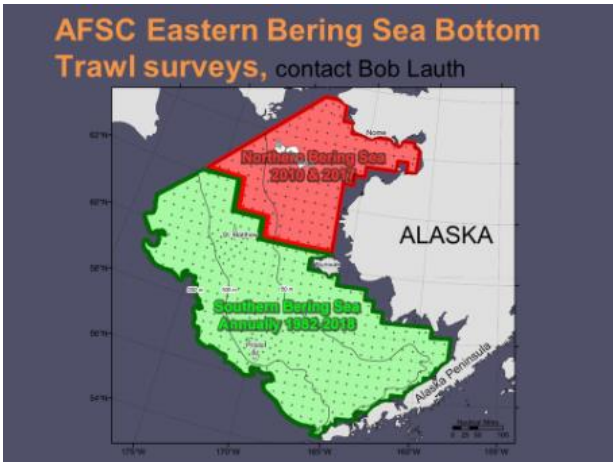


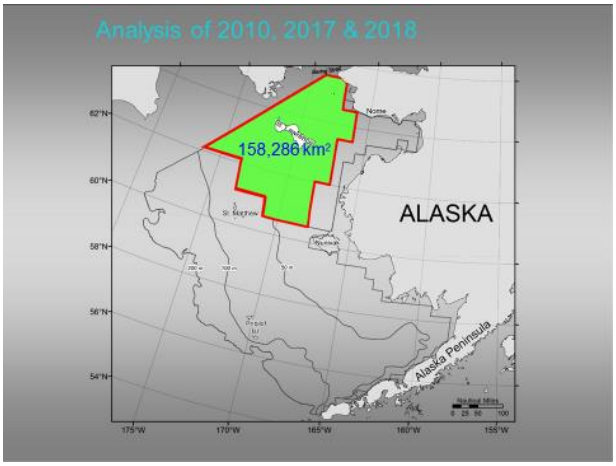
Temperature data from summer AFSC bottom trawl surveys. Green is surface temperature and aqua is bottom temperature.

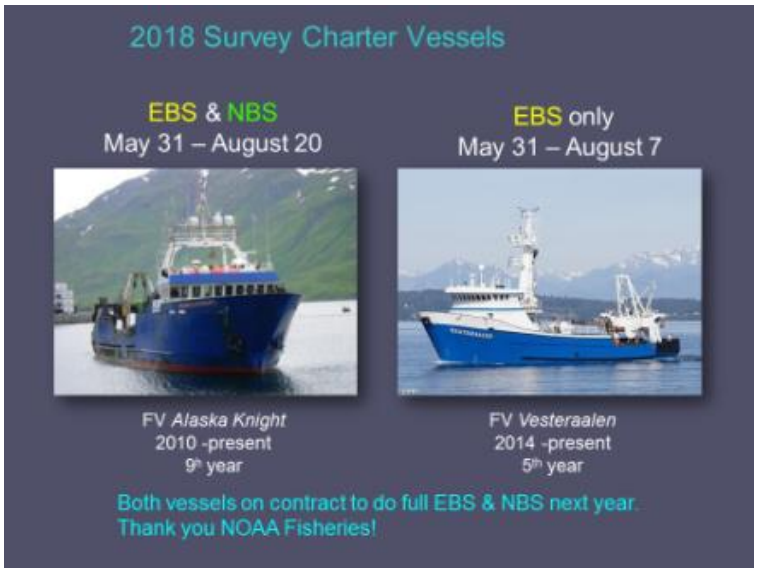




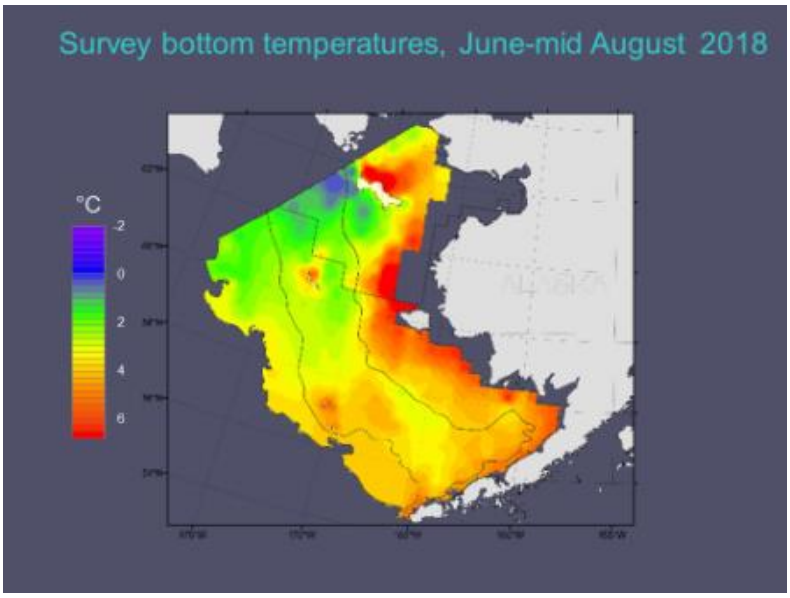
Bottom trawl surveys were conducted by NOAA AFSC in both the eastern Bering Sea (EBS) and northern Bering Sea (NBS) in 2018. North Bering Sea comparisons were made using only the area that was sampled in all 3 years (2010, 2017, 2018).



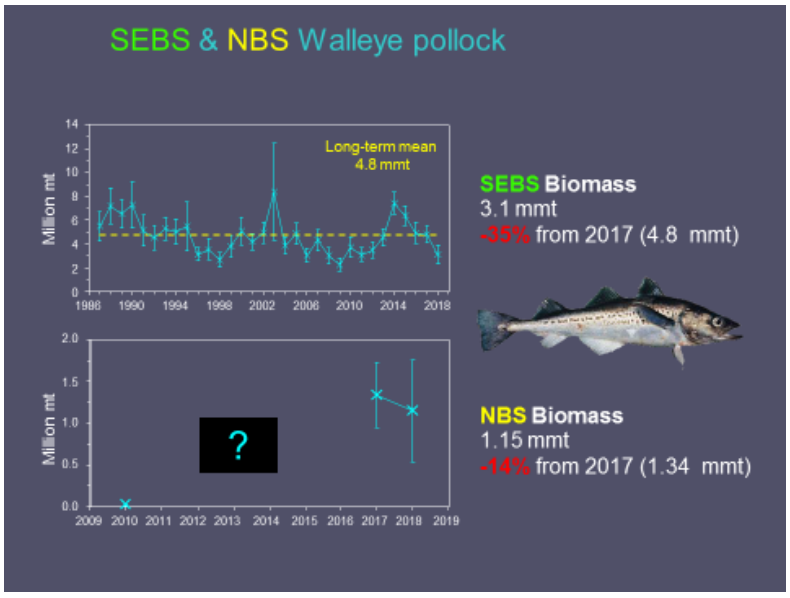




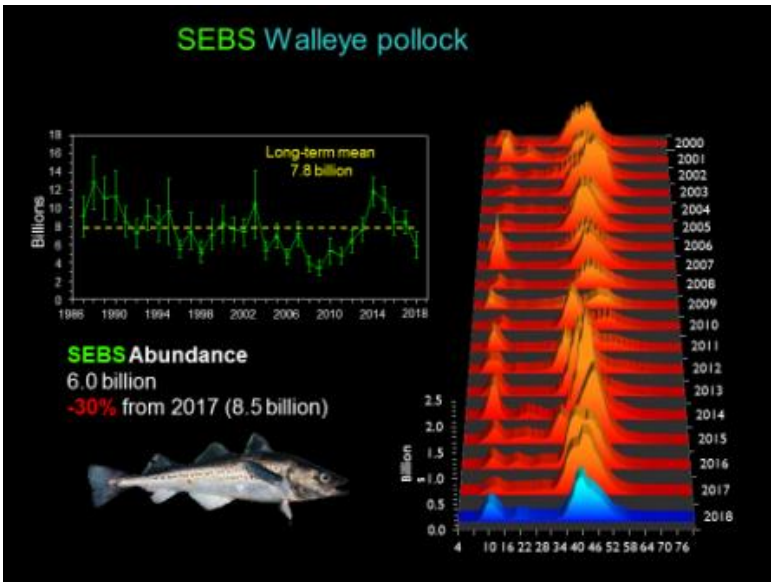
Very warm bottom temperatures in 2018.

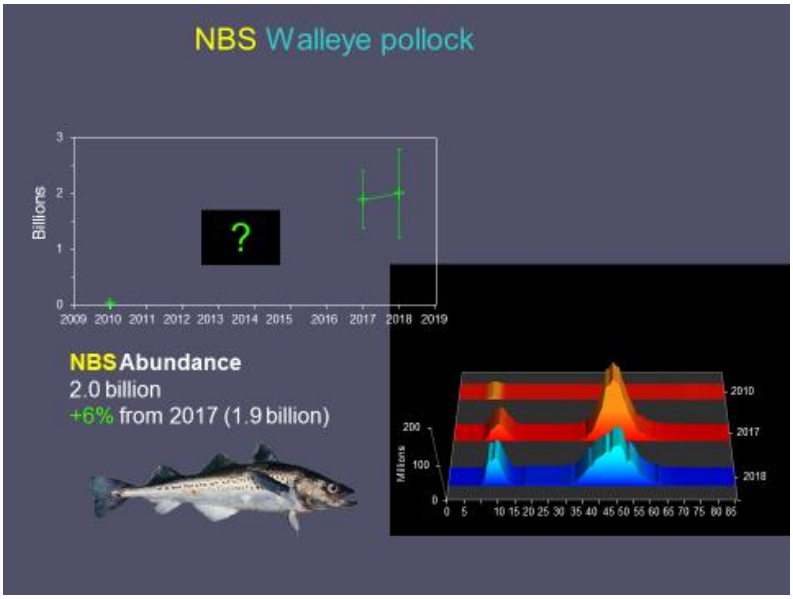


Biomass and abundance of adult pollock were low (below average) in 2018 in the southeastern Bering Sea (SEBS). In the NBS, biomass and abundance of adult pollock was much higher in 2017 and 2018 than in 2010. Length distribution (cm) by year is shown at the right in pollock abundance figures.

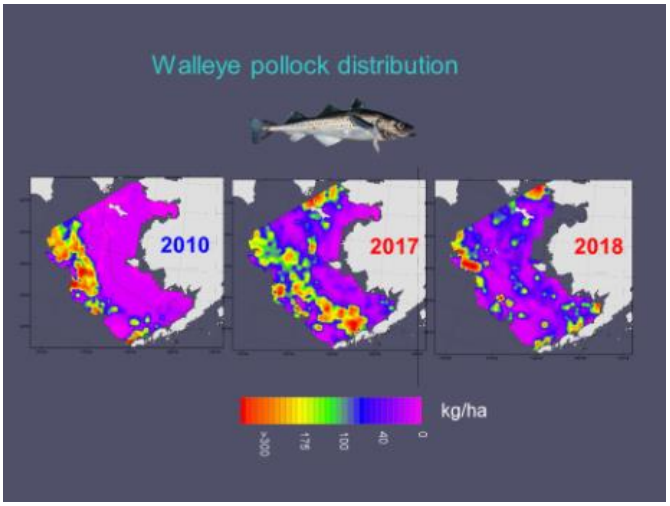


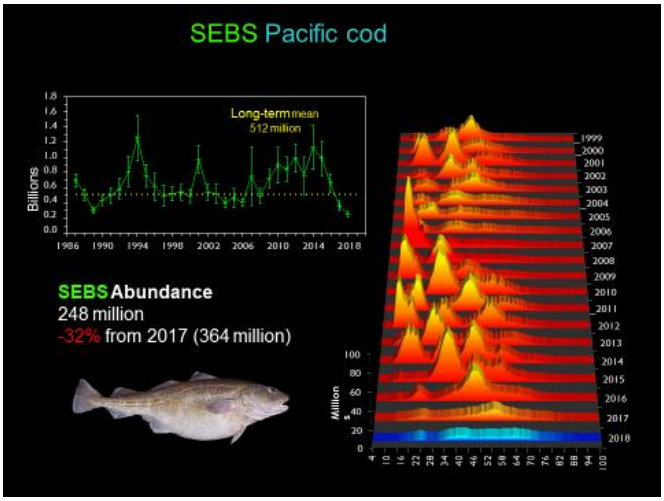
Adult pollock were distributed further north in 2017 and 2018 than in 2010.

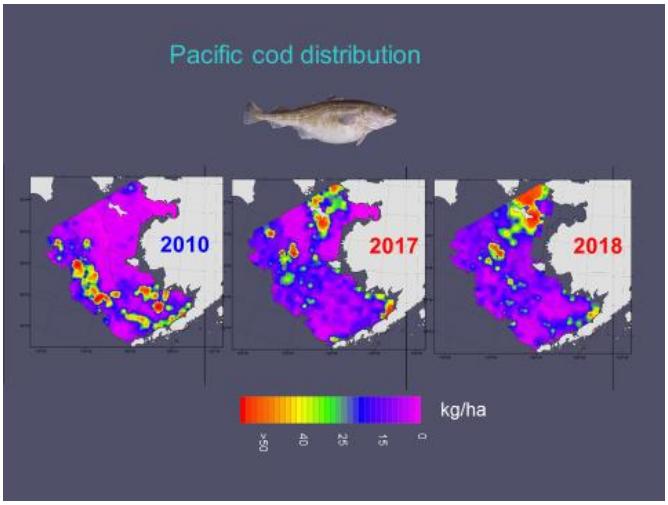




Similar to pollock, biomass (not shown) and abundance of adult Pacific cod were below average in 2018 in the southeastern Bering Sea (SEBS) and were distributed further north in 2017 and 2018 than in 2010.

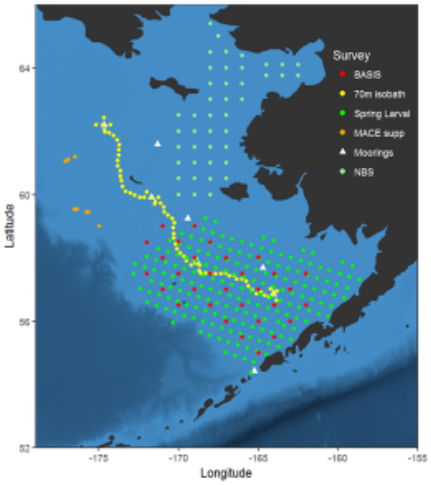






A profiling mooring (Prawler) located on the southeast middle shelf was able to capture the spring phytoplankton bloom. The bloom occurred late, typical for a warm year.

Bering Sea Recruitment Processes Alliance (RPA) surveys, AFSC and PMEL



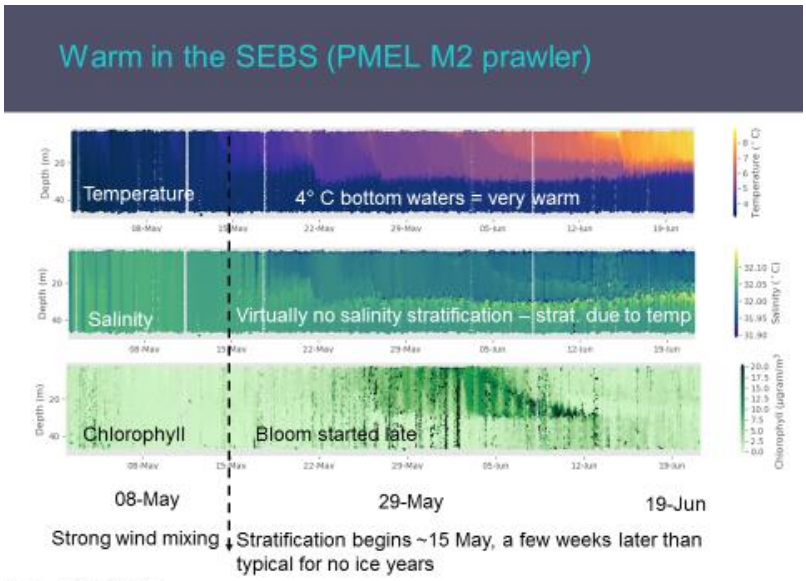
Moorings and 70m Isobath
Latitudinal picture of lower trophics and processes on middle shelf in spring and autumn

Spring Larval Survey
Spatially-extensive sampling of zooplankton and fish early life stages.

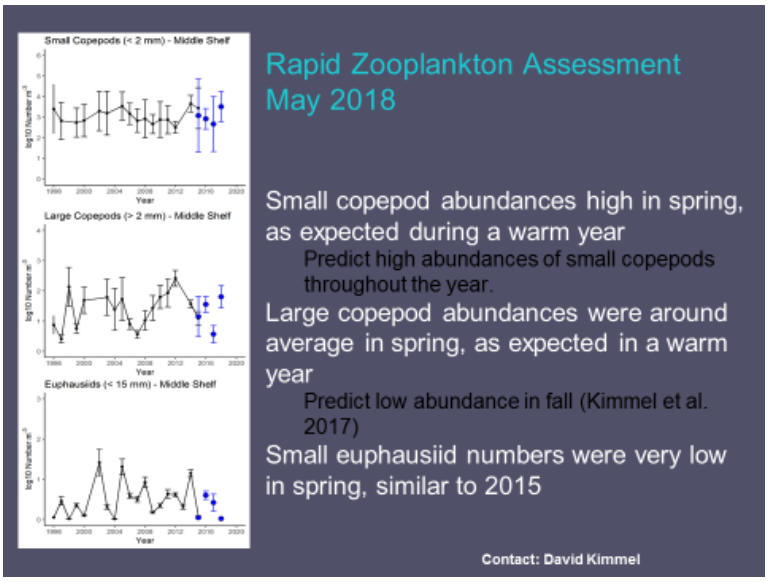
BASIS
Ecology of YOY gadids, salmon, forage fishes and their prey in late summer.

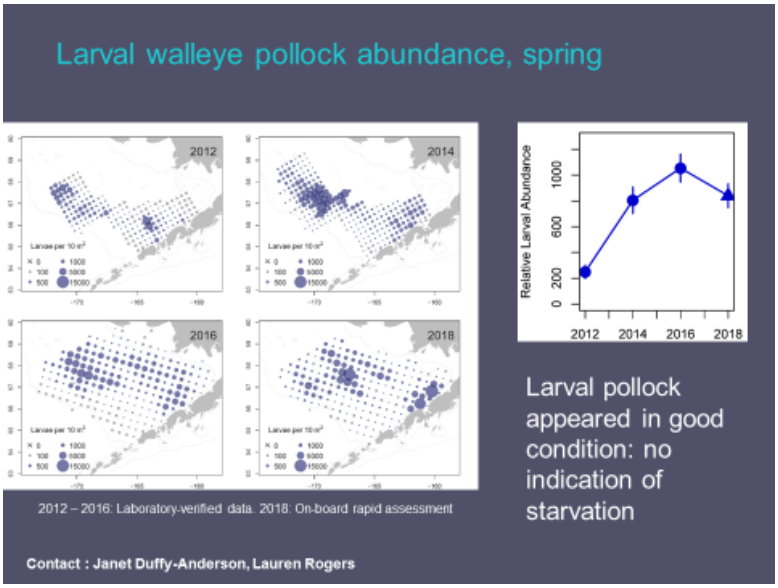
Northern Bering Sea Survey
Ecology of YOY gadids, salmon, herring, capelin and lower trophic levels in late summer.

MACE supplemental sampling
Zooplankton and YOY gadids on outer shelf in late summer.



Contact: Phyllis Stabeno


Small Copepods (< 2 mm) - Middle Shelf
Large Copepods (> 2 mm) - Middle Shelf
Euphausiids (< 15 mm) - Middle Shelf
Year
Rapid Zooplankton Assessment
May 2018
Small copepod abundances high in spring, as expected during a warm year
Predict high abundances of small copepods throughout the year.
Large copepod abundances were around average in spring, as expected in a warm year
Predict low abundance in fall (Kimmel et al. 2017)
Small euphausiid numbers were very low in spring, similar to 2015
Contact: David Kimmel


Larval walleye pollock abundance, spring
2012
2014
2016
2018
Relative Larval Abundance
0
200
600
1000
2012
2014
2016
2018
2012 – 2016: Laboratory-verified data. 2018: On-board rapid assessment
Larval pollock appeared in good condition: no indication of starvation
Contact : Janet Duffy-Anderson, Lauren Rogers

Southeast Bering Sea summary from RPA surveys

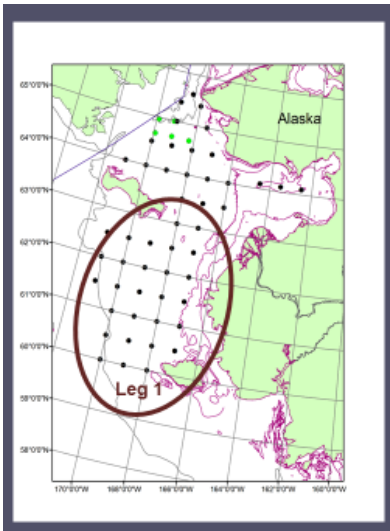
2018: Warm year conditions

Spring (May)

- Warm bottom temperatures, late stratification, and late spring bloom.
- Despite late bloom, large and small zooplankton relatively abundant, as expected in a warm spring.
- Larval pollock widespread and abundant.

Fall (September)

- Zooplankton was comprised mainly of small copepods, chaetognaths, and furcilia, with a noticeable absence of large copepods.
- Age-0 pollock were widely distributed horizontally and vertically in the area surveyed.



Northern Bering Sea Survey, Aug/Sep 2018

Leg 1 (circled):

- Coldest bottom T was 2.9 °C
- SST from 9.2 to 11.6 °C, warmest temperatures nearshore
- Pacific herring = dominant fish.
- Adult walleye pollock in low numbers in surface waters at least as far north as St Lawrence I.
- Age 0 walleye pollock were more abundant along the 60°N transect and at stations further offshore
- Plentiful chum and pink salmon.
- Low catches of Chinook salmon.
- Small copepods were relatively abundant, but very few large copepods.

Contact: Ed Farley

Gulf of Alaska (GOA) summary from RPA surveys

2018: Recovery from the Warm Blob

Eastern GOA

Average temperatures.
Abundant small calanoid copepods, few large calanoid copepods.
Average to high lipid content of zooplankton.
Low juvenile salmon abundance.
Whale condition improving.

Western GOA

Age-0 P cod and pollock present in high numbers.
Age-1 Pacific cod continue to be abundant, suggesting potential for strong 2017 and 2018 year classes following the Blob.

Other NOAA surveys in Alaska, 2018

- AFSC:
  - Summer Acoustic Trawl in Bering Sea: **ground fish**
  - Winter Acoustic Trawl in Bering Sea: **ground fish**
  - Summer Bottom Trawl in the Aleutian Islands: **crabs, invertebrates, ground fish**.
  - Field work (June-Oct) in eastern Bering and Chukchi seas for **marine mammals**.
  - Western GOA Beach Seine (July/Aug): **YOY gadids**
  - Eastern GOA inshore (May-Aug): **salmon, zooplankton, hydrography**
  - Prince William Sound and SE Alaska: **humpback whales**
  - Auke Creek Research Station in Southeast Alaska: **salmon**

For more observations and data compilations, see Alaska Marine Ecosystem Status Report:
http://access.afsc.noaa.gov/reem/ecoweb/Index.php

The seabird data is data collected by U.S. Geological Service (USGS), U.S. Fish and Wildlife Service (USFWS), National Park Service and other organizations. In the NBS, near St. Lawrence Island, there were high levels of bird die-offs, primarily thick-billed murres (TBMU) and common murres (COMU).

Seabird die-offs

USGS Alaska Region, Alaska Science Center, USGS National Wildlife Health Center, and USFWS Alaska Region Migratory Bird Management

- Unusual seabird die-offs throughout Alaska since 2015.
- Direct cause of death attributed to starvation.
- Saxitoxin found in both dead and apparently healthy seabirds.
- No evidence that seabirds died from acute toxicity, but little is known about the effects of low-level saxitoxin exposure on seabirds. Toxin is produced by some dinoflagellates (*Alexandrium* spp).

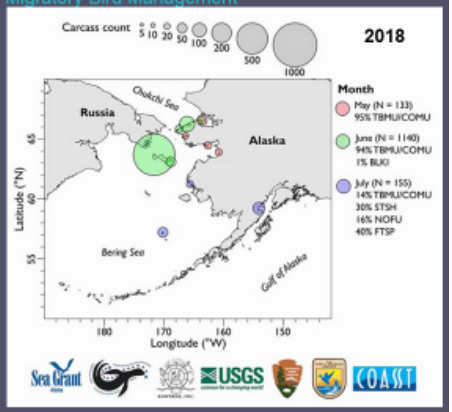
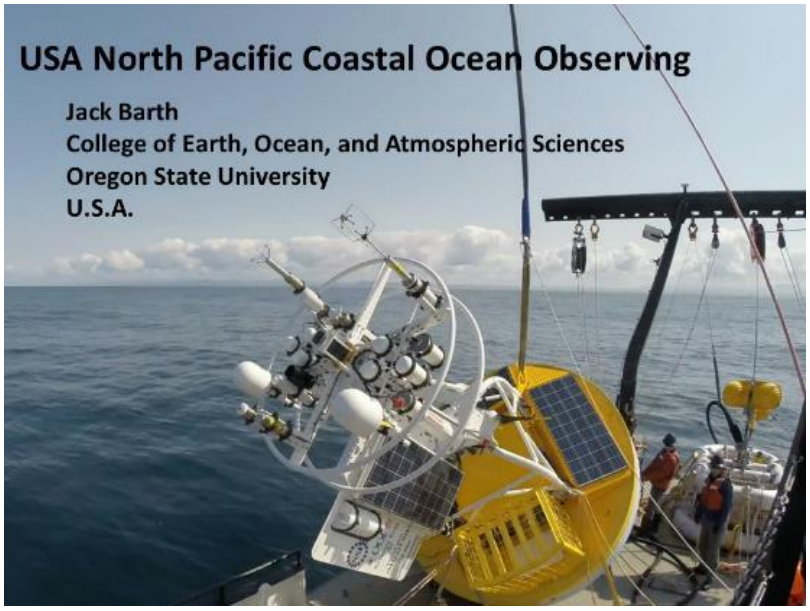


Figure: https://www.nps.gov/subjects/aknatureandscience/commonmurrewreck.htm
Contact: Kuletz, Labunski, Kaler (USFWS) Parrish, Jones, Burgess (COASST), Sheffield (UA-Nome), Ahmasuk (Kawerak, Inc.), Schoen (USGS)

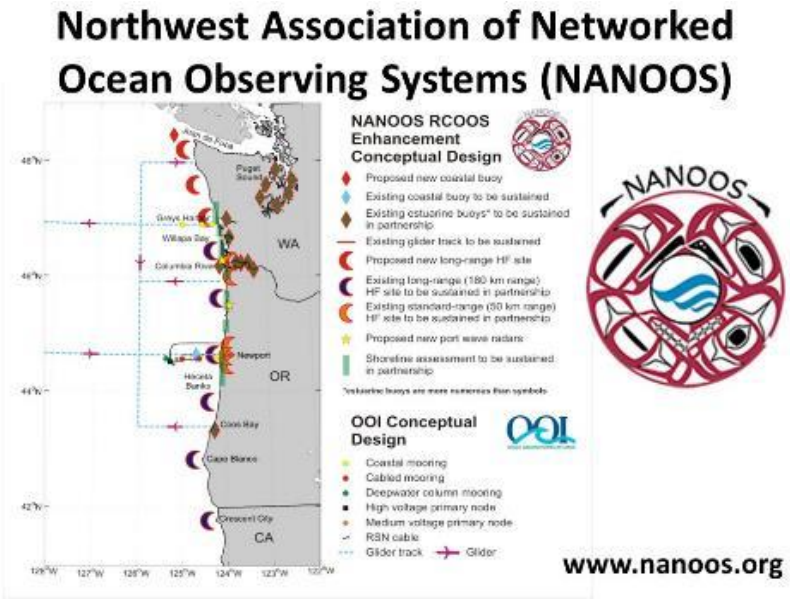


There is a wide range of coastal ocean observing off the U.S. Pacific coasts: U.S. Integrated Ocean Observing System (NOAA); NOAA fishery surveys (groundfish, hake, sardine); long-term hydrographic and zooplankton lines (*e.g*., CalCOFI, Newport Hydrographic Line); underwater gliders; wave buoys and wave models; rocky intertidal biodiversity and recruitment; carbon chemistry (pCO_2, pH) (NOAA, university); the U.S. National Science Foundation's Ocean Observatories Initiative (OOI); and observations from First Nations and Native Americans.

In addition to ocean observing systems, the U.S. National Oceanic and Atmospheric Administration sponsors a "best practices" office called "Quality Assurance of Real Time Ocean Data, QARTOD": http://www.ioos.noaa.gov/qartod/welcome.html

QARTOD is part of the U.S. NOAA IOOS Data Management and Communication (DMAC) core services. QARTOD has issued many manuals for real-time quality control of various data types including *in-situ* currents, temperature, salinities, dissolved oxygen, ocean optics, water level, winds, and dissolved nutrients. These manuals reflect the state-of-the-art quality control (QC) testing procedures for real-time observations. They are written for the experienced operator but also provide examples for those who are just entering the field.

NANOOS is part of the U.S. Integrated Ocean Observing System (IOOS). A conceptual design of NANOOS is shown below.



NANOOS is part of a larger ocean observing effort in the Northeast Pacific as shown in the following map constructed from a base map produced by Ocean Networks Canada.

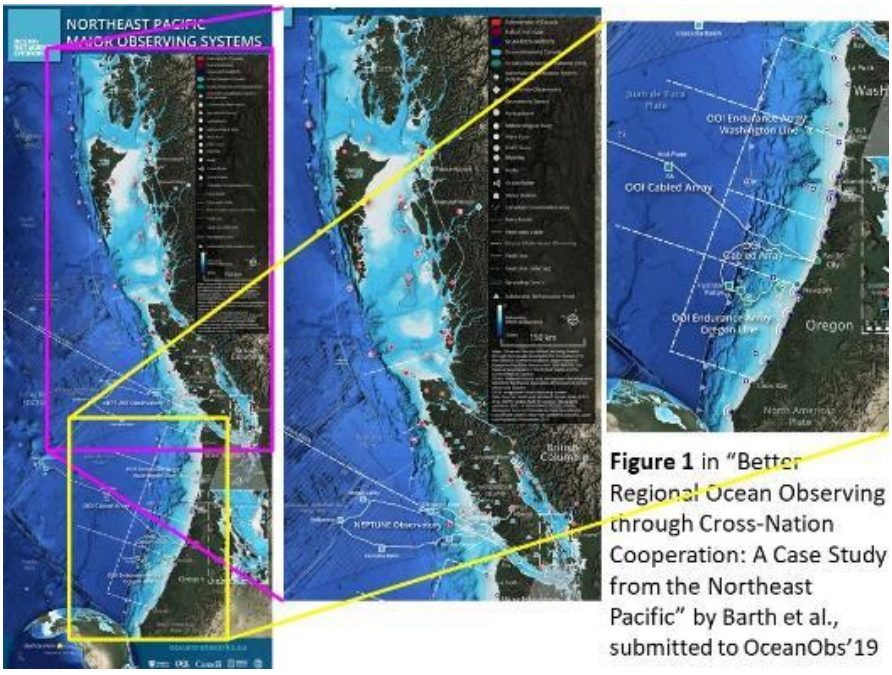
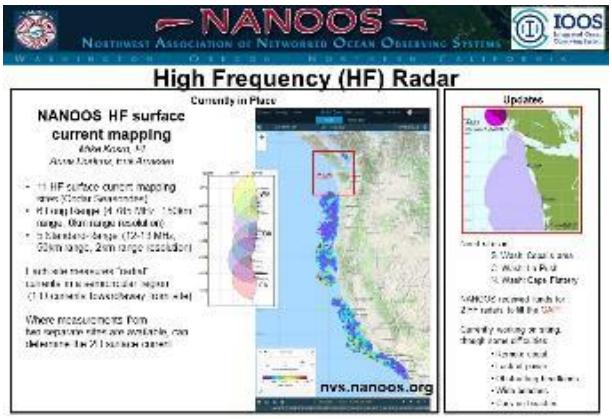
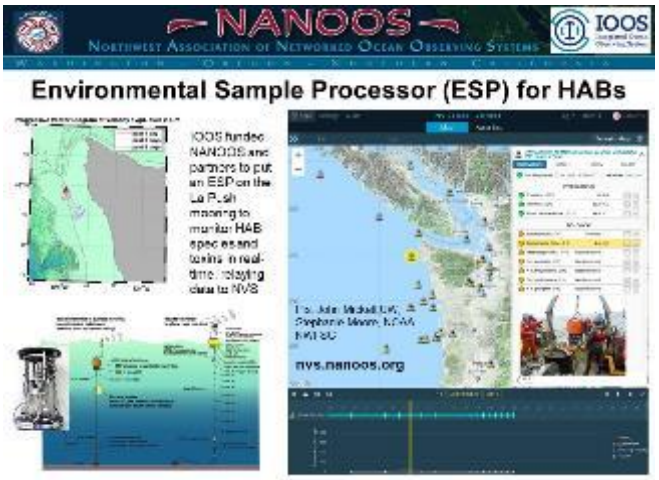
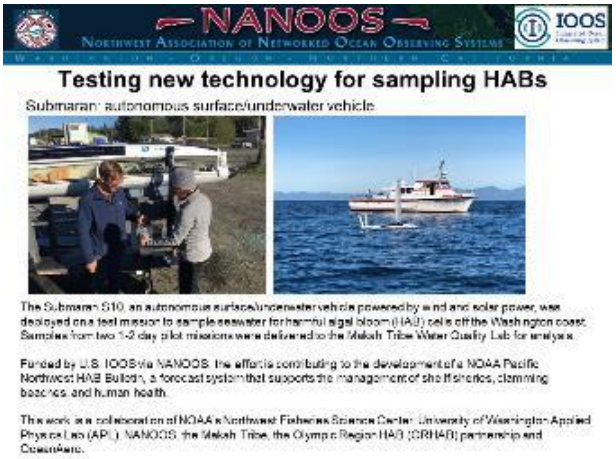


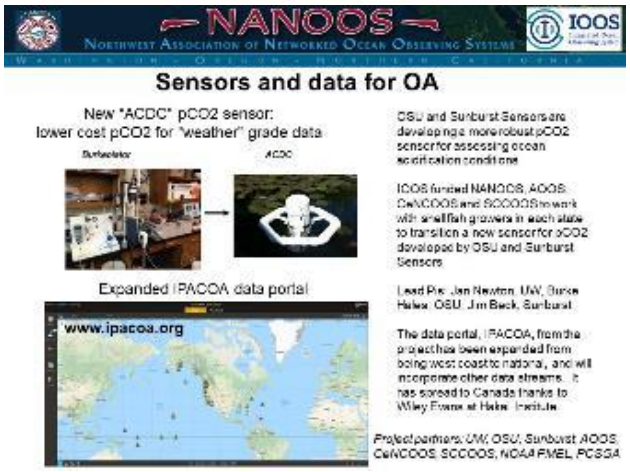
Figure 1 in "Better Regional Ocean Observing through Cross-Nation Cooperation: A Case Study from the Northeast Pacific" by Barth et al., submitted to OceanObs'19

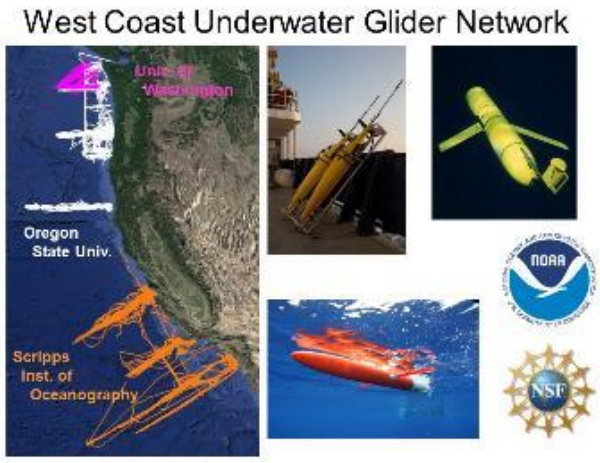
NANOOS is carrying out several new programs: 1) expansion of the HF radar network to include the Washington coast, thus completing the U.S. west coast array; 2) using a moored Environmental Sample Processor to look for HAB indications; 3) testing of an autonomous vehicle to obtain physical samples of water from potential HAB formation zones; and 4) expanding sensors and data for Ocean Acidification.











There is now a U.S. West Coast underwater glider network, maintained by several university glider groups and funded by the U.S. National Oceanic and Atmospheric Administration and the U.S. National Science Foundation.

The U.S. National Science Foundation-funded Ocean Observatories Initiative is fully operational. A wide range of ocean and atmosphere parameters are measured and returned to shore.

Coastal Endurance Array Platforms & Instruments

Cabled Shallow Profiler Mooring

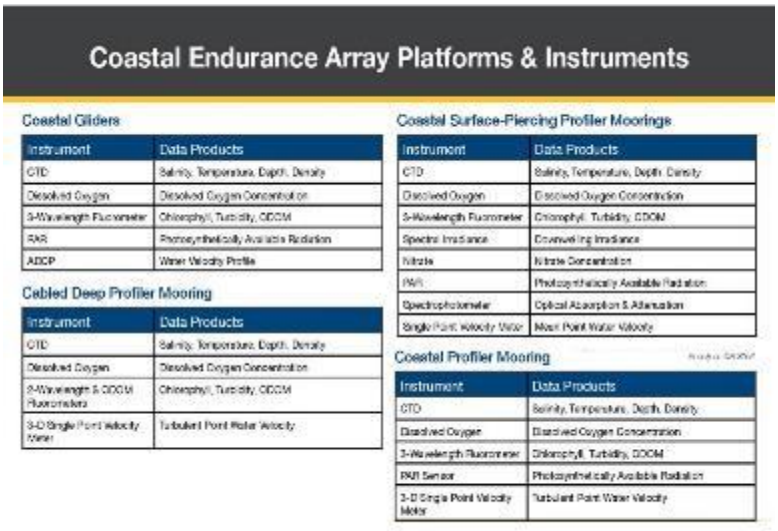
Instrument	Data Products
Bio-acoustic Sonar	Multi-frequency Acoustic Backscatter
CTD	Salinity, Temperature, Depth, Density
Dissolved Oxygen	Dissolved Oxygen Concentration
3-Wavelength Fluorometer	Chlorophyll, Turbidity, CDOM
Spectral Irradiance	Downwelling Irradiance
Nitrate	Nitrate Concentration
PAR Sensor	Photosynthetically Available Radiation
Seawater pCO2	Partial Pressure of CO_2
Seawater pH	pH
Spectrophotometer	Optical Absorption & Attenuation
Single Point Velocity Meter	Mean Point Water Velocity

Cabled Benthic Experiment Packages (BEP's)

Instrument	Data Products
Bio-acoustic Sonar*	Multi-frequency Acoustic Backscatter
CTD	Salinity, Temperature, Depth, Density
Digital Still Camera	Still Images
Dissolved Oxygen	Dissolved Oxygen Concentration
Broadband Hydrophone	Acoustic Pressure Waves & Frequency
Seawater pCO_2	Partial Pressure of CO_2
Seawater pH	pH
Spectrophotometer	Optical Absorption & Attenuation
ADCP	Water Velocity Profile
3-D Single Point Velocity Meter	Turbulent Point Water Velocity

Coastal Surface Moorings

Instrument	Data Products
Air-Sea Interface pCO_2	Partial Pressure of CO_2 in Atmosphere & Gas-Into-Seawater Air-Sea CO_2 Flux
Bio-acoustic Sonar*	Multi-frequency Acoustic Backscatter
CTD	Salinity, Temperature, Depth, Density
Digital Still Camera*	Still Images
Dissolved Oxygen	Dissolved Oxygen Concentration
3-Wavelength Fluorometer	Chlorophyll, Turbidity, CDOM
Spectral Irradiance	Downwelling Irradiance
Meteorological Instrument Package*	Water Temperature & Salinity, Precipitation, Atmospheric Pressure, Air-Sea Heat Flux, Wind Velocity, Humidity, Air Temperature, Downwelling Longwave & Shortwave Irradiance
Nitrate	Nitrate Concentration
Direct Covariance Flux*	Air-Sea Heat Flux, Wind Velocity, Air Temperature
Vector Pressure*	Seafloor Pressure
Seawater pCO_2	Partial Pressure of CO_2
Seawater pH	pH
Surface Wave Spectra*	Wave Properties
Spectrophotometer	Optical Absorption & Attenuation
ADCP	Water Velocity Profile
Single Point Velocity Meter	Mean Point Water Velocity
3-D Single Point Velocity Meter*	Turbulent Point Water Velocity



Coastal Endurance Array Platforms & Instruments

Coastal Gliders

Instrument	Data Products
CTD	Salinity, Temperature, Depth, Density
Dissolved Oxygen	Dissolved Oxygen Concentration
3-Wavelength Fluorometer	Chlorophyll, Turbidity, CDOM
PAR	Photosynthetically Available Radiation
ADCP	Water Velocity Profile

Cabled Deep Profiler Mooring

Instrument	Data Products
CTD	Salinity, Temperature, Depth, Density
Dissolved Oxygen	Dissolved Oxygen Concentration
3-Wavelength & CDOM Fluorometers	Chlorophyll, Turbidity, CDOM
3-D Single Point Velocity Meter	Turbulent Point Water Velocity

Coastal Surface-Piercing Profiler Moorings

Instrument	Data Products
CTD	Salinity, Temperature, Depth, Density
Dissolved Oxygen	Dissolved Oxygen Concentration
3-Wavelength Fluorometer	Chlorophyll, Turbidity, CDOM
Spectral Irradiance	Downwelling Irradiance
Nitrate	Nitrate Concentration
PAR	Photosynthetically Available Radiation
Spectrophotometer	Optical Absorption & Attenuation
Single Point Velocity Meter	Mean Point Water Velocity

Coastal Profiler Mooring

Instrument	Data Products
CTD	Salinity, Temperature, Depth, Density
Dissolved Oxygen	Dissolved Oxygen Concentration
3-Wavelength Fluorometer	Chlorophyll, Turbidity, CDOM
PAR Sensor	Photosynthetically Available Radiation
3-D Single Point Velocity Meter	Turbulent Point Water Velocity

Here are diagrams of the OOI Endurance sites off Oregon and Washington.