Report of the Technical Committee on Monitoring

The Technical Committee on Monitoring (hereafter MONITOR) met twice, virtually, during PICES-2020 from 16:00 to 18:00, Pacific Time, on September 16, 2020 and from 18:00 to 19:00 on September 17, 2020, under the chairmanship of Prof. Sung Yong Kim.

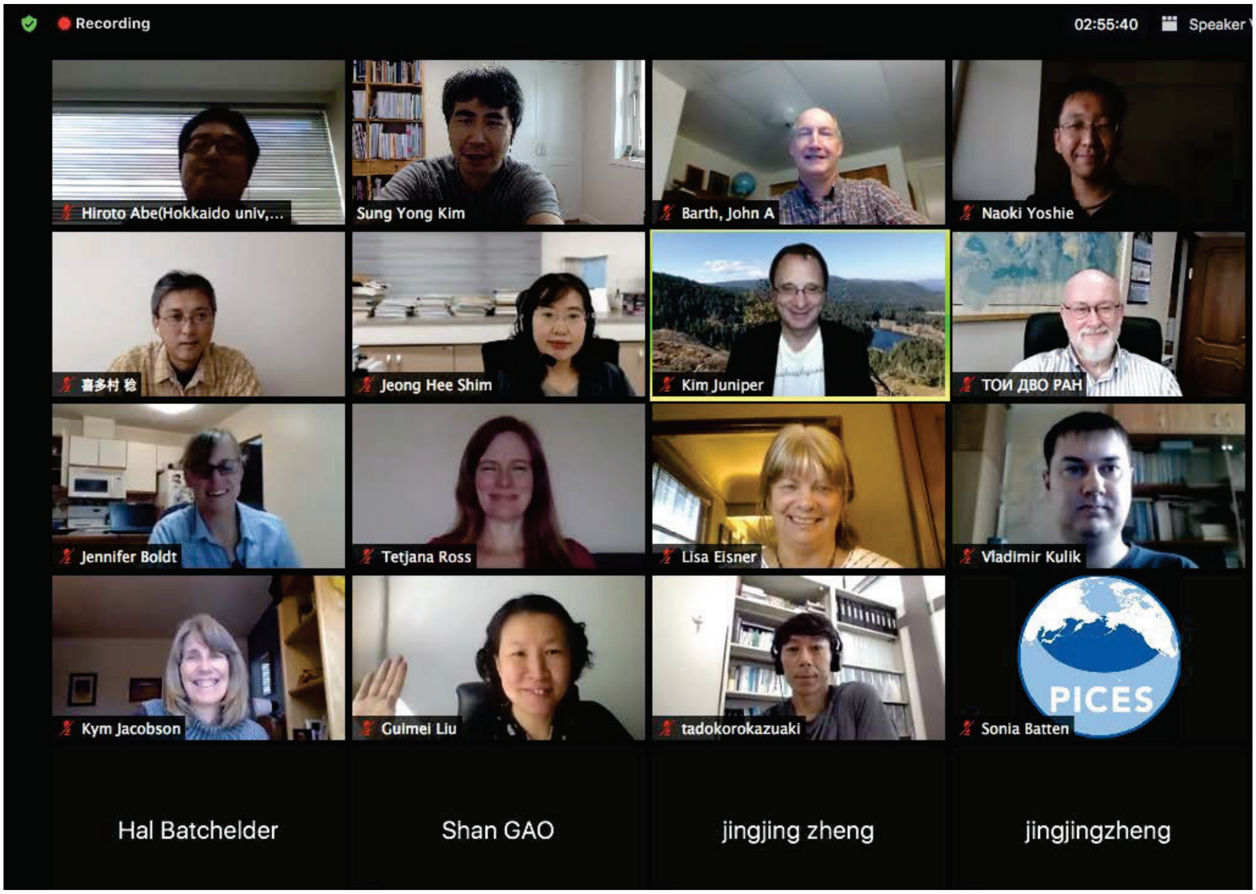
DAY 1

September 16/17, 2020 hh:00-hh+2:30

AGENDA ITEM 1
Welcome and introductions

MONITOR Chair, Prof. Sung Yong Kim, called the meeting to order, and participants introduced themselves (*MONITOR Endnote 1*) The agenda was reviewed and adopted (*MONITOR Endnote 2*). The teleconference was PICES Executive Secretary, Dr. Sonia Batten.

At the beginning of the1st day meeting**:** Hiroto Abe (Japan), Sung Yong Kim (MONITOR Chair, Korea), Naoki Yoshie (AP-NPCOOS Co-Chair), Jeong Hee Shim (Korea), Kym Jacobson (USA), Jack Barth (USA), Minoru Kitamura (Japan), Kazuaki Tadokoro (Japan), Jennifer L. Boldt (Canada), Alex Bychkov (PICES), Vyacheslav B. Lobanov (Russia), Tetjana Ross (Canada), Alex Harper (CeNCOOS), Hal Batchelder (PICES), Lisa B. Eisner (MONITOR Vice-Chair, USA), Sonia Batten (PICES, CPR for Clare Ostle), Vladimir V. Kulik (Russia), Carol Janzen (AMAP), Peter Chandler (WG 35, Canada), Shan Gao (Observer, China), Xianyong Zhao (China), and Guimei Liu (NEAR-GOOS).



At the end of the 1st day meeting**:** Hiroto Abe (Japan), Sung Yong Kim (MONITOR Chair, Korea), Jack Barth (USA), Naoki Yoshie (AP-NPCOOS Co-Chair), Minoru Kitamura (Japan), Jeong Hee Shim (Korea), Kim Juniper (AP-NPCOOS Co-Chair), Vyacheslav B. Lobanov (Russian), Jennifer L. Boldt (Canada), Tetjana Ross (Canada), Lisa B. Eisner (MONITOR Vice-Chair, USA), Vladimir V. Kulik (Russia), Kym Jacobson (USA), Guimei Liu (NEAR-GOOS), Kazuaki Tadokoro (Japan), Sonia Batten (PICES, CPR for Clare Ostle), Hal Batchelder (PICES), Shan Gao (Observer, China), Jingjing Zheng (Observer, China)

List of acronyms

AMAP Arctic Monitoring and Assessment Programme
AOOS Alaska Ocean Observing System
AP-CREAMS Advisory Panel for a CREAMS/PICES Program in East Asian Marginal Seas
AP-NPCOOS Advisory Panel on North Pacific Coastal Ocean Observing Systems
CeNCOOS Central and Northern California Ocean Observing System
CPR Continuous Plankton Recorder
ETSO Environmental Time Series Observations
FUTURE Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems
GC Governing Council
GOA Gulf of Alaska
ISB Inter-sessional Science Board meeting
LME Large Marine Ecosystem
NANOOS Northwest Association of Networked Ocean Observing Systems NEAR-
GOOS North Eastern Asian-Global Ocean Observing System
NMFS AFSC National Marine Fisheries Service, Alaska Fisheries Science Center
NPRB North Pacific Research Board
OOI Ocean Observatories Initiative
POGO Partnership for Observation of the Global Oceans
POMA PICES Ocean Monitoring Service Award
SB Science Board
SEES Social-Ecological-Environmental System
SSC Scientific Steering Committee
TCODE Technical Committee on Data Exchange
WG 35 Working Group on the *Third North Pacific Ecosystem Status Report* (WG NPESR3)
WG 38 Working Group on *Mesoscale and Submesoscale Processes*
WOA World Ocean Assessment

AGENDA ITEM 2

Updates from the Inter-sessional Science Board meeting

1. MONITOR
   a. NPSER3 was reviewed by the parent committee (by Chair / all members) within 2–3 weeks from when it was delivered (by July 2020).
   b. Revised EAST-II final report was sent to MONITOR reviewers; confirmation was requested by September 24, 2020.
   c. FUTURE III Implementation Plan draft was circulated to MONITOR members. Any monitoring issues related to?
   d. Dr. Clare Ostle was approved by Science Board during ISB-2020 and by Governing Council as an *ex-officio* representing CPR in MONITOR.
   e. Committee Action Plan may need to be updated (valid for 3 or 5 years); Action Plans of MONITOR-parented Advisory Panels should be renewed at every 5 years.); MONITOR's Action plan has been completed; one additional term of reference was added (see *MONITOR Endnote 3*, ToR 4).
   f. Zhu-Peterson Early Career Scientist Award application template has been completed.
   g. New members: Dr. Jeong Hee Shim and Mr. Eun Ho Jung (Korea), replacing Drs. In-Seong Han and Jung Hyun Kim.

2. Working Group on *Third North Pacific Ecosystem Status Report* (WG 35)
   a. One-day business meeting was approved for including NPSER4 initiation.

3. Advisory Panel on *North Pacific Coastal Ocean Observing* Systems (AP-NPCOOS)
   a. Renewal of Terms of Reference is needed for a five-year extension (January 2015–December 2019 will be a first five-year term)
   b. New leadership: S. Kim Juniper (Canada) and Naoki Yoshie (Japan)
   c. Plans for make-up of a spring/summer school (budget allocated, but venue is not yet discussed) to be discussed; this was cancelled due to COVID-19.

AGENDA ITEM 3

Updates from PICES expert groups

1. Activities of WG 35: Peter Chandler

Key objectives
- Publish the third NPESR3, 2009–2016 synthesis and regional reports,
- Establish an online system to develop a database of ETSOs.

Originally ETSOs were going to be stored at NMFS AFSC; but now they are stored on the Cloud (costs) and working with Submittables.com to acquire the data.

The report is summarized by numbered regional ecosystems (typically follow LME regions with slight modifications by PICES); regional chapters are produced with similar formats; synthesis chapter provides an overview of all chapters. There are different lead authors for each region.

Synthesis report:

- MONITOR and editorial board comments on the draft report submitted to ISB-2020 have been reviewed and incorporated by authors.
- Formatting of the document as a PICES Special Publication is underway and expected to be completed by October 2020.
- GC to review the report prior to approving it as a Special Publication.
- Expected to be published as a full colour hard copy document, ~80–100 pages.

Regional reports (much higher level of detail than synthesis report):

- All regional reports (with the exception of Region 19, which is close to being ready) have been submitted and preliminary formatting is complete.
- Editorial reviews completed on 6 reports; need objective review by people who are not authors.
- Approval of synthesis report by GC to precede publication of regional reports.
- Expected to be pdf documents hosted on PICES website (not a hard copy) which can be easily updated if needed.
- Revised delivery date: winter 2020.

At this PICES Annual Meeting, there is 1-day business meeting to generate recommendations for NPESR4:

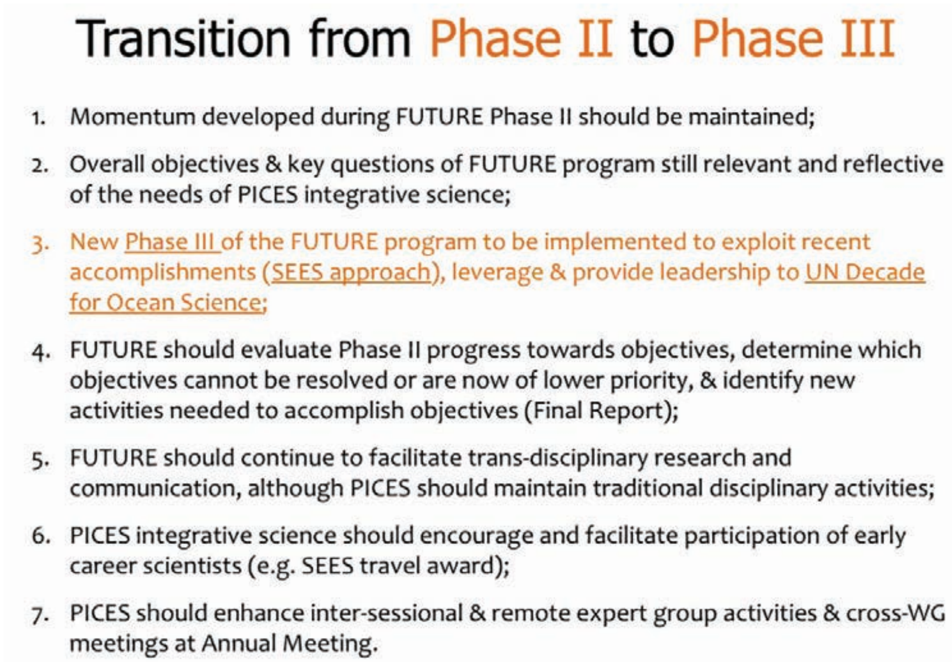
- How are the NPESR reports used and who is the intended audience?;
- What timeframe should be used for a retrospective ecosystem status report (such as the NPESR) and what factors determine this?
- Is the ETSO approach worthwhile? What should be included in the ETSO database, who should be contributing, and who should be curating?
- How should PICES support the NPESR process (Editor, ETSO coordinator, types of meetings)?

Dr. Batten informed MONITOR that the Secretariat is working on technical editing and layout of the synthesis report, and plan to submit it to GC for review. A printing firm has been contacted, but the Secretariat will await GC approval.

A complete report was presented at ISB-2020, but had not been reviewed by MONITOR. Since that time, MONITOR has reviewed it and comments have been reviewed by Mr. Chandler and sent to authors. Comments are being addressed and the report will go back to MONITOR for approval.. Region 19 is included in the report.

2. Activities of FUTURE: Vyacheslav Lobanov

FUTURE is an integrated science program spanning all disciplines. The program is run by the FUTURE SSC, with members from each member country. Transition from Phase II to Phase III will be implemented to exploit recent accomplishments (the SEES approach; https://www.frontiersin.org/articles/10.3389/fmars.2019.00333/full), leverage and provide leadership to the UN Decade for Ocean Science (in collaboration with ICES, PICES and UN Decade for Ocean Science). The establishment of PICES/ICES Study Group on the UN Decade of Ocean Science will be discussed by SB. The FUTURE SSC strongly recommends that PICES should take a regional role in the North Pacific and provide leadership in marine science.



Action: MONITOR members to think about how the MONITOR committee can contribute to the UN Decade for Ocean Science.

Dr. Jack Barth asked whether the FUTURE SSC has mapped the FUTURE science program against the goals of the UN Decade of Ocean Science. Dr. Lobanov reported that we should use the momentum of the UN Decade of Ocean Science to accomplish goals that we could not otherwise. Society needs to understand the importance of ocean science. We need to involve young people.

3. Activities of AP-CREAMS: Vyacheslav Lobanov

Completion of previous business

<u>Status of the report on EAST-II publication</u>

Dr. Lobanov noted that some final work is needed to respond to POC and MONITOR reviewers; it will be done in 1 month.

<u>Status of the CREAMS-related chapters of the North Pacific Ecosystem Status Report-3</u>

Dr. Lobanov noted that this chapter needs some additional work on some sections. There were some delays from some authors and communication has improved. The chapter will be submitted for review soon.

Joint cruises and field observations

<u>China, Japan, Korea joint cruises</u>

Field observations in the EAST-II region originally tried as a China-Japan-Korea joint cruise but planned as a Korean national cruise for the period from August 10 to 20, 2020 using R/V *Onnuri*. Preliminary results were presented along with future plans for on-going analysis and potential international collaboration.

Suggestions on development of international collaboration

Feasibility of the idea of national cruise with coordination in advance was discussed as one of possible ways of future collaboration among the member countries. In addition to coordinated national cruises, exchanges of data, samples, and students among the member countries and joint analysis of the samples could enhance the international collaboration. Personal level collaborations among the individual CREAMS scientists are also recommended.

Brief update on national activities and plans related to the AP-CREAMS Program

See AP-CREAMS 2020 annual report for details.

Capacity building activities

- A Summer School on ocean turbulence, originally planned for 2020 in China, has been postponed to 2021 due to COVID-19.
- Two NOWPAP-related training courses, originally planned for 2020, will be postponed to 2021. Series of webinars for satellite information and a face-to-face training course on eDNA are currently considered for the next year.

Cooperation with other active programs/organizations in the region

See AP-CREAMS 2020 annual report for details.

AP-CREAMS Roadmap for 2021–2024

Dr. Lobanov presented new plans for AP-CREAMS activities and roadmap for 2021–2024. Four issues to set the roadmap up are: a CREAMS database, a coordinated cruise, contribution to UNDOS, and proposals for a training course/summer school.

Action: Dr. Lobanov to provide the two summer school proposals to MONITOR Chair. (Completed on 9/17/2020, KST)

4. Activities of AP-NPCOOS: Naoki Yoshie

Dr. Naoki Yoshie provided an overview of the AP-NPCOOS planned meeting for September 23–24 during PICES-2020 and reviewed its goals and the Terms of Reference.

The primary goals for this year's meeting include:
1) The best way to document and share best practices for coastal ocean observations,
2) How AP-NPCOOS can advise/assist FUTURE,
3) Defining the relationship between AP-NPCOOS, AP-CREAMS, MONITOR, and TCODE,
4) Identifying how AP-NPCOOS might relate the global programs (*e.g.*, GOOS, Argo, POGO, *etc*.) in preparation for NPESR4,
5) Defining motivations and applications for PICES member countries' coastal ocean observations,
6) Identifying what is unique about AP-NPCOOS that is not being covered elsewhere,
7) Identifying open-ocean observing assets most relevant to coastal issues and how they are linked to coastal observing systems,
8) Identifying how nations' coastal ocean observing efforts are doing at sampling Essential Ocean Variables (EOVs; coordination among PICES groups and other groups), and
9) A review the PICES data inventory policy.

Dr. S. Kim Juniper also highlighted the importance of EOVs and asked about the feasibility of implementing best practices within PICES countries as the outcomes of AP-NPCOOS under new leadership.

AGENDA ITEM 4
Updates from international organizations

1. Activities of the CPR Survey: Sonia Batten/Clare Ostle

North Pacific CPR Survey

Dr. Clare Ostle has replaced Dr. Sonia Batten as the co-ordinator of the Pacific CPR survey, as Dr. Batten has become the Executive Secretary of PICES. Dr. Ostle's specialty is the Arctic. This year marks the 21st consecutive year of data collection and the figure below (Figure 1) shows the sample coverage:

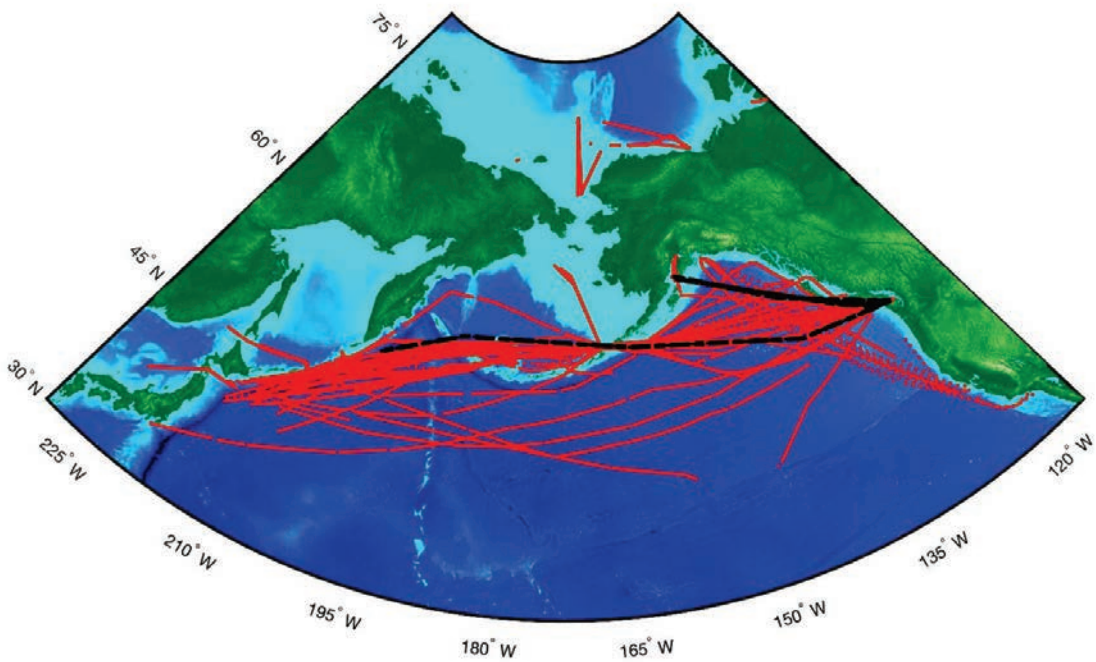


Figure 1. Historical CPR sample locations in red (2000–2019) and samples collected in 2020 so far (to June) in black.

There are additional transects to be added to the figure for 2020 once sample processing has been completed. Funding remains consistent and there have been no major issues with ships or equipment so far this year. There has been some delay in the plankton analysis due to COVID-19 restrictions affecting lab access. However, restrictions in the workplace are easing now and 2019 has been finalised. The 2020 CPR sampling has not been impacted so far; since CPR sampling is almost autonomous, the ships have been comfortable in taking the equipment on board and deploying it. We are expecting all tows to be completed as scheduled, although it may take a bit longer for the lab-based analysis to be completed.

Other instrumentation has been added onto the CPR (*e.g.*, oceanographic sensors) and they are now evaluating automated image analysis of data to more quickly sort the plankton groups.

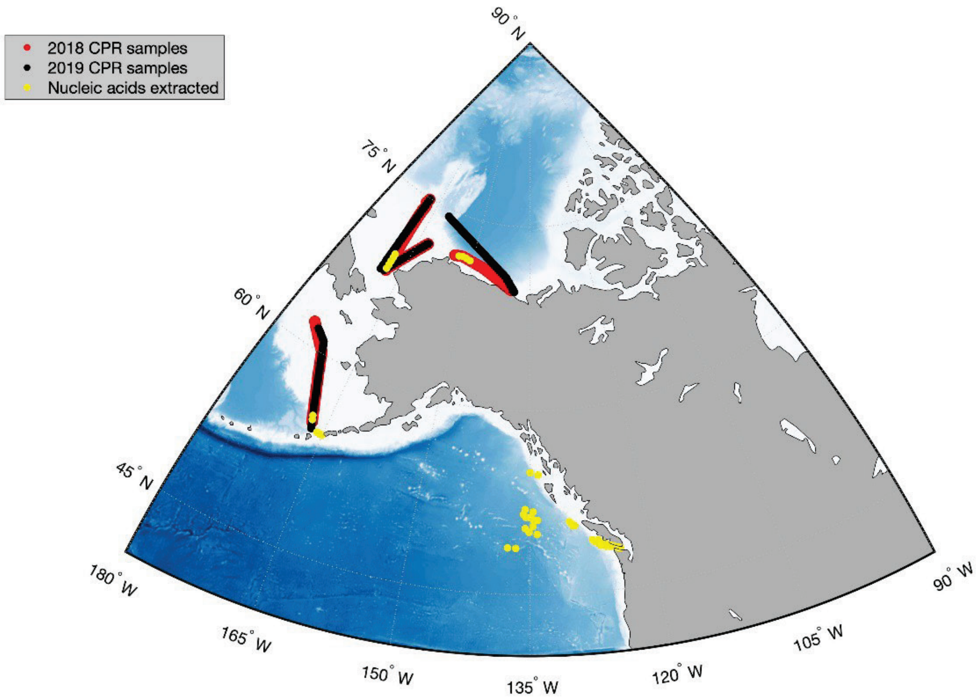


Figure 2. CPR samples collected from the CCGS *Sir Wilfrid Laurier* in 2018 (red) and 2019 (black). Yellow dots are where nucleic acids have been extracted from CPR samples for genetic analyses.

As well as the regular Pacific CPR sampling, the Canadian icebreaker the CCGS *Sir Wilfrid Laurier* has now sampled the Bering shelf and in the western Chukchi Sea and Beaufort Sea for the first time during the summer months of 2018 and 2019 (Figure 2). There are plans to sample in similar areas in 2020 and this cruise, although initially delayed, has departed Victoria, British Columbia with a CPR ready to tow on August 7, 2020. These preliminary Arctic routes have been funded via short (annual) research bursary schemes awarded to Dr. Ostle; we are looking for potential funding to continue sampling in these areas in the future, as they provide important information on this transition area and have instigated a number of fruitful collaborations. If there are any potential avenues for such funding please contact either Dr. Ostle (claost@mba.ac.uk) or Dr. Batten (Sonia.Batten@pices.int). Funds are needed to continue to process samples (collection of the samples is less costly that processing). PICES holds all the CPR data grouped by region.

SCOR Working Group P-Obs

Dr. Batten represented PICES as an Associate Member of the SCOR WG on Integration of Plankton-observing Sensor Systems to Existing Global Sampling Programs. 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).

There have been no meetings since the last report, although work has continued on the OceanSites recommendations. A virtual P-OBS meeting is planned for the week of September 14–18, 2020. If possible, a verbal update will be given to MONITOR but the two meetings may be simultaneous. After the report is completed it will be submitted to Ocean Best Practices, bringing the SCOR committee activities to a close.

GOOS Biology and Ecosystems Panel

PICES has been represented on the Panel by Drs. Batten and Sanae Chiba, but Dr. Batten stepped down at the end of 2019.

Recent publications, reports and articles

Arimitsu, M., J. Piatt, R.M. Suryan, S. Batten, M.A. Bishop, R.W. Campbell, H. Coletti, D. Cushing, K. Gorman, S. Hatch, S. Haught, R.R. Hopcroft, K.J. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J. Moran, R.S. Pegau, A. Schaefer, S. Schoen, J. Straley, and V.R. von Biela. (2019). Chapter 3 Synchronous collapse of forage species disrupts trophic transfer during a prolonged marine heatwave. In M.R. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (Exxon Valdez Oil Spill Trustee Council Program 19120114). Exxon Valdez Oil Spill Trustee Council, Anchorage, Alaska.

Batten, S., Chiba, S. and Sydeman, W. (2020) Two decades of the North Pacific CPR program. PICES Press, 18, 18-21.

Batten, S., Helaouet, P., Ostle, C. and Walne, A. (*in prep.*) Responses of Gulf of Alaska plankton communities during and after a marine heatwave.

Fisher, J.,Kimmel, D., Ross, T., Batten, S., Bjorkstedt, E., Galbraith, M., Jacobson, K., Keister, J., Sastri, A., Suchy, K., Zeman S., and Perry, I. (2020) Copepod responses to, and recovery from, the recent marine heatwave in the Northeast Pacific. PICES Press, 18, 68-71.

June 2020 article covered CPR survey in The Guardian:
https://www.theguardian.com/environment/2020/jun/19/tiny-plankton-tell-the-oceans-story-this-vast-marine-mission-has-been-listening

Litzow, M., Hunsicker, M. E., J. Ward, E., C. Anderson, S., Jin Gao, Zador, S., Batten, S. Dressel, J. Duffy-Anderson, E. Fergusson, R. Hopcroft, B. Laurel, J.O'Malley, R. (2020). Evaluating ecosystem change as Gulf of Alaska temperature exceeds the limits of preindustrial variability. *Progress in Oceanography*, (accepted), 1–15.

Ostle, C., and Batten, S. (*in prep.*) NOAA Ecosystem Status Report 2019: Continuous Plankton Recorder Data from the Aleutian Islands and Southern Bering Sea: Lower Trophic Levels in 2019.

Ostle, C., and Batten, S. (*in prep.*) NOAA Ecosystem Status Report 2019: Continuous Plankton Recorder Data from the Gulf of Alaska: Lower Trophic Levels in 2019.

2. Activities of AMAP: Jan Larsen

Dr. Jan Larsen reviewed the AMAP mandate, which includes integrated assessment reports on the status and trends in the condition of the Arctic ecosystem; identifying possible causes for changing conditions; detecting emerging problems, their possible causes, and potential risks to Arctic ecosystems including Indigenous peoples and the Arctic residents; and recommending actions required to reduce risks to the Arctic ecosystem. He also reviewed the deliverables of AMAP, which include scientific assessments and other information, all of which is available on their website (https://www.amap.no/). AMAP also provides summaries for policy makers and provides information to the Arctic Council, IPCC, *etc*.

AMAP has a strategic Framework with several strategic goals. Strategic Goals include: 1) Improved knowledge and understanding of Arctic change through collaborative assessment processes, for use in evidence-based decision making; Strategic Goal 2) A strong, sustained and coordinated circumpolar monitoring and observation network; Strategic Goal 3) Enhanced understanding of Arctic change and its impacts through inclusive partnership with Indigenous Peoples; Strategic Goal 4) Effective communication on Arctic challenges and global implications; Strategic Goal 5) Support relevant international processes.

AMAP is addressing pollution issues and climate change as well as looking at future prospectives (multiple stressors, combining knowledge sources). In answer to Dr. Lobanov's question on where data is kept, Dr. Larsen indicated that where and when AMAP has data depends on the parameter and how much interest there is to provide data.

3. Activities of the AOOS: Carol Janzen

Alaska Ocean Observing System (AOOS) Observing Highlights 2020

<u>CDIP (Coastal Data Information Program) Wave Buoys (real time)</u>

AOOS supports the operations and maintenance (O&M) of 3 CDIP wave buoys in Alaska (Lower Cook Inlet near Homer, Kodiak, Bering Strait off the Port of Nome). COVID-19 caused delays in buoy operations in 2020, as did weather and vessel/buoy incidents:

- The Lower Cook Inlet buoy stopped reporting in March, and was not recovered until July 2020. A new buoy was deployed in August. The mooring line was cut and the buoy was recovered two weeks later. The buoy will be redeployed in mid-September.
- The Port of Nome buoy was damaged in October 2019 from a tug-tow snag. A new buoy deployed in August was recovered a week later due to a leak in the hull. There are no plans to redeploy in 2020.
- The Kodiak buoy has been operational since 2017, when deployed by the National Renewable Energy Lab. AOOS assumed O&M of this buoy in 2019 through 2021.

<u>High Frequency Radar (HF Radar) for Areal Mapping Surface Currents (near real time)</u>

- AOOS continues support for 3 HF Radars along the Chukchi Sea coastline (Wainwright, Utqiagvik and Cape Simpson). Travel restrictions prevented an annual site visit in 2020. Local residents and regional partners were enlisted to get 2 downed HF radars operational for 2020.
- <u>New 2019:</u> Two new HF Radar systems were installed in the Bering Strait region in 2019. Trial sites include Wales and Shishmaref in western Alaska. They are not yet operational.
- <u>New in 2021–2026:</u> AOOS build-out plans for HF Radar include installations along the GOA coastline, including Unimak Pass, Lower Cook Inlet and Prince William Sound areas.

<u>Ecosystem Moored Observatories:</u>

- AOOS contributes to a pan-Alaska network of Ecosystem Moored Observatories.
- Completed: Chukchi Sea near Hanna Shoals (CEO since 2015).
- Completed: Northern GOA on the outer Seward Line (GEO since 2019).
- Observatories under development in the Bering Sea at existing NOAA PMEL sites M2 and M8.
- <u>New in 2021–2026:</u> AOOS plans to partner with existing projects in the Bering Strait (UW-APL long-term moorings) and in the Beaufort Sea with the Beaufort Lagoon LTER.
- <u>New in 2021–2026:</u> A new observatory is planned for southeast Alaska near Sitka.

<u>Shipboard Observing Transects</u>

- AOOS continues to support long-term, ship-based oceanographic surveys along the Seward Line and in the Lower Cook Inlet/Kachemak Bay region.

<u>Glider Surveys</u>

- AOOS continues to support a long-term, annual glider mission in the Chukchi Sea (since 2013).
- <u>New in 2020:</u> AOOS received Congressional funding to sustain glider missions in the GOA and the Bering Sea, aimed at supplementing fisheries management data needs.

Ocean Acidification (OA) Observing

- An underway OA system onboard the M/V *Columbia* commenced weekly round-trip transects between Skagway, Alaska, and Bellingham, Washington, in 2017. The 2020 sailing is delayed until October 2020, due to a combination of COVID-19 and state funding issues.
- 4 shore-based Burke-o-Lator OA monitoring systems are operational in Ketchikan, Sitka, Seward and Kodiak. AOOS proposes to keep these continuous OA sites operational in 2021–2026.

AOOS Data Services, Products, and Data Portals: (Most regional data assets including non-AOOS data)

- New in 2020: A glider data visualization tool allows the user to virtually transit the glider route and visualize water column data for a variety of parameters, as well as observe a 4-D image of the entire transit path by parameter with respect to the shoreline and local bathymetry.

Action: Dr. Janzen to communicate with Dr. Tetjana Ross about the glider data presentation on their website and the portability to the software.

The glider also records sounds of marine mammals.

A member asked whether you removed the wave buoy in the winter with sea ice, and Dr. Janzen answered that the buoys are deployed in June/July and recovered in October in areas of sea ice.

4. Activities of the CeNCOOS: Alex Harper

The CeNCOOS Collaborative: Advancing Ocean Observing In Central and Northern California

Natural resource management in the U.S. is often mandated at the national level. However, a regional approach involving collaborative partnerships is required to develop and operationalize dynamic management tools (*e.g.*, acquisition, prediction, dissemination, automation). The Central and Northern California Ocean Observing System (CeNCOOS), a Regional Association of U.S. Integrated Ocean Observing System (IOOS), works with regional partners to identify, develop, and deliver observations and information products useful for improving ocean stewardship—including research, analysis, and education to strengthen and support all levels of ocean policy formation (CeNCOOS Strategic Plan 2020–2025). CeNCOOS engages a diverse array of stakeholders to develop and maintain value-added information products and deliver actionable information on regional ocean physics, biogeochemistry, biology and ecosystems. CeNCOOS partners range from citizen scientists and individual investigators to large programs and federal agencies, and they contribute data to support product development and provide feedback on system priorities.

Delivering information solutions for this diverse membership requires strong communication, consultation, and collaborative approaches—including public-private partnerships. Marine managers, such as NOAA's National Marine Sanctuaries and Pacific Fishery Management Council, the California Ocean Protection Council (OPC), California Departments of Fish and Wildlife (CDFW), Water (CDW), and Public Health (CDPH), need data that are accessible in an easily navigable and interpretable format that meets the needs of users with a wide variety of technical abilities. In response, CeNCOOS engages in vibrant partnerships, including with the region's three National Marine Sanctuaries, SWFSC, California's network of MPAs, and many others to harness the collective suite of ocean data into actionable information to inform decision- making.

CeNCOOS develops data products which include visualization tools and interpretive vehicles for disseminating up-to-date scientific information to different target audiences. Guiding this effort has been the FAIR principle (Wilkinson *et al.*, 2016) which emphasizes the findability, accessibility, interoperability, and reuse of digital assets by machine with none or minimal human intervention in order to contend with the increasing volume, complexity, and creation speed of data. The potential of integrating more biology, biodiversity, and ecosystem observations into a coherent system is great and will bring this valuable information to new and diverse audiences.

There is a new 5-year plan: One focus is Bio-Eco data integration and another focus is advanced drones for marine mammals and forage fish. They also currently have new web site products and outreach.

References:

Wilkinson, M., Dumontier, M., Aalbersberg, I. *et al*. The FAIR Guiding Principles for scientific data management and stewardship. *Sci Data* **3,** 160018 (2016). https://doi.org/10.1038/sdata.2016.18.

CeNCOOS Strategic Plan (2020–25): Advancing Ocean Observing In Central & Northern California. 2020. https://www.cencoos.org/images/docs/CeNCOOS-Strat-Plan-2020.pdf

AGENDA ITEM 5

Other issues

1. Potential POMA candidates

Dr. Kim reviewed previous POMA recipients, the POMA background, aims, and eligibility (see https://meetings.pices.int/awards/POMA_award) . The MONITOR committee is responsible for identifying or helping to identify candidates.

The POMA nominations for 2021 will be opened on November 1, 2020 and will be closed on March 31, 2021.

Action: MONITOR members to solicit POMA nominations. These need to be received before the next ISB.

2. Other business issues

Dr. Juniper asked which groups in PICES would be responsible for collecting/coordinating Essential Ocean Variables. Dr. Barth noted that this may be coordinated with FUTURE/UN Decade of Ocean Science. Members agreed that the plan is to ask FUTURE for some help in coordination among PICES expert groups and committees.

Action: AP-NPCOOS to ask FUTURE for help in coordination among PICES expert groups and committees.

The DAY 1 meeting was adjourned.

DAY 2

September 17/18, 2020 hh:00-hh+2:40

AGENDA ITEMS 6 AND 7

Welcome and introductions and review of first day

MONITOR Chair, Prof. Sung Yong Kim called the meeting to order, participants introduced themselves, and the meeting followed the agenda for Day 2. Prof. Kim reviewed the main points from yesterday's meeting. He noted that there were no topic session proposals to review for PICES-2021 and no oral or poster presentations to judge this year.

At the beginning of the 2nd day meeting**:** Hiroto Abe (Japan), Sung Yong Kim (MONITOR Chair, Korea), Kazuaki Tadokoro (Japan), Minoru Kitamura (Japan), Jan Newton (NANOOS), Jennifer L. Boldt (Canada), Kym Jacobson (USA), Jeong Hee Shim (Korea), Toshio Suga (Argo), Tetjana Ross (Canada), Jack Barth (USA), Matthew Baker (NPRB), Hal Batchelder (PICES), Naoki Yoshie (Observer, Japan), Vyacheslav B. Lobanov (Russia), Sonia Batten (PICES), Vladimir V. Kulik (Russia), Guimei Liu (Observer, China), Lisa B. Eisner (MONITOR Vice-Chair, USA), Shan Gao (Observer, China).

At the end the 2nd day meeting**:** Jeong Hee Shim (Korea), Sung Yong Kim (MONITOR Chair, Korea), Minoru Kitamura (Japan), Jack Barth (USA), Hiroto Abe (Japan), Naoki Yoshie (Observer, Japan), Vyacheslav B. Lobanov (Russia), Kazuaki Tadokoro (Japan), Tetjana Ross (Canada), Lisa B. Eisner (MONITOR Vice-Chair, USA), Kym Jacobson (USA), Jennifer L. Boldt (Canada), Jan Newton (NANOOS), Toshio Suga (Argo), Sonia Batten (PICES), Matthew Baker (NPRB), Guimei Liu (Observer, China), Hat Batchelder (PICES), Vladimir V. Kulik (Russia), Jingjing Zheng (Observer, China).

AGENDA ITEM 7

Updates from international organizations (cont'd)

1. Activities of the NPRB: Matthew Baker

The North Pacific Research Board (NPRB) is dedicated to supporting marine science in the North Pacific, including the Gulf of Alaska, Aleutian Islands, Bering Sea and Pacific Arctic (Figure 1). We have a two-part mission:

1) To further understanding of marine ecosystems,
2) To inform fisheries management and sustainable use of marine resources.

This report focuses on our Long-term Monitoring (LTM) Program but also addresses some recent results from our Integrated Ecosystem Research Programs (IERP).

The NPRB LTM Program was launched in 2014 and supports collaborative long-term monitoring. The goal of the program is to support new or existing time-series research to enhance understanding of baseline states and to predict ecosystem responses to changing ocean conditions. NPRB has defined long- term monitoring programs as those that aid in understanding ecosystem variability and the effect of variability on subsistence or commercial marine resources. This program supports timeseries data collection and analyses to better characterize baseline data and track change over time, understand system processes, assess resource trends, and evaluate effectiveness of management actions. The intent is to better understand variability in magnitude and range, directional trends, and its impacts on system structure.

NPRB has funded programs to support monitoring and retrospective analyses through a variety of programming in the past. One of the first projects was initiated in 2004 through its Core Program to establish a series of 4 moorings along the middle shelf of the eastern Bering Sea. These moorings measure temperature, salinity, nutrients, oxygen, fluorescence, currents, zooplankton. These data have led to the development of various hypotheses related to system structure and phenology and improved understanding of the influence of the timing of ice retreat, phenology of production, and relative influence of bottom-up vs top-down forcing on fish recruitment. It has also provided time series data of seasonal and annual temperatures and salinity, and seasonal cycles in nutrients.

Figure 1. North Pacific Research Board 2020 MONITOR Report and area of geographic interest.

Continuous Plankton Recorded Survey

The Continuous Plankton Recorder Survey is well-known to this group. This is a mechanical device towed behind ships of opportunity to survey the quantity, community composition, and variability of plankton. NPRB is funding continued sampling along two paths through the North Pacific in collaboration with a consortium of international partners. PICES has been involved since the outset. PICES advocated for CPRs in 1998 and the survey began soon after in 2000. PICES convened a CPR Advisory Panel meeting each year, reporting to the

MONITOR Technical Committee. The data from this survey has supported many analyses, including two publications led by PICES Executive Secretary, Dr. Sonia Batten, highlighted here to demonstrate insights related to:

1) Bottom-up forcing in the Gulf of Alaska (GOA) where plankton indices explain interannual variability in first year growth in herring;
2) Highlights research in the Aleutian Islands and top-down control, where pink salmon induced a trophic cascade in plankton populations

NPRB is particularly interested in the expansion of survey effort into the northern Bering Sea, Bering Strait and Pacific Arctic.

Seward Line

The Seward Line is another program supported by NPRB. This is a line survey supporting oceanographic sampling since 1998. It monitors physics, chemistry, plankton, marine bird and mammals in cross-shelf transect of the GOA. NPRB funding facilitates the additional assessment of microzooplankton, a critical linkage between phytoplankton and metazooan zooplankton. Seward Line data are integrated in all major GOA research programs over past decade (*e.g.*, NPRB GOAIERP, Gulf Watch). It has provided infrastructure for ocean acidification studies and since 2018 it has supplied larval fish collections, included in annual NOAA Ecosystem Considerations Reports. Mid-shelf mooring will begin providing real-time meteorological and oceanographic data and as part of the National Science Foundation LongTerm Ecological Research (LTER) site designation, additional lines, summer cruises, new parameters, process studies will be added. In the context of COVID-19, PIs have continued to implement surveys, including two successful cruises since March 2020.

Chukchi Ecosystem Mooring Array

The Chukchi Sea Ecosystem Observatory (CEO) collects year-round autonomous collection of physical and biogeochemical data. This has enabled validation of biogeochemical models and improved understanding of shelf-basin exchange and supported analyses related to wind, waves, and ice effects on regional oceanography; nutrient cycles, particulate fluxes, and carbon transfer; and biological dynamics related to fish and euphausiids. This presentation provided data and visuals illustrating how these various metrics overlay and were integrated to refine and test hypotheses about timing and relative match- mismatch in light, nutrients, algae, plankton, as well as implications for higher trophic level organisms such as fish and pinnipeds.

Arctic Integrated Ecosystem Research Program

NPRB also supports multi-year, multi-disciplinary, international Integrated Ecosystem Research Programs These have been implemented in the Bering Sea, GOA, and, since 2016, we have implemented a program in the Arctic, more specifically the Bering Strait and Chukchi Sea (CS). In February 2020, a manuscript was published in Nature Climate Change that developed as a synthesis of research in this program. It highlights results that suggest that Pacific Arctic in a period of transformation and potentially entering a new ecosystem regime. Visuals and data were presented to highlight those results, including bottom temperature data compiled from the CEO in the CS (LTM Program) and surface temperature data from the M-series moorings in the Bering Sea (Core Program). In recent years, an increasing number of months had bottom temperatures exceeding 0°C (gray portions of bar graph; Figure 2).

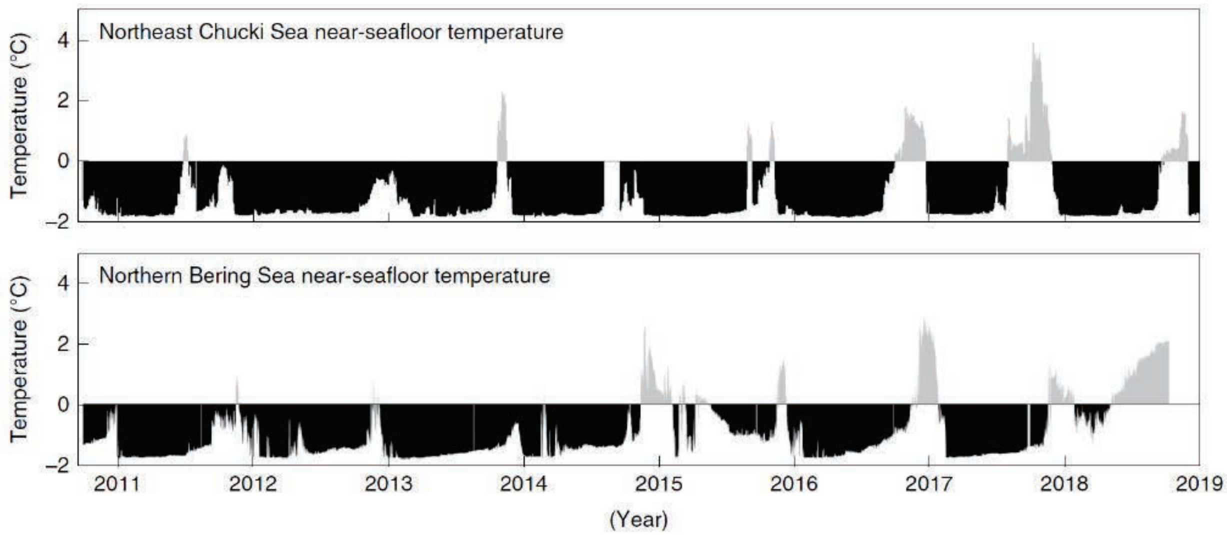


Figure 2. Bottom temperatures in the northern Bering Sea and Chukchi Sea; Huntington *et al*. 2020.

Prior to 2014 it was rare to have bottom temperatures exceeding 0 °C. In 2014-2016 these temperatures were more prevalent, particularly in the northern Bering Sea (NBS). In 2017–2019, bottom temperatures exceeding 0 °C were the pre-dominant condition in the NBS and common in the CS. At the surface, sea surface temperatures have already exceeded predictions recently modeled for late 21st century. Initial research from this program was summarized in a recent Special Issue volume in DSRII (Baker et al. 2020a). This was published in September and includes 14 manuscripts.

International collaboration and data sharing

One of the efforts NPRB has been particularly focused on, in the context of PICES, is international collaboration in data sharing. Working with MONITOR Vice-Chair, Dr. Lisa Eisner, as well as Dr. Kirill Kivva at VNIRO, NPRB developed a series of workshops at PICES-2016 in San Diego and PICES-2017 in Vladivostok. These have led to data sharing in collaborations between NOAA, NPRB, IPHC, VNIRO, JAMSTEC and KOPRI.

Also, as part of the NPRB program in the Arctic, NPRB hosted Russian scientists on research cruises in 2017 and 2019, including VNIRO scientists Natalia Kuznetsova and Igor Grigorov. These efforts also led to a variety of international collaborative manuscripts. Dr. Jim Thorson at NOAA has worked with Dr. Vladimir Kulik and others on groundfish analyses. Dr. Lisa Eisner at NOAA is leading an analysis on ROMs and groundfish distributions with Dr. Yury Zuenko. I recently led a collaboration with Kirill and others at NOAA and VNIRO to document shifts in the seasonal timing of sea ice retreat (Baker *et al*. 2020) and timeseries analyses of temperature trends to better understand transitions in both the eastern and western portions of the Bering and Chukchi Seas.

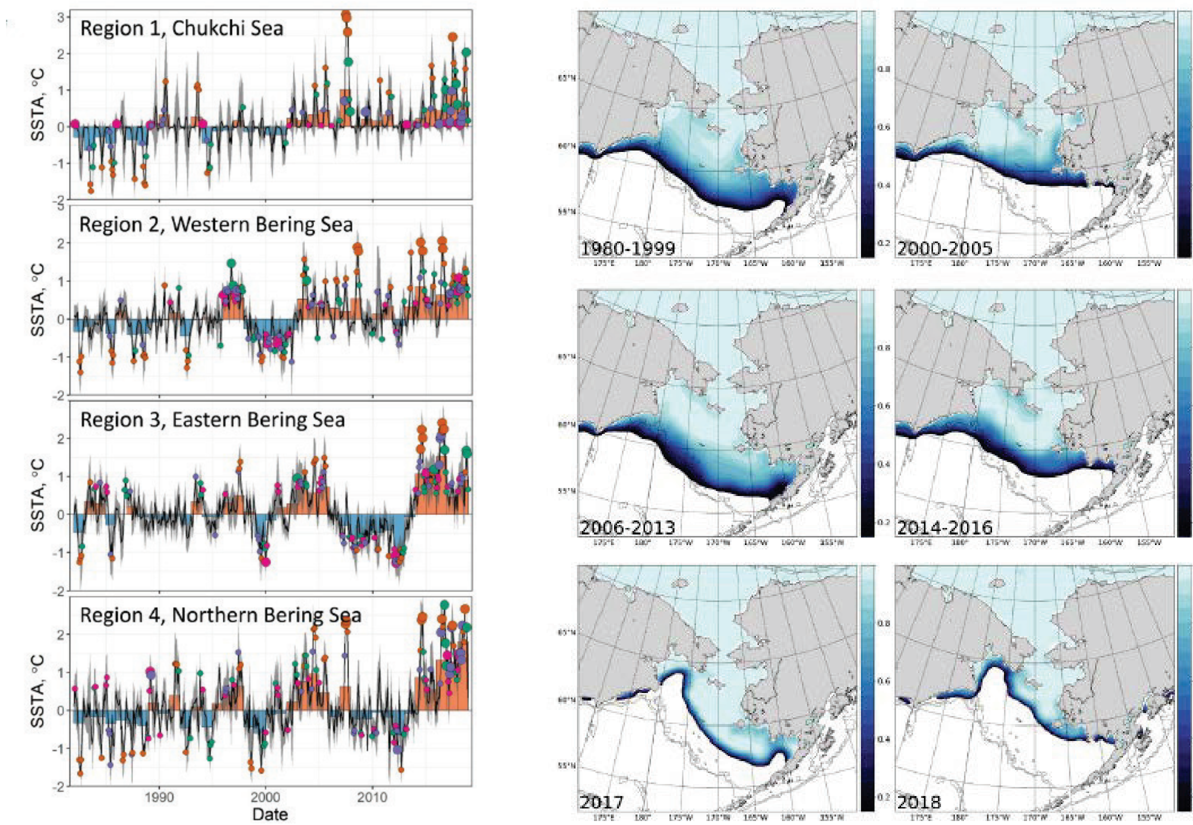


Figure 3. Trends in sea surface temperature (left) and sea ice retreat (right) in the Pacific Arctic; Baker *et al.* 2020.

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Huntington HP, Danielson SL, Wiese FK, Baker M, Boveng P, Citta JJ, De Robertis A, Dickson DM, Farley E, George JC, Iken K. 2020. Evidence suggests potential transformation of the Pacific Arctic ecosystem is underway. Nature Climate Change 10(4):342-8.

Baker MR, Farley EV, Ladd C, Danielson SL, Stafford KM, Huntington HP, Dickson DM. 2020a. Integrated ecosystem research in the Pacific Arctic–understanding ecosystem processes, timing and change. Deep Sea Research II 177:104850. https://doi.org/10.1016/j.dsr2.2020.104850

Baker MR, Kivva KK, Pisareva MN, Watson JT, Selivanova J. 2020b. Shifts in the physical environment in the Pacific Arctic and implications for ecological timing and conditions. Deep Sea Research Part II: Topical Studies in Oceanography 27:104802.

Batten SD, Moffitt S, Pegau WS, Campbell R. 2016. Plankton indices explain interannual variability in Prince William Sound herring first year growth. Fisheries Oceanography 25(4):420-32.

Batten SD, Ruggerone GT, Ortiz I. 2018. Pink salmon induce a trophic cascade in plankton populations in the southern Bering Sea and around the Aleutian Islands. Fisheries Oceanography 27(6):548-59.

Dr. Baker provided an update on the long-term monitoring program and integrated ecosystem assessment program of NPRB. The two-part mission includes ecosystems and fisheries management. The long-term program is dedicated to collaborative projects to characterize baseline data and track changes over time in order to understand variability and directional trends.

NPRB's long-term monitoring was launched in 2014 and funded several programs, such as:

- Biophysical moorings in the Eastern Bering Sea,
- Continuous plankton recorder data collection and research, (emphasized support for expansion north into the Bering Sea and Arctic),
- Seward Line data collection (physical and biological), 2 surveys implemented this year even with COVID-1919 and,
- Chukchi ecosystem moorings (located at shelf edge to measure physical and biogeochemical data).

Information from these long-term monitoring programs is incorporated into integrated ecosystem research in Alaska. These are place-based studies. NPRB is facilitating international collaboration and data integration.

One member asked about the southern border of NPRB's research area of interest. Dr. Baker reported that NPRB is interested in information for the North Pacific down to a latitude of Hawaii; NPRB tends to prioritize the areas that are adjacent to Alaska.

2. Activities of NEAR-GOOS: Guimei Liu

The North-East Asian Regional GOOS (NEAR-GOOS) is a regional pilot project of the Global Ocean Observing System (GOOS), and it is being implemented by China, Japan, the Republic of Korea and the Russian Federation. It aims at facilitating the sharing of oceanographic data gathered by agencies of the partner countries and developing a comprehensive and sustained ocean observing network in the North- East Asian regional seas and coastal regions.

There are two observational data bases operated for NEAR-GOOS. One is Regional Real-Time Data Base (RRTDB), providing observational data acquired from WMO's Global Telecommunication System (GTS). The total volume of oceanographic/marine and meteorological data of RRTDB was 211GB by September 2, 2020. The other is the Regional Delayed Mode Data Base (RDMDB). About 89,000 files and 50.4 GB data were downloaded from the Regional Delayed Mode Data Base (RDMDB). Ocean Forecasting Products are shared every day by Member States of NEAR-GOOS, including wind, current, temperature, wave, sea ice, and so on.

The Decade of Ocean Science for Sustainable Development is once-in-a-life-time opportunity for ocean science development, and an excellent opportunity for development of NEAR-GOOS on observation data and forecasting services. NEAR-GOOS would like to engage in the Decade of Ocean Science for Sustainable Development and GOOS 2030 Strategy to develop regional ocean observations and services with all member states and stakeholders of NEAR-GOOS.

NEAR-GOOS is seeking cooperation in ocean observing activities, data sharing, and ocean forecasting services with PICES. NEAR-GOOS also has pilot projects to increase the number of transects/sections for sampling and to use a ferry box for sampling.

One member asked what new sensor was added to the ferry box. NEAR-GOOS is willing to add sensors as recommended by PICES or others.

3. Activities of the NANOOS: Jan Newton

The Northwest Association of Networked Ocean Observing Systems (NANOOS, www.nanoos.org) is the Regional Association of the national Integrated Ocean Observing System (U.S. IOOS) in the Pacific Northwest, primarily Washington and Oregon. NANOOS has strong ties with the observing programs in California (CeNCOOS and SCCOOS), Alaska (AOOS), and British Columbia (CIOOS-Pacific) through our common purpose and the shared need for data and products.

NANOOS operates as a collective organization to serve the Pacific Northwest (PNW) public and nation, in establishing and maintaining an integrated regional ocean observing infrastructure. The organization is dedicated to providing meaningful observing, monitoring, and modeling solutions for predicting and maintaining ocean health, public safety, while supporting a strong regional economy. The mission of NANOOS is to coordinate and support the development, implementation, and operation of a regional coastal ocean observing system (RCOOS), as part of the U.S. Integrated Ocean Observing System (IOOS). NANOOS provides timely, high quality oceanographic and marine related data and data products to a diversity of stakeholders and user groups. These products encompass temporal and spatial qualities appropriate for the needs of multiple user sectors.

The US Integrated Ocean Observing System (IOOS) was authorized by Congress to fill the gap between the importance of coastal ocean data and its lack of availability to various sectors of society. In response, the Northwest Association of Networked Ocean Observing Systems (NANOOS) was assembled by charter in 2003 and formally established by Memorandum of Agreement (MOA) in 2005 to serve citizenry of the PNW. NANOOS has engaged representatives from a diverse set of stakeholders who are directly involved in the definition and execution of NANOOS within the region and as part of the U.S. IOOS effort. Since 2004, NANOOS has received NOAA funds to build its regional coastal ocean observing system.

Our goal is to sustain and enhance NANOOS to continue as the PNW regional coastal ocean observing system serving regional stakeholders in alignment with the vision and operations of U.S. IOOS. NANOOS has been maintained via U.S. IOOS program funding and a significant array of leveraged re-sources. NANOOS used two strategies to build and maintain operations: coordinate existing assets and place strategic focus on new investments, with the result that NANOOS has produced a distributed observing

system yielding informative and decision-relevant data products serving PNW stakeholders and the broader society in five areas of concern (maritime operations, ecosystem assessment, coastal hazards, biodiversity, climate) across three spatial domains (coastal ocean, estuaries, shorelines). NANOOS currently provides significant societal benefits to a wide spectrum of users including federal, tribal, state and local governments, industries, scientific researchers, non-governmental organizations (NGOs), educators, and the general public.

The PNW waters of the United States are critically linked to the societal and ecological health of the region. They modify and moderate regional weather, serve as highways for marine commerce involving the entire Pacific Rim, are part of an oceanic buffer for the Nation's national security, support a productive ecosystem, including significant natural and cultural resources, and provide exceptional recreational opportunities. The PNW states of Washington and Oregon need access to coastal ocean data and products.

NANOOS has been executed with substantial stakeholder involvement in every aspect: in defining the NANOOS Regional Association, its governance structure, regional coordination, and prioritization. Additionally, stakeholders contribute to and help define our RCOOS subsystems: observations; modeling; data management and products; and outreach, engagement and education.

For its governance, NANOOS has an established Governing Council (GC) that is thriving, diverse, and continues to grow. Membership institutions have grown from 25 in 2007 to ~70 today. Representation is from many sectors: 27% local, state, and federal government, 7% tribes and tribal organizations, 25% NGO/education organizations, 17% industry, and 25% academic institutions.

Key developmental factors for NANOOS have been an equitable focus on coastal ocean, estuarine, and shoreline observations and on product development to meet user needs. A host of data and user-defined data products are currently available through NANOOS and its NANOOS Visualization System (NVS). Prioritization for NANOOS activities/products continues to be advised by our outreach and from active stakeholder involvement within NANOOS governance and committees.

Jan Newton described examples of NaNOOS observations and uses for the data including for the marine heat wave, several latitudinal glider transects to map the movement of the warm water anomalies, OA measurements, models, data for use by shellfish growers and resource managers, HABs.

A member asked how many instruments have been deployed to measure Harmful Algal Blooms. Dr. Newton answered that there is only one now, but there are plans to deploy others.

4. Activities of the OOI: Jack Barth

See the USA national report.

A member asked about the safety of the instruments and how many they have lost. Dr. Barth said their strategy is to have two of each sensor; there have been a couple of lost sensors. Jack said they have spent >10 years advertising sensor positions as well as Automatic Identification System (AIS) locators.

5. Activities of the Argo: Toshio Suga

The Argo Program currently maintains a global array of about 4000 profiling floats. Float reliability has been improved for main float models, which partially compensates for decreasing trend of annual deployment due to flat/declining funding. COVID-19 affected supply and deployment of floats, which degraded the array, while data management remained active via remote work. The good news is that the array has been recovering to some extent since this summer. Argo intends to sustain the 4000 operational floats, mitigating COVID impact, and prepare for the future towards its new design. The global, full depth and multidisciplinary design, "Argo 2020 design," consists of 2500 Core, 1200 Deep and 1000 BGC floats. The three missions should be fully integrated and contribute to core upper 2000-m temperature and salinity observation. Implementation of new BioGeoChemical (BGC) and Deep missions while maintaining Core coverage is a complex challenge. We have set a new Argo governance structure suitable for this challenge and been developing roadmap for fully integrated Core, Deep and BGC missions. There are several major issues to overcome including excessive costs and availability, particularly for BGC, of sensors and more careful and accurate deployment planning. The latter example of the issues is due to the fact that the BGC and Deep missions have thinner arrays and iridium floats do not disperse much. We need a tighter partnership with the RV and other ship operators to address this particular issue, which is a good example that PICES could help with. We should note that global BGC and Deep missions have not been funded yet. We need help from the PICES community in promoting "Argo Beyond 2020" so that we can better serve the broader oceanographic community.

The group discussed the ability of Argo to accomplish its ambitious goals.

A member asked how much more expensive is the BGC compared to regular Argo – answer was approximately five times.

6. Activities of the WOA II: Chiba Sanae

(written update only)

Toward the publication in 2020, writing and reviewing the process of 31 chapters have been carried out. Most of the chapters are ready for editing. The final version will be confirmed by the Group of Experts, the Secretariat (DOALOS), and the Bureau (government officers group representing around 20 States), followed by the approval by a UN Ad Hoc Working Group as a whole in Autumn. The World Ocean Assessment (WOA) II focuses on the "changes" of ocean environments, human activities, and its management from WOA I using the best available data.

Discussion of strategy for WOA III (2021–2025) has already begun, including on "lessons learned" during the WOA II process. Considering the fact that WOA is not fully visible or used for policy compared to other international assessment reports, *e.g.*, IPCC report and IPBES assessment, we emphasize on and make it clear its relevance and contribution to Sustainable Development Goals (SDGs) and The Decade of Ocean Science in the summary (Chapter1) of WOA II. The summary will be submitted to UN Ocean Conference to be held in June to show the contribution and commitment of WOA II. WOA III shall be designed so that it is more clearly aligned to other international and intergovernmental projects/frameworks that aim to deliver the goals of The Decade successfully. As a part of WOA III, a series of regional workshops on capacity building to enhance the science-policy (society) interface is being planned.

7. Activities of the POGO: Sophie Seeyave

A pre-recorded presentation was provided; however, the volume did not work, so the presentation will be posted on the PICES website later. https://1drv.ms/v/s!Aool_JuJM69KlkI3SL0-t9JBYCRC?e=H8Cbjg

AGENDA ITEM 8
National reports

See *MONITOR Endnote 4*.

AGENDA ITEM 9
Other issues

1. AP-CREAMS submitted two proposals for Summer Schools. One was previously submitted (ocean turbulence) and a new one is for satellite training.

Action: MONITOR committee members to review proposals and provide feedback to Prof. Kim.

2. One member suggested documenting the impact of COVID-19 restrictions on long-term monitoring programs, perhaps in a PICES Press article.

Action: Members to provide Prof. Kim information regarding COVID restrictions on long-term monitoring programs.

3. One member suggested that, given gliders and other unmanned autonomous vehicles and given COVID-19, there will be pressure to reduce other types of monitoring (*e.g.*, putting people on boats with sampling nets)

that are critical. It was noted that impacts are not evenly distributed across surveys; for example, some government-run surveys were cancelled but academic institutes were able to carry out their surveys.

Action: Dr. Ross to put this information together with help from MONITOR members.

The DAY 2 meeting was adjourned.

MONITOR Endnote 1

MONITOR participation list

Members

Sung Yong Kim (Korea, Chair)
Lisa B. Eisner (USA, Vice-Chair)
Jennifer Boldt (Canada)
Tetjana Ross (Canada)
Xianyong Zhao (China)
Hiroto Abe (Japan)
Minoru Kitamura (Japan)
Kazuaki Tadokoro (Japan)
Jeong Hee Shim (Korea)
Vladimir Kulik (Russia)
Vyacheslav B. Lobanov (Russia)
Jack A. Barth (USA)
Kym Jacobson (USA)
Clare Ostle (*ex officio*, representing CPR)

Members unable to attend

China: Zhifeng Zhang
Korea: Eunho Jung

Observers

Matthew Baker (NPRB)
Peter Chandler (WG 35 Co-Chair)
Shan Gao (China)
Alex Harper (CeNCOOS)
Carol Janzen (AMAP)
S. Kim Juniper (AP-NPCOOS Co-Chair)
Guimei Liu (NEAR-GOOS)
Jan Newton (NANOOS)
Toshio Suga (Argo)
Naoki Yoshie (AP-NPCOOS Co-Chair)
Jingjing Zheng (China)

PICES

Sonia Batten (Executive Secretary)
Harold (Hal) Batchelder (Deputy Executive Secretary)
Alex Bychkov (past Executive Secretary)

MONITOR Endnote 2

MONITOR meeting agenda

Day 1: September 16/17, 2020 hh:00-hh+2:30 (Note: hh:00 indicates the local starting time; times may shift)

1. hh:00-hh:05 Welcome, Introduction, and Sign-in (ZOOM screen capture) [5 mins]
2. hh:05-hh:20 PICES-2020 Issues: Updates from the ISB [15 mins]
3. hh:20-hh+1:15 Updates from PICES Expert Groups [55 mins]
   a. hh:20-hh:35 Activities of SG-NPESR/WG 35: Peter Chandler [15 mins]
   b. hh:35-hh:50 Activities of FUTURE: Slava Lobanov [15 mins]
   c. hh:50-hh+1:05 Activities of AP-CREAMS: Slava Lobanov [15 mins]
   d. hh+1:05-hh+1:15 Activities of AP-NPCOOS: Kim Juniper/Naoki Yoshie [10 mins]

hh+1:15-hh+1:25 Break [10 mins]

4. hh+1:25-hh+2:05 Updates from International Organizations [40 mins]
   a. hh+1:25:hh+1:35 Activities of the CPR Survey: Sonia Batten/Clare Ostle [10 mins]
   b. hh+1:35:hh+1:45 Activities of the AMAP: Jan Larsen [10 mins]
   c. hh+1:45:hh+1:55 Activities of the AOOS: Carol Janzen [10 mins]
   d. hh+1:55:hh+2:05 Activities of the CeNCOOS: Alex Harper [10 mins]
5. hh+2:05-hh+2:30 Other Issues [25 mins]
   a. hh+2:05:hh+2:20 Discussion on potential POMA candidates [15 mins]
   b. hh+2:20:hh+2:30 Any other issues [10 mins]

Day 2: September 17/18, 2020 hh:00-hh+2:40 (Note: hh:00 indicates the local starting time; times may shift)

6. hh:00-hh:05 Welcome, Introduction, and Sign-in (ZOOM screen capture) [5 mins]
7. hh:05-hh:15 Review of the first day session [10 mins]
8. hh:15-hh+1:05 Updates from International Organizations (Cont'd) [50 mins]
   a. hh:15-hh:25 Activities of NPRB: Matthew Baker [10 mins]
   b. hh:25-hh:35 Activities of NEAR-GOOS: Guimei Liu [10 mins]
   c. hh:35-hh:45 Activities of NANOOS: Jan Newton [10 mins]
   d. hh:45-hh:55 Activities of OOI: Jack Barth [10 mins]
   e. hh:55-hh+1:05 Activities of Argo: Toshio Suga [10 mins]
   f. hh:55-hh+1:05 Activities of POGO: Sophie Seeyave [0 mins]
9. hh+1:05-hh+1:20 Break [15 mins]
10. hh+1:20-hh+2:20 National Reports – Written and Oral [60 mins]
    - Canada Boldt, Ross
    - United States Barth, Eisner, Jacobson
    - China Huang, Zhao, Zhang
    - Korea SY Kim, Shim, EH Jeong
    - Japan Kitamura, Tadokoro, Abe
    - Russia Kulik, Lobanov
11. hh+2:20-hh+2:40 Other Issues [20 mins]

MONITOR Endnote 3

MONITOR Action Plan
(2020–2025)
(new Term of Reference added, in red)

Mission (Terms of Reference)

1. Identify the principal monitoring needs of the PICES region, and develop recommendations to meet these needs, including training and capacity building;
2. Serve as a forum for coordination and development of inter-regional and international components of the North Pacific Ocean Observing Systems, including the Global Ocean Observing System (GOOS). Facilitate method development and inter-comparison workshops to promote calibration, standardization, and harmonization of data sets;
3. Contribute to the development of the North Pacific Ecosystem Status Report (NPESR), advising editors and lead authors on monitoring issues, identifying the need for particular time series and their continuities, the period on which they need to be updated for PICES Science Programs, and recommend to Science Board that they endorse the need to establish or maintain particular time series;
4. Recommend interim meetings to address monitoring needs and PICES–GOOS activities;
5. Review and advise Science Board on outcomes and annual operations of the North Pacific Continuous Plankton Recorder (CPR), including providing technical advice on parameters to be measured and possible linkages to other marine monitoring initiatives and programs in the North Pacific and elsewhere;
6. Provide annual reports to the Science Board and the Secretariat on monitoring activities in relation to PICES;
7. Interact with TCODE on management issues of monitoring data.

To implement its mission, the MONITOR Committee will address each of the six main goals of the PICES Strategic Plan (https://meetings.pices.int/About/PICES-Strategic-Plan-Oct-2016.pdf):

PICES Strategic Plan Goals

1. Foster collaboration among scientists within PICES and with other multinational organizations;
2. Understand the status and trends, vulnerability and resilience, of marine ecosystems;
3. Understand and quantify how marine ecosystems respond to natural forcing and human activities;
4. Advance methods and tools;
5. Provide relevant scientific information pertinent to North Pacific ecosystems that is timely and broadly accessible;
6. Engage with early-career scientists to sustain a vibrant and cutting edge PICES scientific community.

Goal 1: Foster collaboration among scientists within PICES and with other multinational organizations

Action 1.1 Promote collaboration and communication among Ocean Observing Systems internal and external to the PICES region.

- Task 1.1.1 Define PICES' role, assist, and participate in the implementation of international programs (*e.g.*, GOOS).

Action 1.2 Promote the process of creating regular NPESRs as a way to gain collaboration among organizations, scientific programs, and stakeholders.

- Task 1.2.1 Establish and maintain a dialogue with organizations, programs, and stakeholders on potential ways to increase the value of NPESR to scientists, industry, government, and communities.
- Task 1.2.2 Seek input from intergovernmental regulatory organizations on the content, format, and value of the NPESR.

Goal 2: Understand the status and trends, vulnerability and resilience, of marine ecosystems

Action 2.1 Promote the use of Global (GOOS), GOOS Regional Alliances (*e.g.*, IOOS, CIOOS, NEAR-GOOS), and other ocean observing systems as tools to understand the functioning of marine ecosystems.

- Task 2.1.1 Identify and describe the major observing systems and programs (present and proposed) in the PICES region.
- Task 2.1.2 Provide a forum at annual PICES meetings for the exchange of information on ocean observing systems and programs among PICES member countries.

Action 2.2 Promote the use of the PICES NPESR to understand the functioning of marine ecosystems.

- Task 2.2.1 Conduct sessions and workshops at the PICES annual meetings.
- Task 2.2.2 Contribute to the production of the NPESR.
- Task 2.2.3 Evaluate the report and contribute to improving the process used to create it.

Goal 3: Understand and quantify how marine ecosystems respond to natural forcing and human activities

Action 3.1 Linked to the PICES Science Program activities, understand and quantify the impacts of climate on marine ecosystems.

- Task 3.1.1 Solicit advice from member countries, scientists, and stakeholders for what type of information is needed for NPESR to be useful to understand and quantify impacts
- Task 3.2.1 Develop a strategy for promoting and funding PICES observing activities, and actively communicating their relevance and utility. For example, i) North Pacific Continuous Plankton Recorder transects. ii) ocean observing systems, iii) international surveys (*e.g.*, EAST-I area Joint Korea-Russia cruise, ferry-box monitoring between Donghae and Vladivostok , EAST-II area Joint Japan-China-Korea cruise), iv) North Pacific seabird and marine mammal transects.

Goal 4: Advance methods and tools

Action 4.1 Use MONITOR's resources and involvement in global and regional Ocean Observation Systems to provide advice on methods and guide scientific activities.

- Task 4.1.1 Propose sessions or workshops for the PICES annual meeting to address emerging issues in ocean observing science.

Action 4.2 Use NPESR as a forum for providing information on the current status of ocean observing to guide scientific activities.

- Task 4.2.1 Provide a recommendation on emerging information needs and critical issues in methodology to multiple stakeholders, including scientists, industry, government, and communities.

Goal 5: Provide relevant scientific information pertinent to North Pacific ecosystems that is timely and broadly accessible

Action 5.1 Create and oversee expert groups to support PICES Science Programs and activities.

- Task 5.1.1 Make recommendations to the Science Board on the establishment of new expert groups to support the PICES Science Program and activities.
- Task 5.1.2 Delegate representatives as members of the PICES Science Program Advisory Panels to enable communication among groups.
- Task 5.1.3 Review the PICES Data Inventory, and identify data and/or data products developed under the direction of the MONITOR not currently recorded in the Data Inventory and inform the TCODE Chair and the Secretariat.

Action 5.2 Publish reports and workshop proceedings on a timely basis.

Action 5.3 Review the current MONITOR web page and identify new web-based products to support committee's communication with members and stakeholders.

Goal 6: Engage with early-career scientists to sustain a vibrant and cutting edge PICES scientific community

Action 6.1 Use PICES involvement in Ocean Observing Systems as a means for promoting collaboration among scientists.

- Task 6.1.1 Conduct collaborative workshops and summer schools.
- Task 6.1.2 Recruit scientists from under-represented groups to participate

Action 6.2 Use the North Pacific Ecosystem Status Report as a tool or means to promote collaboration and communication among PICES scientists.

- Task 6.2.1 Conduct collaborative workshops for authors, whenever possible, as part of the process that creates the report.
- Task 6.2.2 Recruit scientists from under-represented groups to participate.

List of acronyms

IOOS: Integrated Ocean Observing System
CIOOS: Canadian Integrated Ocean Observing System
NEAR-GOOS: North Eastern Asian-Global Ocean Observing System
TCODE: Technical Committee on Data Exchange

MONITOR Endnote 4

National Reports

1. Canada

I. Overview and Summary of 2019

Fisheries and Oceans Canada (DFO), Pacific Region, conducts annual reviews of physical, chemical and biological conditions in the ocean (Fig. 1) 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 2020 (for conditions in 2019) is available at: https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2019/index-eng.html.

Figure 1. Map of areas reported on in the State of the Ocean report, including Line P, and Ocean Station Papa. Source: Boldt *et al*. (2020).

Below is the overview and summary from that report, with the same Figure and Section numbers as in the report (Boldt *et al*. 2020):

Climate change continues to be a dominant pressure acting on Northeast (NE) Pacific marine ecosystems. Globally, land and ocean temperatures in 2019 were the second warmest on record. In B.C., anomalously warm air temperatures peaked in the spring forcing the early and rapid melt of a near-normal winter snowpack (Anslow, Section 6). The long-term record of sea surface temperatures (SSTs) collected at lighthouses along the B.C. coast showed that 2019 was a continuation of the warm period that started in 2014 (Chandler, Section 10). Overlying the multi-year oscillations in the annual SST there remains a long- term trend towards rising ocean temperatures: 0.86°C over the last 100 years (Figure 3-1; Chandler, Section 10). Increasing CO2 in the atmosphere has led to ocean acidification, which will continue to intensify as anthropogenic carbon content further increases (Evans, Section 35).

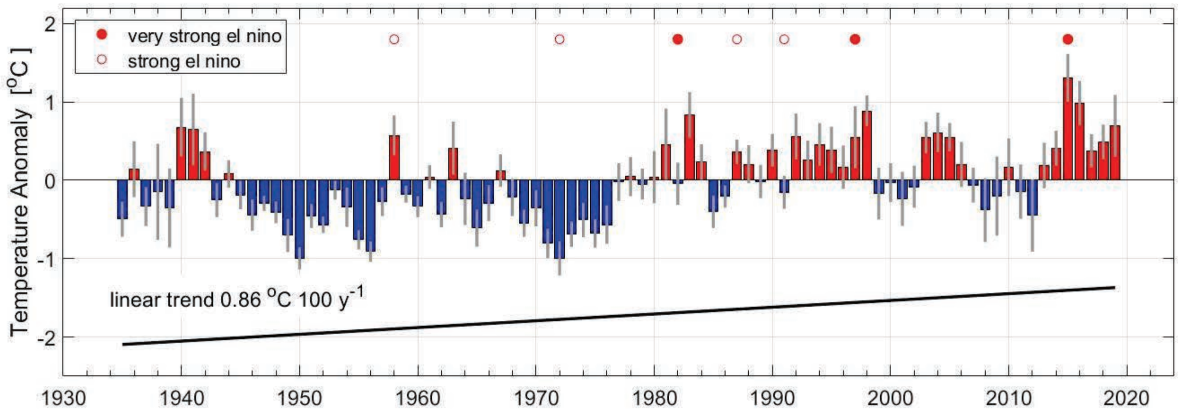

Figure 3-1. The trend in the annual temperature based on the observations of all lighthouses. The data shown are the anomalies from the long-term average temperature (1935-2017). The bars represent the anomalies averaged over all stations (a coast-wide indicator), (red – above average, blue – below average), the vertical grey lines show the variability in the lighthouse data for each year. Source: Chandler, Section 10.

In 2019, the NE Pacific experienced a moderate El Niño and a marine heatwave (MHW). The El Niño was weak in the first half of 2019 and neutral for the latter half of the year, so it had little effect on SSTs (Figure 3-2). The MHW resulted in record-breaking SST anomalies in both surface and subsurface waters (Figure 3-3; Ross and Robert, Section 7; Sastri, Section 13; Hannah *et al.*, Section 48). The occurrence of MHWs in the NE Pacific is increasing, with MHWs observed in 2014-2016, 2018, and 2019; this span of seven warm years has been observed only once before in the last 80 years (during 1992-1998; Chandler, Section 49).

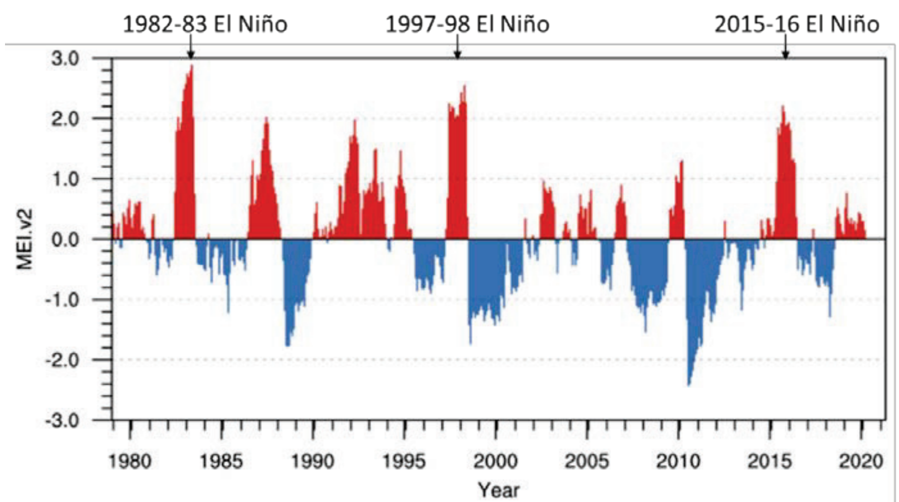

Figure 3-2. The multivariate ENSO Index. Data source: NOAA/ESRL/Physical Sciences Division – University of Colorado at Boulder/CIRES; https://psl.noaa.gov/enso/mei/.

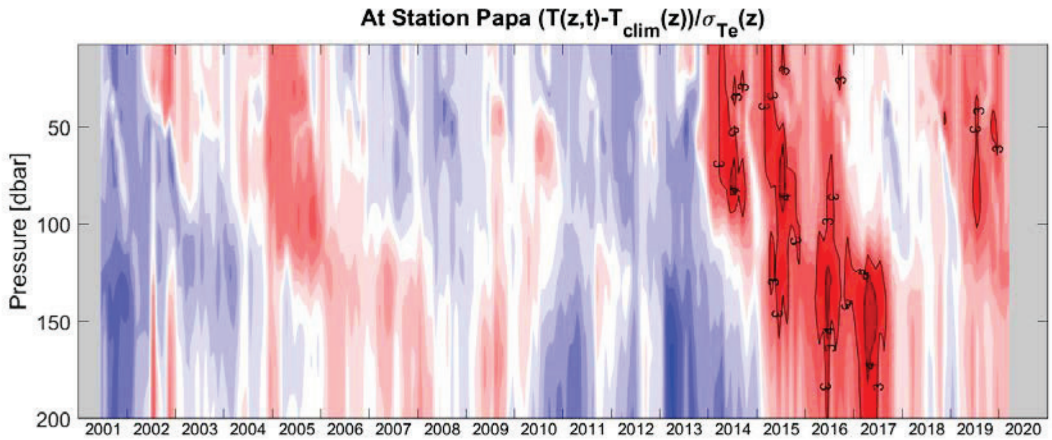

Figure 3-3. Plot of temperature anomalies relative to the 1956-2012 seasonally-corrected mean and standard deviation (from the Line P time series), as observed by Argo floats near Station Papa (P26: 50°N, 145°W). The cool colours indicate cooler than average temperatures and warm colours indicate warmer that average temperatures. Dark colours indicate anomalies large compared with the 1956-2012 standard deviations. The black lines highlight regions with anomalies that are 3 and 4 standard deviations above the mean. Source: Ross and Robert, Section 7.

Marine heatwaves are associated with reduced vertical mixing causing increased winter stratification. This results in decreased nutrient supply from deep to surface offshore waters. For five of the last six winters the strength of winter mixing was weak and stratification was strong (Figure 3-4; Ross and Robert, Section 7). Reduced ecosystem productivity during MHWs has been identified as the cause of reduced abundance of lipid-rich boreal copepods (Galbraith and Young, Section 16; Perry *et al.*, Section 50), seabird die-offs (Jones *et al.* 2018), reduced size-at-age and late entry into streams and rivers by adult salmon (Hyatt *et al.*, Section 51) due to prolonged drought in northern B.C. (Anslow, Section 6).

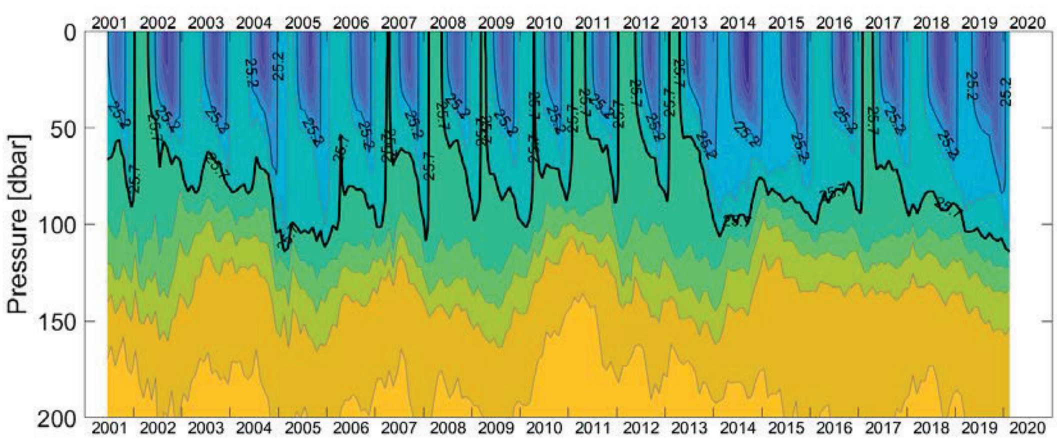

Figure 3-4. Coloured contour plot of density as observed by Argo floats near Station Papa (50°N, 145°W). The colours indicate potential density (yellow is denser and blue lighter). The black lines highlight the $\sigma\theta = 25.2$ kg/m^3 (thin) and 25.7 kg/m^3 (thick) isopycnals. Source: Ross and Robert, Section 7.

The timing and magnitude of upwelling of deep, nutrient-rich water off the west coast of Vancouver Island (WCVI) is an indicator of marine coastal productivity across trophic levels from plankton to fish to birds. Variability in the upwelling index corresponds with variations in the strength and/or longitudinal position of the Aleutian low-pressure system in the Gulf of Alaska. The average to above average intensity of the upwelling in 2019 was associated with average to above average upwelling-based productivity (Hourston and Thomson, Section 8; Dewey *et al*., Section 37). The timing of the transition to upwelling was average, favouring average upwelling-based coastal productivity (Hourston and Thomson, Section 8; Figure 3-5).

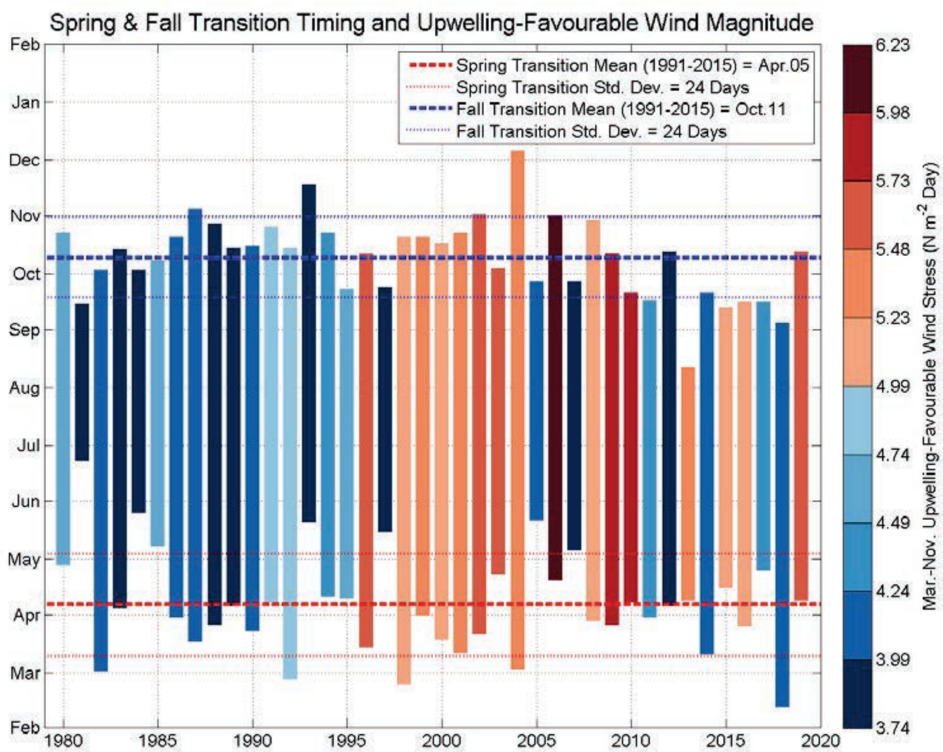

Figure 3-5. The upwelling index for the west coast of British Columbia. Bar plot showing Spring and Fall transitions and upwelling-favourable wind stress magnitude. The length of the bar corresponds to the duration of the upwelling season, coloured by the intensity of the upwelling (red indicates intense upwelling, blue indicates weak

In the spring and summer 2019, surface nutrient concentrations along Line P were among the lowest on record (Peña and Nemcek, Section 14). In particular, the summer mixed layer nitrate was depleted at Ocean Station Papa for the first time in 60 years of observations. In 2019, on the west coast of B.C., the phytoplankton biomass was within the range of past values. The phytoplankton community composition in spring 2019 was similar to that of 2018 but different from years prior to 2018, with diatoms dominating phytoplankton biomass at several open-ocean stations (Peña and Nemcek, Section 14; Batten and Ostle, Section 15).

The zooplankton community off the WCVI continues to reflect warm water conditions, with higher abundances of gelatinous and lower abundances of crustacean taxa (Galbraith and Young, Section 16) and, on the shelf, a dominance of small-sized copepod species (Batten and Ostle, Section 15). Large subarctic and boreal copepods are more favourable for fish growth than small, southern copepod species. In 2019, biomass anomalies of boreal copepods increased on the shelf; whereas, subarctic copepods anomalies decreased or were low in all areas except Hecate Strait (Galbraith and Young, Section 16; Figure 3-6). Southern copepod anomalies were positive in all regions in 2019 (Figure 3-6). The colonial tunicate, *Pyrosoma atlanticum*, that first appeared in B.C. waters in 2017, and was found in lower abundances along the shelf break in 2018, was absent from B.C. waters in 2019 (Galbraith and Young, Section 16).

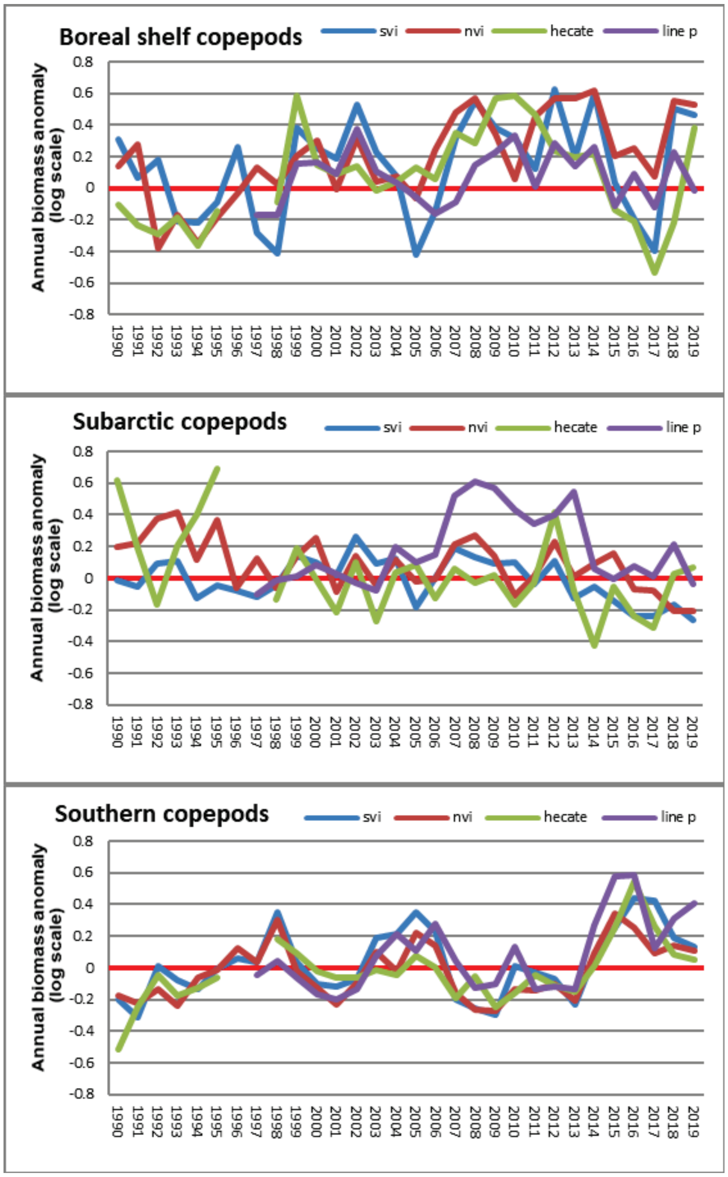

Figure 3-6. Zooplankton species-group anomaly time series for the regions shown in Figure 1. Line graphs are annual log scale anomalies. Southern Vancouver Island (SVI) blue; Northern Vancouver Island (NVI) red; Hecate Strait (HEC) green; Line P – purple for all graphs. Blank years mean no samples were collected. Source: Galbraith and Young, Section 16.

Changes to the physical environment, and phytoplankton and zooplankton communities can have impacts on higher trophic levels. In 2019, the WCVI Smooth Pink Shrimp biomass, which is negatively correlated with SST (lagged 1 year), was among the lowest on record; anomalies have been below the climatological mean for the last four years (Perry et al., Section 23). During warm ocean conditions, Pacific Hake migrate north to Canadian waters; however, in 2019, only a relatively small proportion of the stock was observed in Canadian waters, despite warm ocean conditions and total stock biomass being ~20% above the time series median (Gauthier *et al.*, Section 25). In the 2019 Hecate Strait and Queen Charlotte Sound synoptic bottom trawl surveys, biomass indices increased for several Rockfish species (including Redbanded, Bocaccio, and Silvergray Rockfish), increased for North Pacific Spiny Dogfish, leveled off for Sablefish, Pacific Cod and Shortspine

Thornyhead, but showed decadal-scale decreases for Arrowtooth Flounder and Spotted Ratfish (English *et al*., Section 24). Albacore tuna annual catch-per-unit-effort (CPUE) increased in 2018 and 2019 (Zhang, Section 69).

The growth rate of Cassin's Auklets is linked to the abundance of their primary prey, *Neocalanus cristatus* copepods, which are more abundant during relatively cold years (Hipfner *et al*. 2020). In 2019, growth rates of Cassin's auklet nestlings on Triangle Island were below the long-term average (Hipfner, Section 29). Marine mammal populations are also linked to their primary prey and while the population of southern resident Killer Whales remains low, the populations of the northern resident Killer Whales, Bigg's (transient) Killer Whales, and Humpback Whales have been increasing (Doniol-Valcroze *et al*., Section 27). The abundance of Steller sea lions in B.C. increased in the 1990s to 2000s and, in 2017, was at ~40,000, unchanged since 2013 (Tucker and Majewski, Section 26).

During 2019 in the Strait of Georgia (SoG), water temperatures were again generally above-normal (Chandler, Section 36). Following below-normal oxygen concentrations in 2018, a transition to near-normal oxygen concentrations has been observed throughout the system in 2019, and above-normal oxygen concentrations in the deep water of Haro Strait (Chandler, Section 36). Fraser River discharge was below normal in 2019 (although the long-term trend is for increasing annual discharge), with a relatively low discharge period in mid-summer. Normal, and above-normal flows were observed during the spring salmon outmigration period, and the fall spawning period (Figure 3-7).

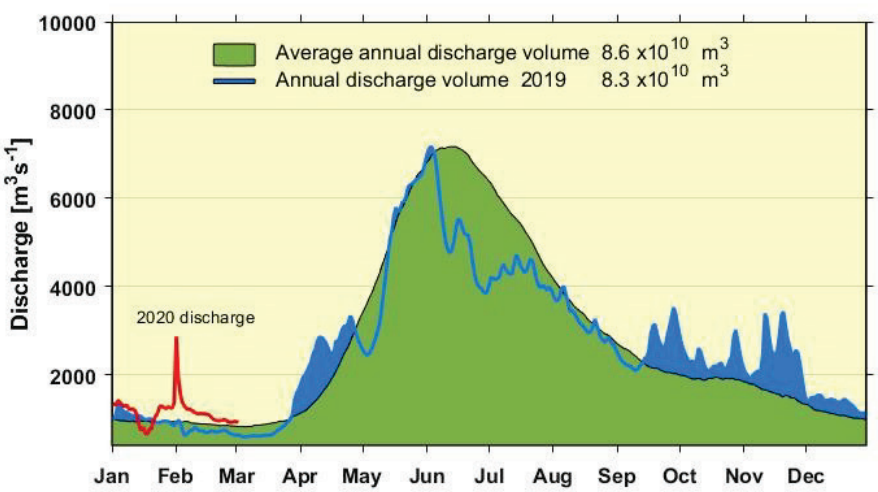

Figure 3-7. Fraser River discharge at Hope B.C.; 2019 (blue), 107 year average (green). The red line shows the above normal discharge in early 2020. Data source: Extracted from the Environment and Climate Change Canada Real-time Hydrometric Data web site (https://wateroffice.ec.gc.ca/mainmenu/real_time_data_index_e.html) on 2 March 2020.

In 2019 in the SoG, there were fewer dense Harmful Algal Blooms (HABs) than in 2018, but more than in 2015-2017 (Esenkulova *et al.*, Section 40). On the WCVI, several fish farms experienced mortality events due to blooms of non-toxic, mechanically harmful diatoms *C. convolutus* and *C. concavicornis* (Esenkulova *et al*., Section 40). European Green Crab, an Aquatic Invasive Species that was first observed in Canadian waters during the 1997/98 El Niño, are widespread along the WCVI and have been found in low numbers in North and Central B.C. and the northern Salish Sea (Howard and Therriault, Section 46). More recently, this high-impact invader that negatively affects eelgrass, an important fish habitat, has been detected in the southern Salish Sea (Howard and Therriault, Section 46).

There has been no long-term trend in total primary productivity in the SoG over the last 100 years (Johannessen *et al*., Section 41); however, annual variation in spring bloom timing and community composition may affect the food web, through a temporal match or mismatch between prey and their predators. In the SoG, the spring bloom timing was similar to the long-term average (Allen *et al*., Section 38; Dewey et al., Section 37) – which implies good feeding conditions for juvenile fish.

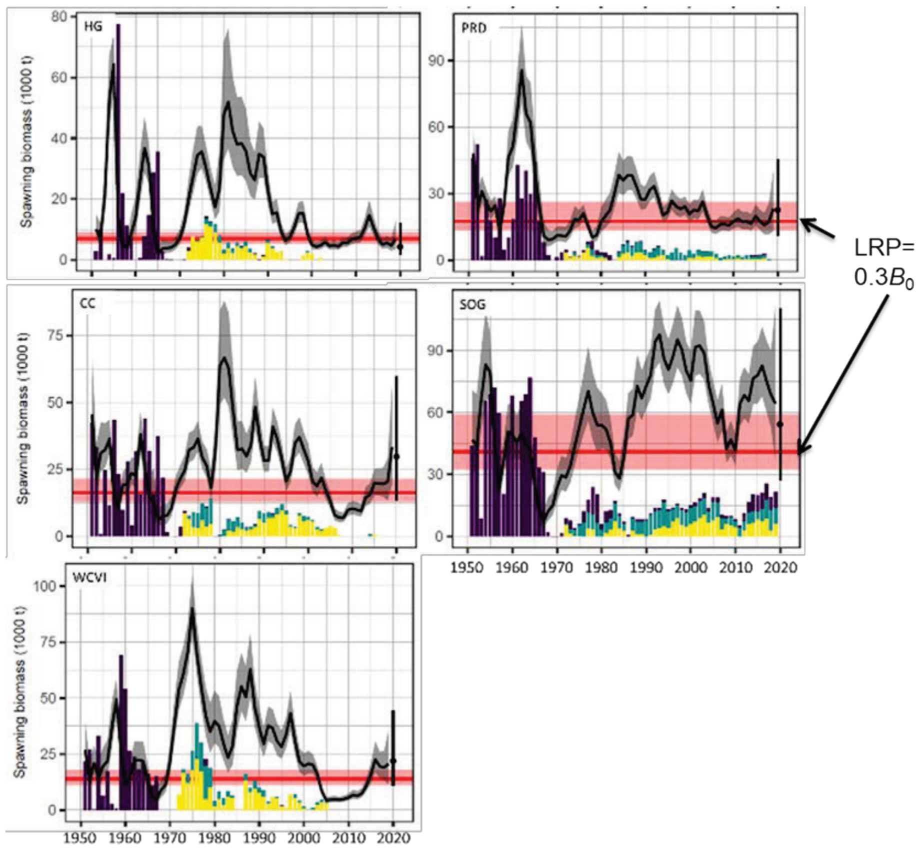

Figure 3-8. Summary of the dynamics of the five Pacific Herring stocks from 1951 to 2019, where solid lines with surrounding grey envelopes, represent medians and 5-95% credible intervals. Also shown is the reconstruction of spawning biomass (SB_t) for each year t, with unfished values shown at far left (solid circle and vertical lines) and the projected spawning biomass given zero catch (SB2019) shown at the far right (solid circle and vertical lines). Time series of thin vertical lines denote commercial catch (excluding commercial spawn-on-kelp; colours indicate different gear types; see DFO 2020). LRP= limit reference point ($0.3B_0$). B_0 = unfished biomass. Figure adapted from DFO (2020).

In 2019, SoG zooplankton biomass was above the long-term average but the summer peak was later in the season than previous years (Young *et al*., Section 42). There were positive biomass anomalies of hyperiid amphipods, decapods, and euphausiids, which are important zooplankton prey for juvenile salmon and forage fish (Young *et al*., Section 42). Pacific Herring biomass decreased in the SoG, remained low for Haida Gwaii, and showed modest increases in Prince Rupert District, Central Coast, and WCVI (Cleary *et al*., Section 18; Figure 3-8). In 2019, multiple sizes of Northern Anchovy continued to be present in survey catches (Boldt *et al*., Section 43, Neville, Section 44). An index of Eulachon spawning stock biomass in the Fraser River was relatively low in 2019 (similar to 2004-2014; Flostrand, Section 17).

In the SoG, juvenile Coho and Chinook Salmon survey catch-per-unit-effort (CPUE) was average or above average and, in the fall survey, CPUE of juvenile Chum Salmon was the second highest in the time series (Neville, Section 44). In summer 2019, off the WCVI, however, the catch per unit effort (CPUE) of all juvenile Pacific Salmon was low (Anderson *et al*., Section 20). Adult Sockeye, Chinook, Chum, and Coho (southern latitudes) Salmon returns in 2019 were generally poor (Grant *et al*., Section 21). Pink Salmon have generally had better returns than most species in recent years. In 2019, returns of B.C.'s Sockeye Salmon 'index stocks' (Transboundary, North Coast, Central Coast, WCVI, Fraser, and Okanagan) were below average (Hyatt *et al*., Section 22) and returns and productivity of the Fraser River Sockeye Salmon aggregate were the lowest on record (Figure 3-9, Grant *et al*., Section 21). Poor salmon returns to the Fraser River watershed were compounded by the Big Bar landslide, which blocked upstream migration of many salmon populations (Grant *et al*., Section 21; Hyatt *et al*., Section 22).

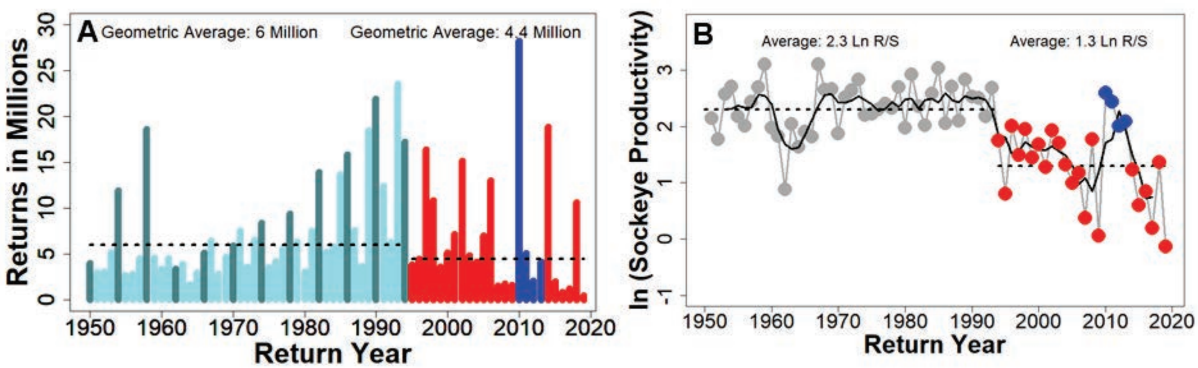

Figure 3-9. (A) Total Fraser Sockeye annual returns (dark blue vertical bars for the 2018 cycle and light blue vertical bars for the three other cycles) (B) Total Fraser Sockeye productivity (loge (returns/total spawner)) is presented up to the 2019 return year. The grey dots and lines represent annual productivity estimates. For both figures, the dashed line is the time series average. Productivity and returns have declined in recent decades, highlighted red, with the exception of four years from 2010-2013, which were closer to average, highlighted blue. Source: Grant *et al*., Section 21.

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II. Observational programs

In 2020, many surveys were cancelled and others were reduced, due to COVID-19 concerns.

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; May/June missed in 2020), starting in the 1950s; in early years there were >3 surveys per year (Fig. 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, O2, T, S, pH), and their links to climate variability and trends. The La Perouse plankton survey is carried out twice per year in May-June (July in 2020) and September, 1979-present; in early years, surveys were conducted >2 times each year. 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. Endeavour Ridge physical and biological sampling and current meter mooring, 1984-2006.

3. Strait of Georgia (Fig. 1): continuing at 4 surveys per year (3 in 2020), with intensified sampling in 2010 and 2011. Areas of emphasis: hydrography and circulation, nutrients, phytoplankton, vertical flux of organic matter and contaminants.

4. Strait of Georgia zooplankton survey (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 (Fig. 2). 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.

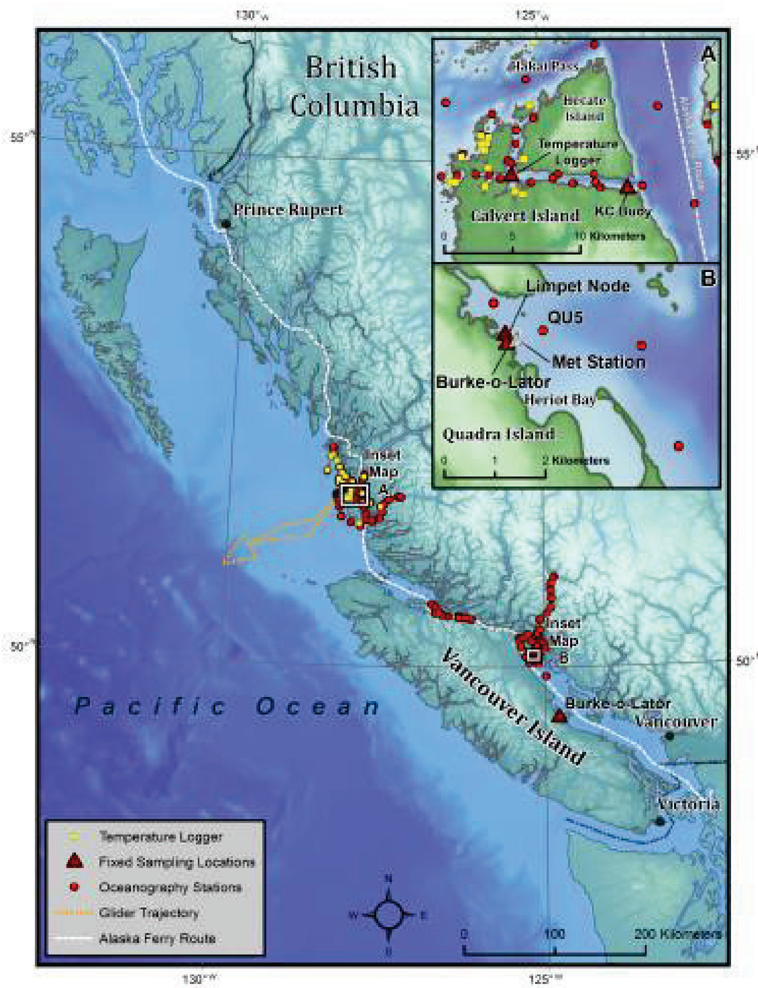

Figure 2. Locations where the Hakai Institute collects ocean data in British Columbia. Hydrographic stations (red circles) are where physical, biological and chemical measurements are made at bi-weekly to monthly frequencies. High frequency data from fixed sampling locations (red triangles) and temperature 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).

6. Discovery Islands near Quadra Island (Fig. 2). 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: 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 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. Partially integrated into the Integrated pelagic ecosystem survey (see below).

4. Juvenile herring and nearshore pelagic survey: annual; Strait of Georgia (1992-present, except 1995 and 2020) 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, except 2020) 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

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 synoptic 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 (2005-present) and Queen Charlotte Sound (2003-present) (Anderson et al. 2019); includes temperature, salinity, and dissolved oxygen data (2009-present). Historically, multispecies assemblage surveys were conducted at irregular intervals in Hecate Strait (1984-2004).

2. Pacific hake acoustic survey: biennial (was triennial); west coast North America, Southern California to Dixon Entrance (1977-present).

3. Other fish surveys: sablefish (trap), lingcod (dive), rockfish (video), Pacific halibut (longline; conducted by the International Pacific Halibut Commission).

4. Groundfish hard bottom longline survey: Conducted in inside and outside waters (important primarily for rockfish and Pacific Halibut). Alternates north and south BC regions in even and odd years. 2003-present for inside waters; 2006-present for outside waters.

5. Salmon abundance (freshwater): estimates of adult salmon leaving and juvenile salmon arriving at the ocean are obtained annually in many rivers.

6. 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.

7. 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.

8. Marine mammal surveys: throughout British Columbia
   - 2018 – Pacific Region International Survey of Marine Megafauna (PRISMM) –goal of PRISMM was to estimate the abundance and distribution of cetaceans within the Canadian Pacific Exclusive Economic Zone's 200 nautical mile offshore limit. These estimates are necessary to assess the sustainability of current bycatch levels of marine mammals in Canadian fisheries, in order to abide by the NOAA rule for seafood exports under the U.S. Marine Mammal Protection Act. Visual and acoustic detections were made along 17,000 km of pre-determined systematic line transects (Fig. 3). http://dfo-mpo.gc.ca/science/atsea-enmer/missions/2018/prismm-eng.html

9. 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.

10. 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.

11. 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.

12. 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.

13. 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 five 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.

14. Sea cucumber surveys: The goal is to provide biomass estimates. Survey times are 1997 – present.

Month of sampling is area dependent (Feb-Sep) on 4year+ intervals, coast-wide. This is a dive survey in which the following species are sampled: *Parastichopus californicus* (sometimes *Cucumaria miniata* and *C. pallida*).

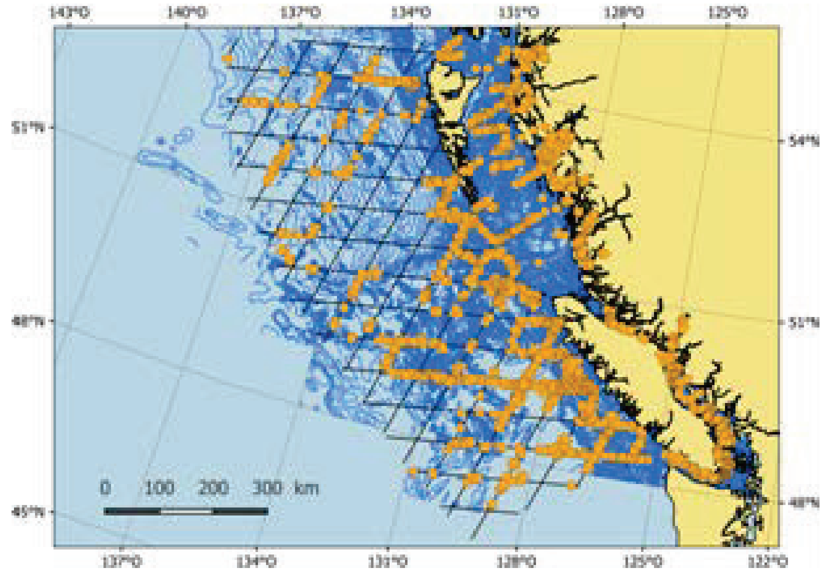

Figure 3. 2018 Pacific Region International Survey of Marine Megafauna (PRISMM). Visual and acoustic detections were made along 17,000 km of pre-determined systematic line transects. The survey resulted in over 2800 sightings of marine mammals, mostly concentrated in inshore passages and inlets, on the continental shelf and shelf break, as well as around some seamounts offshore. Source: Thomas Doniol-Valcroze (DFO).

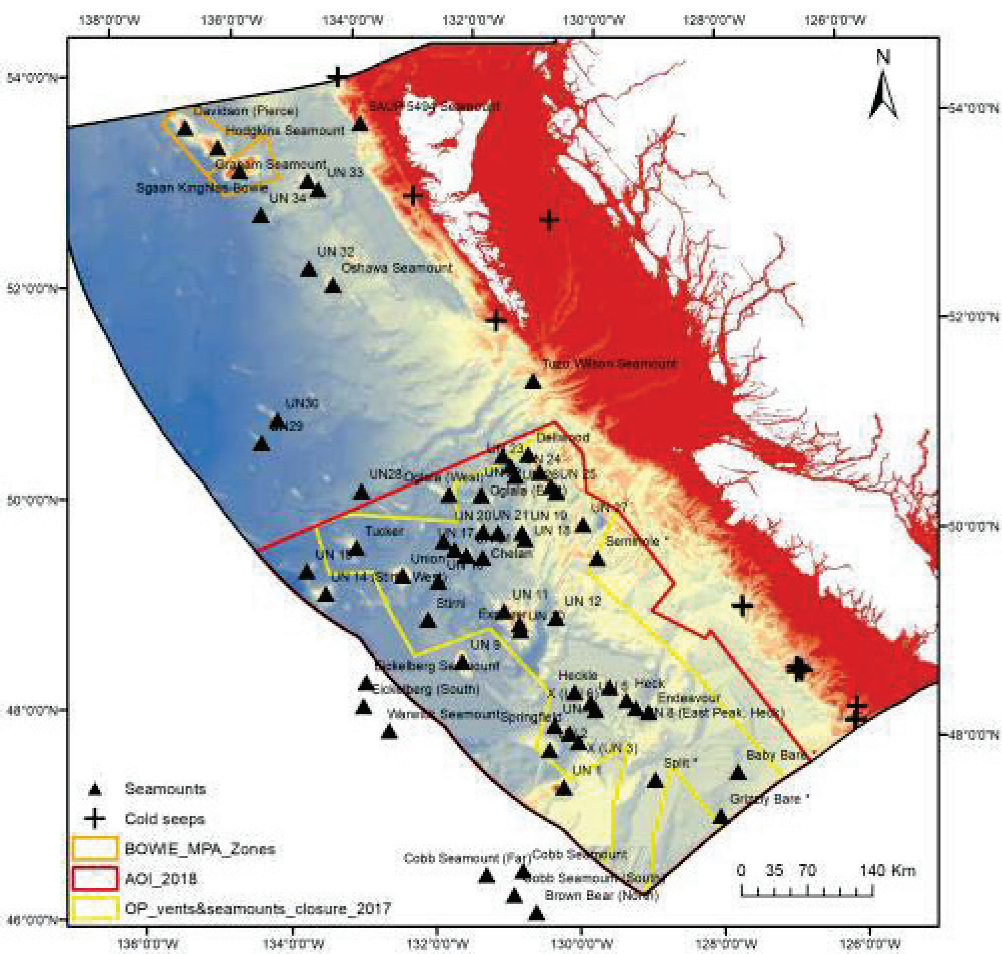

Figure 4. 2019 Survey of the Offshore Area of Interest (AOI). Source: Tammy Norgard (DFO).

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); 2020 mapping survey by Ocean Networks Canada and Ocean Exploration Trust.
   c) 2017, 2019 – Survey of the Offshore Area of Interest (AOI) (Fig. 4). 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, 2019: Four Remotely Operated Vehicle (ROV) surveys to map, assess, and develop monitoring methods for glass sponge reefs in the Salish Sea (Strait of Georgia and Howe Sound; Dunham et al. 2018a, b; DFO 2018). This work supported two initiatives to establish 17 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 analysis for 7 potential reef areas in Howe Sound is currently underway. Data collected include video (approx. 180 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 (Grant *et al.* 2019), (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. Both

surveys were 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. Autonomous monitoring with gliders and Argo profiling drifters

Canada has been very active in this successful international Argo program. Since the start of the program, Canada has deployed many floats (see http://www.argo.ucsd.edu/). In 2019, a glider monitoring program began in Canada's Pacific waters, with a DFO/academic collaboration completing two repeat glider transects of Line P and several across Queen Charlotte Sound (north of Vancouver Island). The data are available at http://cproof.uvic.ca/gliderdata/.

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 (now Clare Ostle) 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 and other monitoring instruments include (Fig. 2):

i) Burke-o-later (BoL) for determining T, S, pCO_2 and TCO_2 in Hyacinthe Bay, near Quadra Island since 2015;
ii) Multiple temperature sensors at fixed nearshore locations throughout the central coast near Calvert Island since 2015;
iii) A MApCO_2 buoy near Calvert Island that measures S, T, surface seawater and atmospheric pCO_2, and meteorological data since 2018;
iv) A cabled observatory called the Limpet has measured T, S, and oxygen at the seafloor in Hyacinthe Bay off Quadra Island since 2015;
v) A string of moored temperature and salinity sensors has collected T data every 10 minutes in 10 meter intervals since 2017;
vi) The Alaska Marine Highway System M/V Columbia has collected T, S, O, and seawater and atmospheric pCO_2 since 2017;
vii) A 150 kHz ADCP that has measured currents in a few locations around Calvert and Quadra Islands since 2019
viii) A mooring that measures temperature, salinity and oxygen at 2 depths in Rivers Inlet since 2020;
ix) Collaboration with CPROOF to deploy and recover gliders from Calvert Island since 2019.

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Dunham, A., Mossman, J., Archer, S., Pegg, J., Davies, S., Archer, E. 2018b. Glass sponge reefs in the Strait of Georgia and Howe Sound: status assessment and ecological monitoring advice. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/010.

DFO. 2018. Glass sponge aggregations in Howe Sound: locations, reef status, and ecological significance assessment. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/032.

Grant, N., Matveev, E., Kahn, A.S., Archer, S.K., Dunham, A., Bannister, R., Eerkes-Medrano, D., Leys, S.P. 2019. Effect of suspended sediments on the pumping rates of three species of glass sponge in situ. Marine Ecology Progress Series 615: 79-100.

2. China

No report available at this time.

3. Japan

Report from Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Minoru Kitamura, RIGC JAMSTEC

Highlight of 2020: Microplastic monitoring

Development of a new technique for rapidly detecting and classifying microplastics
http://www.jamstec.go.jp/e/about/press_release/20200331/#z2

A new technique for rapidly detecting and classifying microplastics based on hyperspectral imaging have been developed. Detection is based on the intrinsic spectral properties of microplastic polymers. Specifically, the spectral features of 11 types of authentic plastic polymers, such as polyethlen, polypropylene, and polystyrene, in the near-infrared wavelength range of 900–1700 nm were classified. Based on the similarities of such features, the microplastic particles of these materials were successfully classified. A scan over a 1 cm × 1 cm detection area takes only 10 seconds, which is 100 times faster than previously employed methods. In the future, this technique will be evaluated for the detection of microplastics in seawater samples and then an automatic detection system will be developed. The new technique has the potential to make significant contribution to monitoring observation of microplastic.

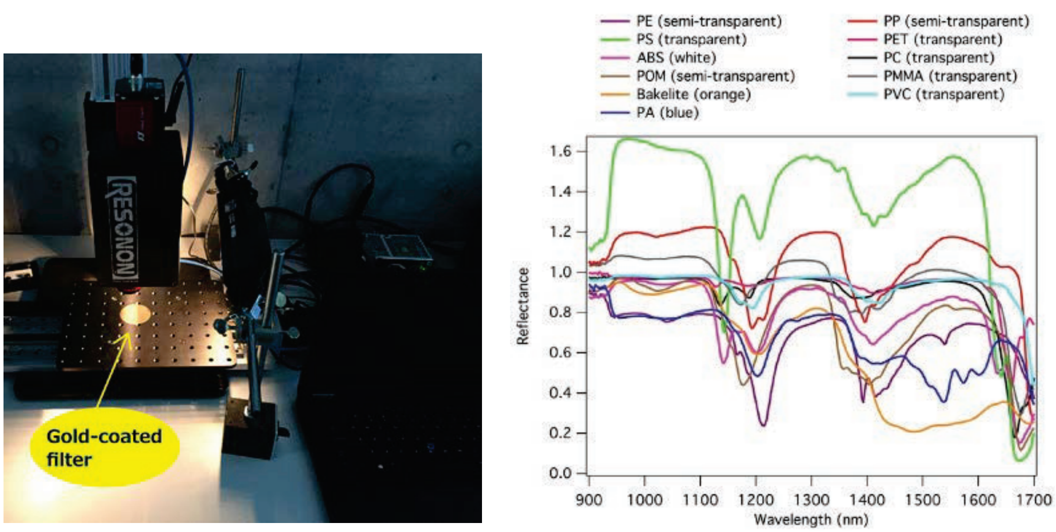


Figure 1. Left: hyperspectral imaging system. Right: spectra of 11 plastic polymers in the near-infrared wavelength (900-1700 nm).

Update of Observation Programs of RIGC, JAMSTEC

RIGC (Research Institute for Global Change) is in charge of variety of ocean observation programs. Conventional monitoring projects as shown below are succeeded and under operation by RIGC. These projects yet are mainly limited to physical, chemical and atmospheric observation.

- **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). The PARC takes 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 July 2020) http://www.jamstec.go.jp/ARGO/argo_web/argo/?page_id=56&lang=en. The example maps of gridded mixed layer depth and average temperature in mixed layer are shown in Figure 2.

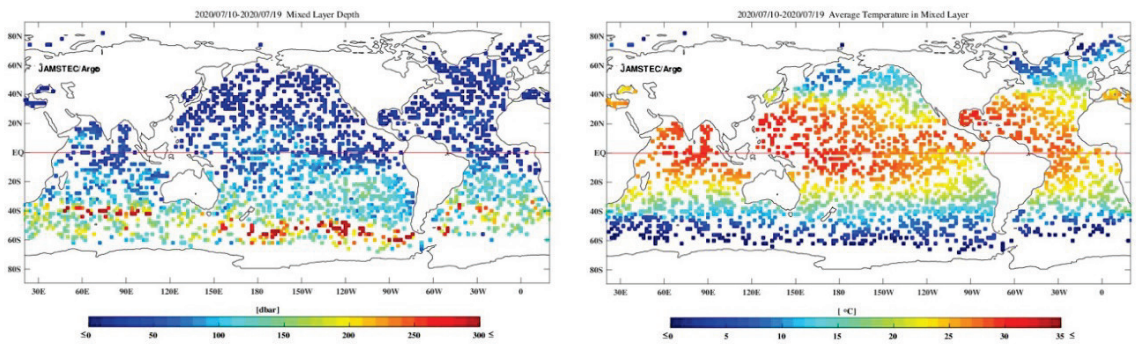


Figure 2. Left: mixed layer depth defined by $\Delta\sigma\theta$ = 0.125 kg/m^3 and ΔT = 0.5°C, July 2020. Right: average temperature in mixed layer, July 2020.

- **Deep NINJA: Deep ocean observation by deep-sea float**

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

JAMSTEC had deployed 30 Deep NINJA floats in collaboration with Tsurumi-Seiki Co. Ltd, primarily in the Southern Ocean since 2012 up to 2019. In 2020, an additional Deep NINJA float (S/N 29) was deployed off the Adelie Coast of Antarctica. Among the 31 floats, five ones are active as of May 1, 2020. One of the five active floats (S/N 27) is in the eastern equatorial Pacific. The example trajectory and profiles of the float (S/N 27) are shown in Figure 3.

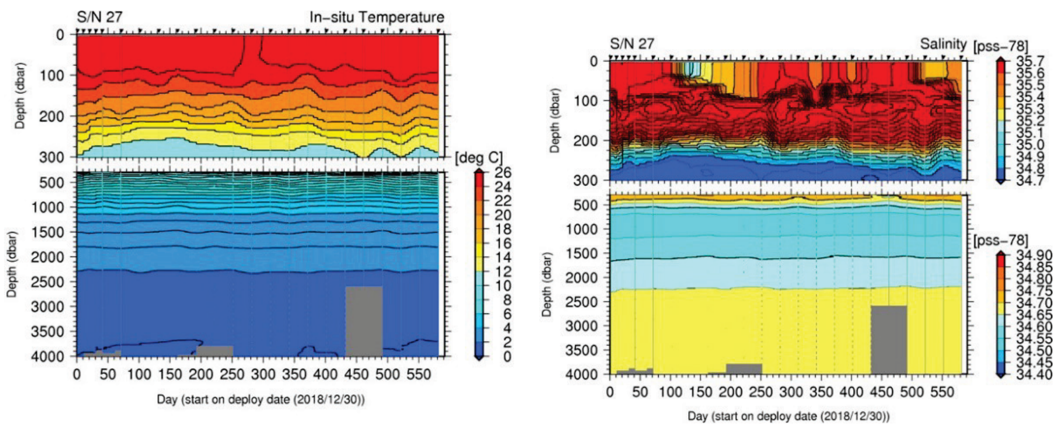


Figure 3. In-situ temperature (left) and salinity (right) profiles obtained by the Deep NINJA float S/N 27 in the eastern equatorial Pacific.

- **TAO and TRITON Project**

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

Operating moored ocean buoy (TRITON) network 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. From Feb. to Mar. 2020, TRITON buoys were recovered and redeployed in two sites of the western equatorial Pacific (0°, 156°E; 8°N, 137°E).

- **IOMICS Project: Indian Ocean Moored buoy network Initiative for Climate Studies**

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

Developed new-type of moored buoy network, which observe sea surface heat flux components and ocean temperature and salinity in the upper layer, to understand mechanism of the Indian Ocean’s variation and its importance for global climate system under a cooperative framework among surrounding countries.

- **Post-WOCE Hydrography**

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

Repeat hydrography along the WOCE observation lines etc. Observation 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. Next cruise of repeat hydrography along the P01 WOCE observation line is planned for 2021.

Report from Hokkaido University

Hiroto Abe, Sei-Ichi Saitoh at Faculty of Fisheries Sciences, Hokkaido University

Hydrographic observations by T/S *Oshoro-Maru* and *Ushio-Maru*

Hokkaido university have two training ships, one is T/S *Oshoro-Maru* and the other is T/S *Ushio-Maru*. The former has contributed to monitoring open ocean/marginal seas in the North Pacific including Bering Sea over the decades, while the latter has monitored coastal areas around Japan. For the last one year, T/S *Oshoro-Maru* was scheduled to observe meridional line east off Japan, but this cruise has been canceled in the COVID2019 crisis. Coastal monitoring in Tsugaru Strait by T/S *Ushio-Maru*, which has been quarterly done since 2009, has been carried out with researches from JAMSTEC this year as well (Fig. 1). Surface current monitoring in the Tsugaru Strait by High Frequency Ocean Radar (Mutsu Institute for Oceanography, JAMSTEC) has been done as usual (Fig. 2).

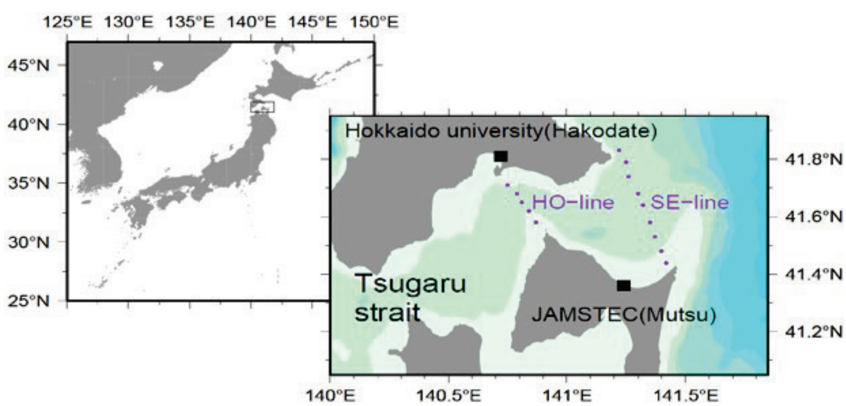


Figure. 1. Location of Tsugaru Strait and SE, HO line.

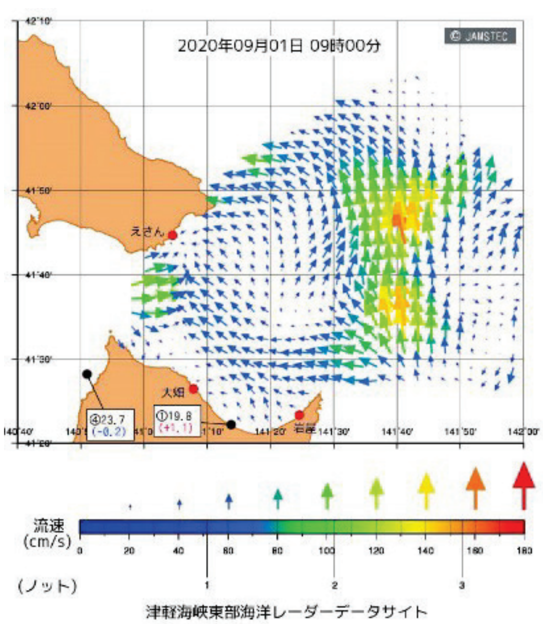


Figure. 2. Surface current map in the Tsugaru Strait measured by JAMSTEC's HF radar (http://www.godac.jamstec.go.jp/morsets/e/top/).

One member asked about temperature measurements in Tsugaro Strait. Dr. Abe answered that ship observations of temperatures were recorded.

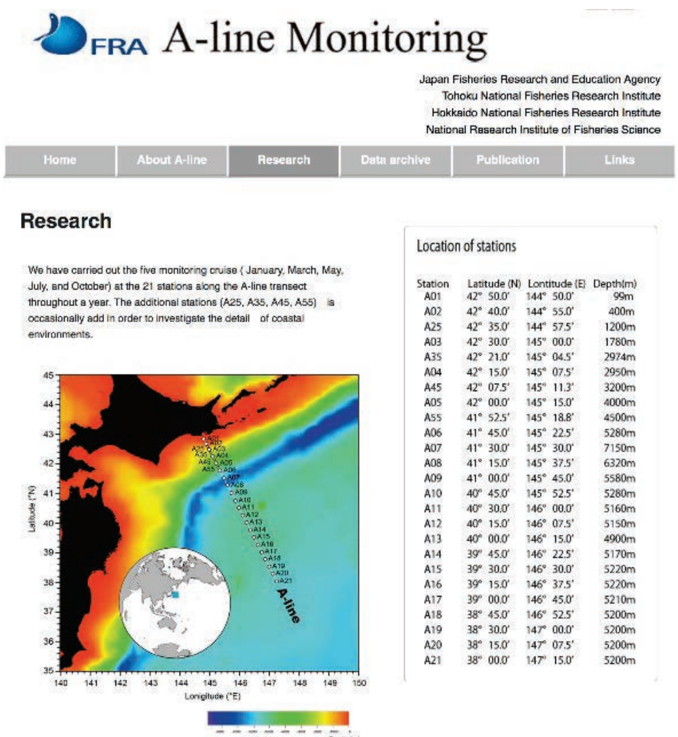
National Report of Japan Fisheries Research and Education Agency (FRA)

Kazuaki Tadokoro, Fisheries Resources Institute, Shiogama branch

Observation at Monitoring lines

A-Line

Fisheries Resources Institute of Shiogama and Kushiro branch have carried out oceanographic monitoring from 1987 to present at a transect A-line in the Oyashio and Kuroshio-Oyashio transition waters. In recent year, 5 times observations were carried out in January, March, May, July, and October throughout a year. Observation items are CTD, water sampling by Niskin bottles, Norpac net, and Bongo net. In this year, 5 time of cruses were carried out. The oceanographic data are opened and available from the website. Period of published data are from 1990 to 2018 for CTD and from 1990 to 2014 for others.


A-line Monitoring

Japan Fisheries Research and Education Agency
Tohoku National Fisheries Research Institute
Hokkaido National Fisheries Research Institute
National Research Institute of Fisheries Science

Home | About A-line | Research | Data archive | Publication | Links

Research

We have carried out the five monitoring cruise (January, March, May, July, and October) at the 21 stations along the A-line transect throughout a year. The additional stations (A25, A35, A45, A55) is occasionally add in order to investigate the detail of coastal environments.

Location of stations

Station	Latitude (N)	Lontitude (E)	Depth(m)
A01	42° 50.0'	144° 50.0'	99m
A02	42° 40.0'	144° 55.0'	400m
A25	42° 35.0'	144° 57.5'	1200m
A03	42° 30.0'	145° 00.0'	1780m
A35	42° 21.0'	145° 04.5'	2974m
A04	42° 15.0'	145° 07.5'	2950m
A45	42° 07.5'	145° 11.3'	3200m
A05	42° 00.0'	145° 15.0'	4000m
A55	41° 52.5'	145° 18.8'	4500m
A06	41° 45.0'	145° 22.5'	5280m
A07	41° 30.0'	145° 30.0'	7150m
A08	41° 15.0'	145° 37.5'	6320m
A09	41° 00.0'	145° 45.0'	5580m
A10	40° 45.0'	145° 52.5'	5280m
A11	40° 30.0'	146° 00.0'	5160m
A12	40° 15.0'	146° 07.5'	5150m
A13	40° 00.0'	146° 15.0'	4900m
A14	39° 45.0'	146° 22.5'	5170m
A15	39° 30.0'	146° 30.0'	5220m
A16	39° 15.0'	146° 37.5'	5220m
A17	39° 00.0'	146° 45.0'	5210m
A18	38° 45.0'	146° 52.5'	5200m
A19	38° 30.0'	147° 00.0'	5200m
A20	38° 15.0'	147° 07.5'	5200m
A21	38° 00.0'	147° 15.0'	5200m

Figure. 1 Website of A-line monitoring (http://tnfri.fra.affrc.go.jp/seika/a-line/a-line_index.html)

O-Line

Fisheries Resources Institute of Yokohama branch have carried out the monitoring from 1999 to present at a transect O-line (138°E, 27°N to 34.30°N) in the Kuroshio waters. The observations were carried out in January, March, May, August, and October throughout a year. Observation items are CTD, water sampling by Niskin bottles, and Norpac net. In this year, 5 time of cruses were carried out.

CK-line

Fisheries Technology Institute of Nagasaki head quarter 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 throughout a year. Observation items are CTD, water sampling by Niskin bottles, and Norpac net. In this year, 5 time of cruses were carried out.

SI-line

Fisheries Resources Institute of Niigata branch have carried out the monitoring from 2016 in the Sea of Japan. The observations were carried out in February, April, June, and September throughout a year. Observation items are CTD, water sampling by Niskin bottles, and Norpac net. In this year, 5 time of cruses were carried out.

N-line, S-line

Fisheries Resources Institute of Kushiro branch have carried out the monitoring from 2000 in the Sea of Okhotsk. The observations were carried out in May and September throughout a year. Observation items are CTD, water sampling by Niskin bottles, and Norpac net. In this year, 5 time of cruses were carried out.

Website: http://hnf.fra.affrc.go.jp/n-line/index.html

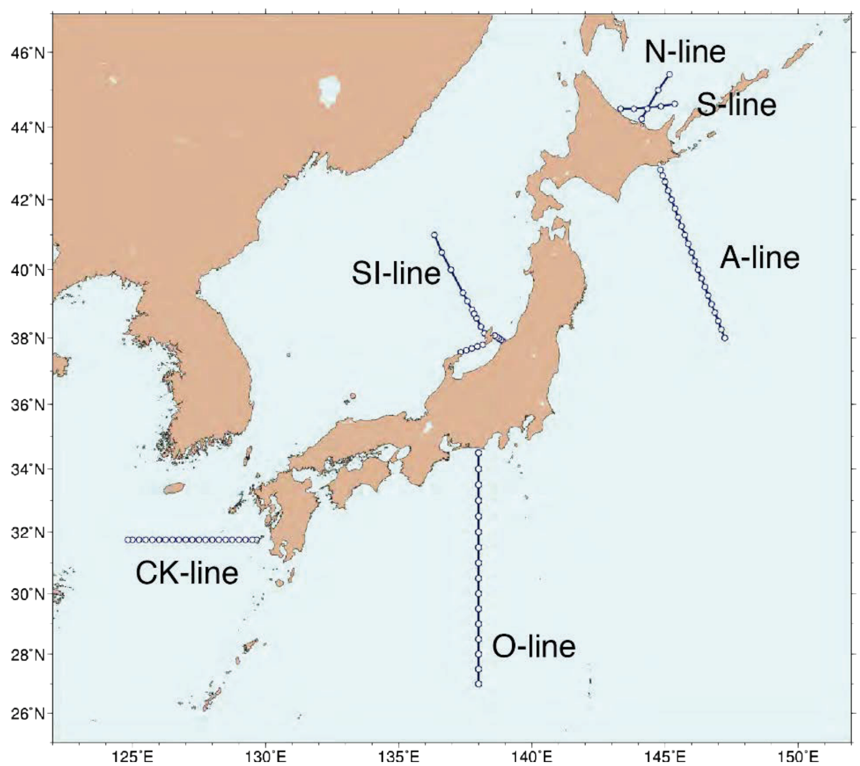


Figure. 2 Monitoring lines of FRA

Meta genomic and HPLC sample collecting

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

Monitoring of stock assessment project commissioned by Fisheries Agency of Japan

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

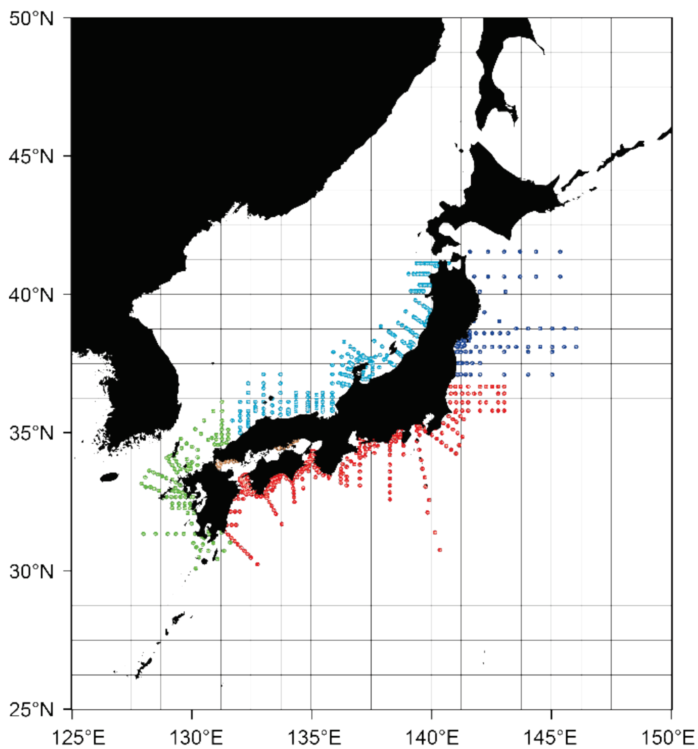


Figure. 3 Observation station for Monitoring of stock assessment project

Zooplankton sample collection

Tohoku National Fisheries Research Institute is collecting zooplankton samples from 1951 to present. Total number of sample is more than 200000 at present (September 1, 2020). The samples are preserved by 5% buffered formaldehyde. Sampling area is mainly in the waters around Japan. However the samples were also collected in the western North Pacific, central North Pacific, and Peruvian waters. Samples were collected by FRA, prefectural fisheries institutes, Japan Meteorological Agency, and university. The inventory of the sample is archived to the closed database.

Web site: http://tnfri.fra.affrc.go.jp/seika/plankton/hyohon_home.html

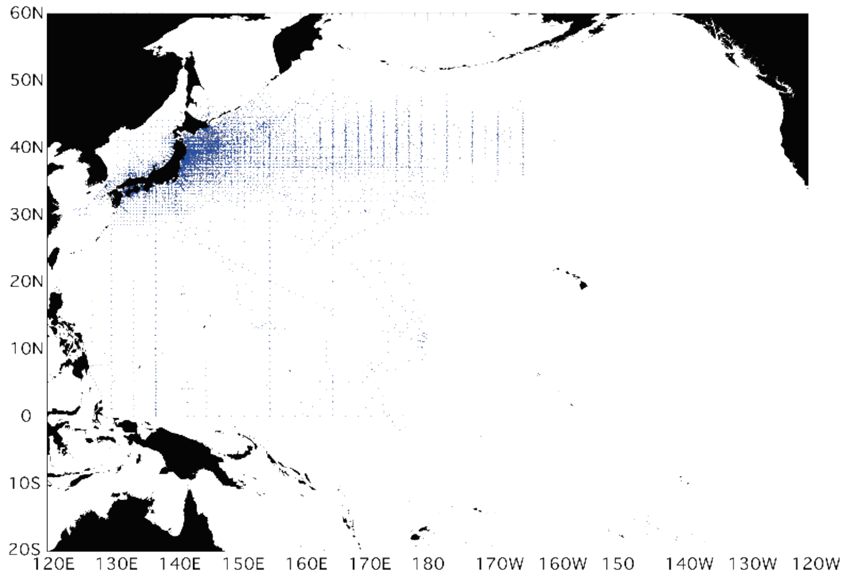


Figure. 4 Sampling location of zooplankton samples

Zooplankton photo, sketch, and genomic information library

Genomic information of mesozooplankton have not enough to analysis based on species level. There for we started to collect the genomic information (COI, 18S, *etc*.) of mesozooplankton around Japan. We also collected the morphological information (photo and sketch) of mesozooplankton at the same time. Until present, we collected samples and photos for the 3 cruises (western north Pacific subtropical waters, western north Pacific tropical waters, Kuroshio-Oyashio Transition waters). The information will be open by using the web site and other methods. This program is collaborated with SCOR working group of MetaZooGene.

Figure. 5 Mesozooplankton photos

Fish eggs, larvae, juvenile sample collection

National Fisheries Institute started to collect the samples from 2015. The samples were mainly collected by monitoring of stock assessment project commissioned by Fisheries Agency of Japan. Now the recent samples are collecting, however the historical samples will collect in immediate future.

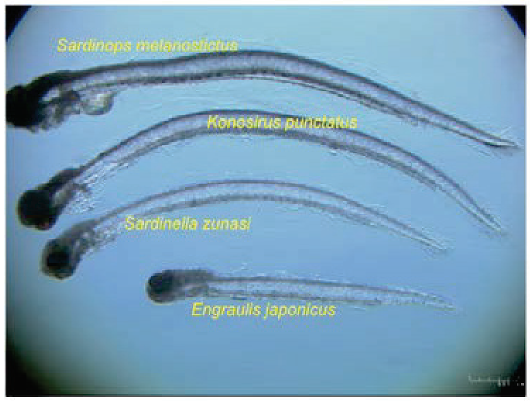


Figure. 6 Fish larvae specimen samples

Fish specimens sample collection

http://snf.fra.affrc.go.jp/gyoruihyouhon/index.html. is about 1200, and the total number of sample is about 32000. The samples are mainly preserved by isopropyl alcohol. DNA samples were also collected from a part of the sample.

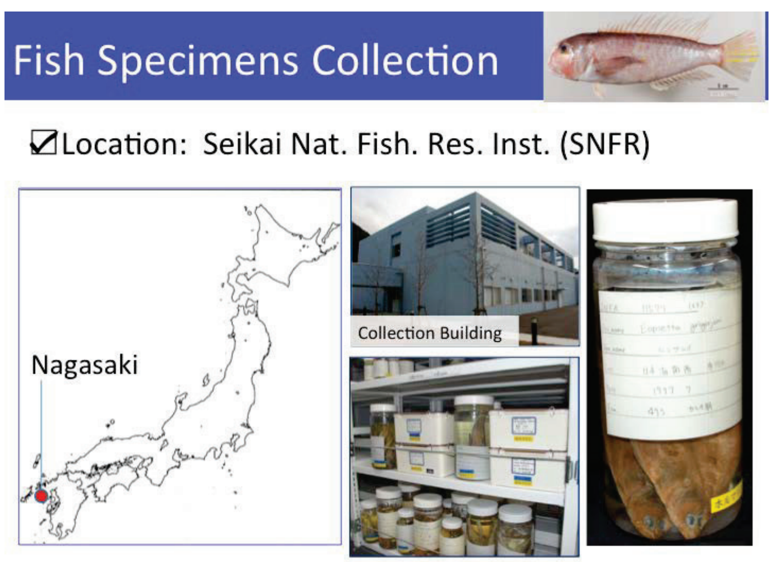


Figure. 7 Location, collection building and specimens of fish samples

4. Republic of Korea

National Institute of Fisheries Science (NIFS)
Dr. Jeong Hee Shim, NIFS

Low Salinity Water monitoring in the Korea Waters

Low salinity water (salinity below 28) observed at East China Sea area (Korea Ocean Observing Line 315~317, with 10 m depth) in this summer due to massive discharge from Three Gorges Dam with rate of more than 70,000 m^3/s after torrential rains in China. To understand the moving pattern of low salinity water-mass, 5 drift buoys dropped near the boundary area in 7^{th}~14^{th} Aug. and traced that they were moved to Jeju Is. with speed of 20 cm/s. In addition, surface salinity distribution calculated by GOCI satellite image also showed that there were a sharp salinity gradient of west-east direction in East China Sea, suggesting low salinity water-mass might affect to Korea for more long-span. NIFS will do more detailed observations to trace the low salinity water with high-resolution methods until this year.

Marine Heatwaves (MHWs) monitoring in the Korea Waters

Since 2016, Marine Heatwaves (MHWs) were frequently occurred around the Korean coastal area in the Yellow Sea and Northern East China Sea every summer. SROCC (Special report on Ocean and Cryosphere in a Changing Climate) by IPCC (Intergovernmental Panel on Climate Change) has been published by adding the Yellow Sea and Northern East China Sea as MHWs occurring ocean areas. Fisheries damage by MHWs around the Korean coastal area in the Yellow Sea and Northern East China Sea was also described in this special report. NIFS expands the real-time water temperature monitoring systems from 105 to 118 to observe the abnormal water temperature including MHWs around the Korea coastal area in 2020. In addition, NIFS issues abnormal water temperature warning to minimize the fisheries damage in aqua-farm when the abnormal water temperature appears in the coastal area.

Hypoxia monitoring in southcoast of Korea

Hypoxia has been usually developed in summer seasons (from June to October) at Jinhae, Gamak and Gosung Bays mostly in south-coast of Korea. The intensity, magnitude and duration of hypoxia in this year might be a recordable one compared to the past. The heavy rain on July and August and massive river discharge to coastal area made strong stratification in the water column and little vertical mixing, thus hypoxia developed in bottom waters for wide area of south coast of Korea. The NIFS's hypoxia monitoring has been conducted by every one or two weeks and the results were informed to the ministries of those provinces as well as aquaculture farmers to warning to minimize the fisheries damage.

Korea Meteorological Administration (KMA)

Hyun Min Um, KMA

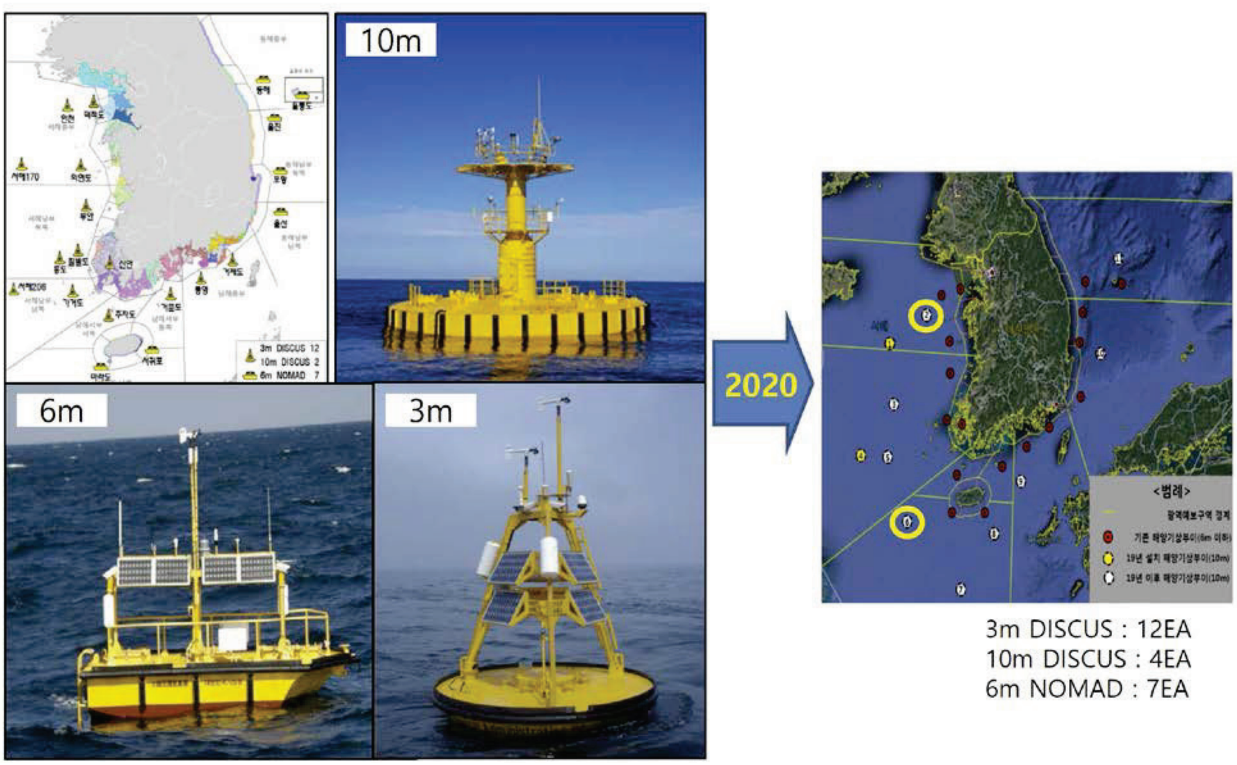


Figure 1. Expansion of large-scale ocean weather Buoy in the Yellow Sea by KMA.

5. Russia

Monitoring Activities (fishery-independent surveys) at the Pacific branch of VNIRO (TINRO)

Dr. Vladimir V. Kulik, VNIRO (TINRO)

TINRO's vessels conducted 549 midwater trawls during fishery-independent surveys in the North Western part of the Pacific Ocean and 74 midwater trawls in the North Eastern part of the Pacific Ocean in 2019 (Fig. 1). 135 of those trawls were conducted in the high seas.

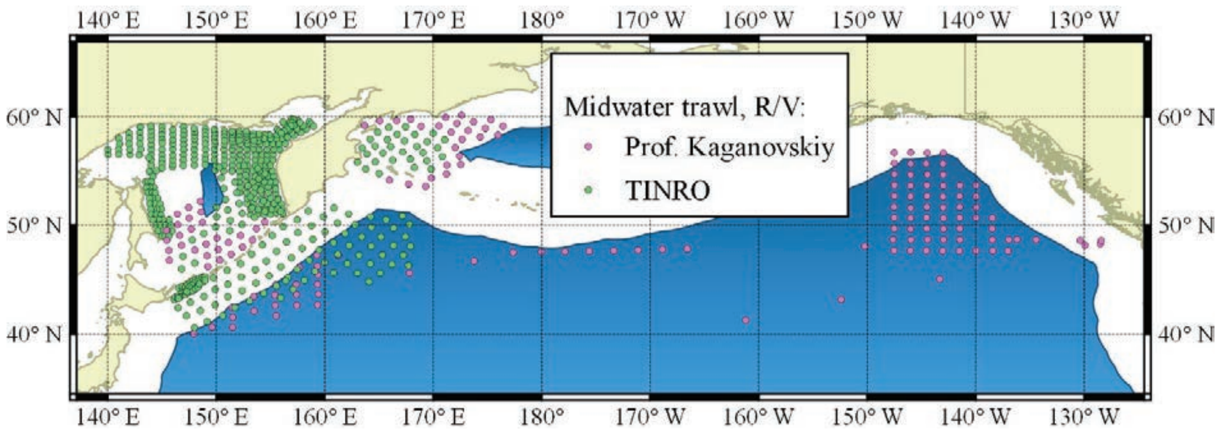


Figure 1. Macroscale surveys conducted by TINRO's R/V, including the International Gulf of Alaska Expedition 2019.

There are 412 midwater trawls, conducted by R/V *Prof. Kaganovskiy* in the North Western part of the Pacific Ocean in 2020, which have been processed already (Fig. 2). In the high seas there were 52 trawls conducted during summer.

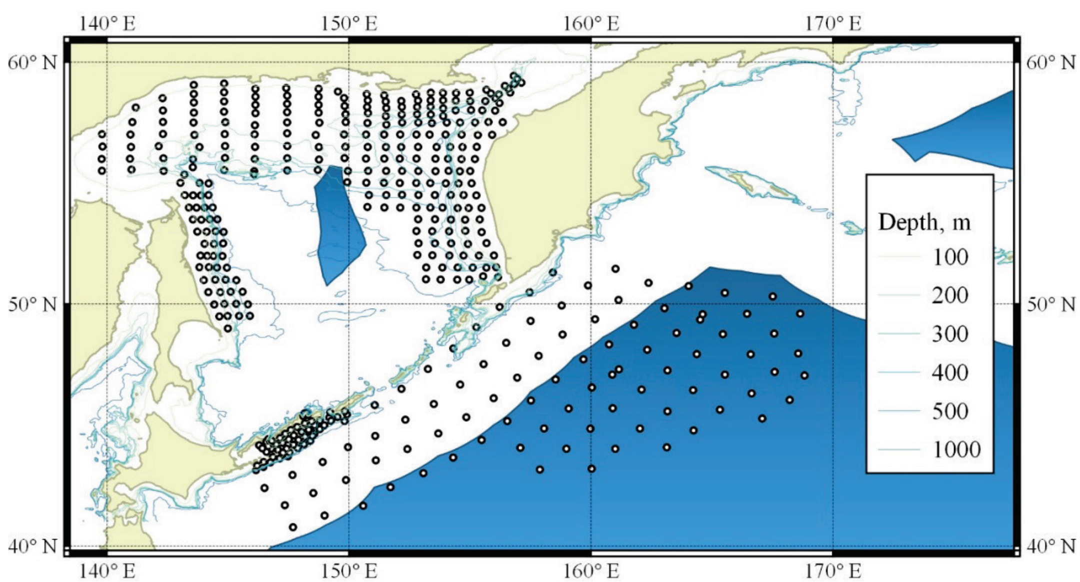


Figure 2. Midwater trawls, conducted by R/V *Prof. Kaganovskiy*, in summer 2020.

There were 1112 bottom trawls conducted by TINRO's vessels in 2019 (Fig. 3).

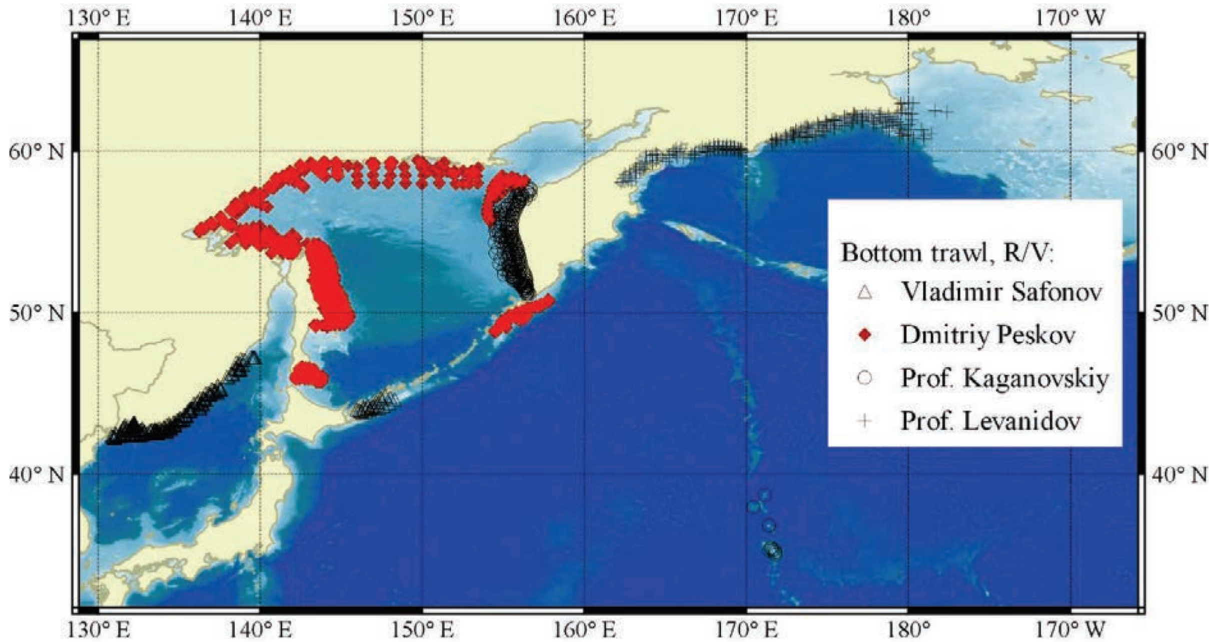


Figure 3. Bottom trawls conducted by TINRO's vessels in 2019.

In 2020 the Division for fishing statistics and databases has processed fully only 2 surveys with 263 bottom trawls (Fig. 4).

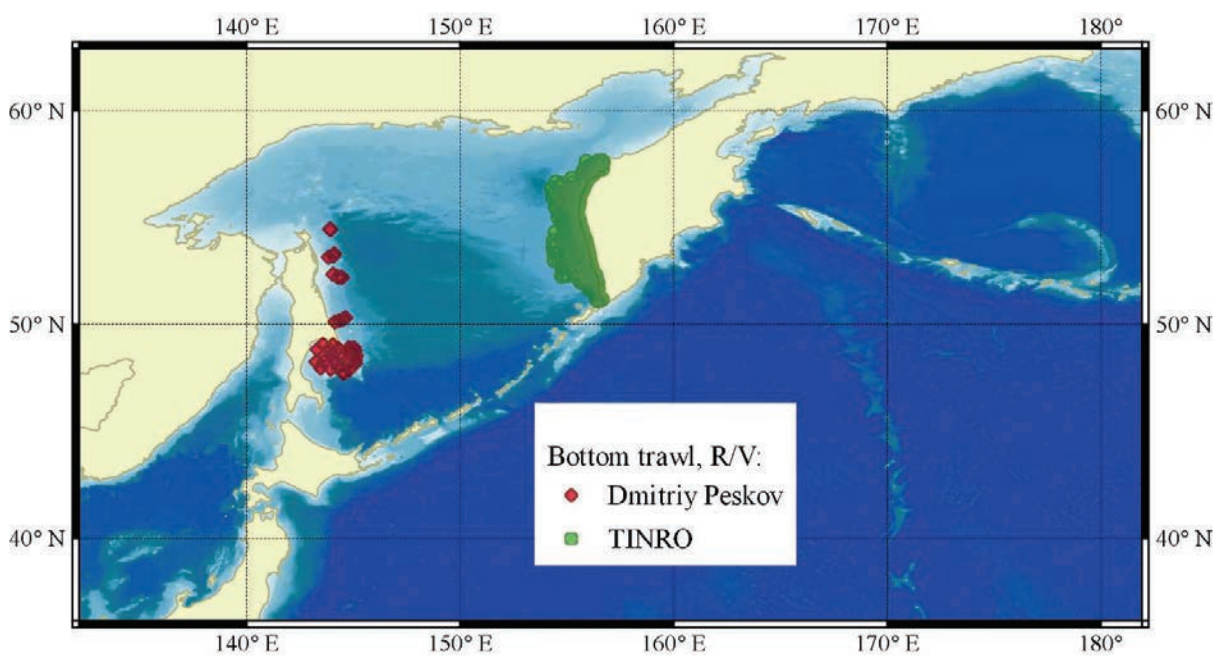


Figure. 4. Bottom trawls conducted by TINRO's vessels in 2020, which have been processed so far.

Other surveys are in progress or have not been processed yet.

6. United States of America

USA National Report to MONITOR, 2019-2020

Jack Barth (Oregon State University), Lisa Eisner (Alaska Fisheries Science Center, NMFS, NOAA) and Kym Jacobson (Northwest Fisheries Science Center, NMFS, NOAA)

There is a wide range of coastal ocean observing off the US Pacific coasts. These include:

- NOAA fishery surveys (groundfish, hake, sardine)
- Long-term hydrographic and zooplankton lines: CalCOFI (California), Newport Hydrographic (Oregon), Trinidad Head (California)
- US Integrated Ocean Observing System (NOAA)
- Moorings, hydrographic and biogeochemical sampling off Monterey Bay, California
- Gliders
- Wave buoys and wave models
- Rocky intertidal biodiversity and recruitment
- Carbon chemistry (pCO2, pH) (NOAA, university)
- National Science Foundation's Ocean Observatories Initiative (OOI)
- Native American

Alaska oceanography and fisheries surveys and observations for 2019-2020 include:

- Sea Level Pressure (SLP) and Sea Surface Temperature (SST) by season over the north Pacific Ocean
- Arctic and Bering Sea Ice Extent
- Eastern Bering Sea SST (northern and southeastern)
- Coccolithophore bloom
- Mooring and Distributed Biological Observatory in Bering and Chukchi seas
- New project: Pop-up floats and Pacific cod spawning habitat in the eastern Bering Sea
- Rapid Response project: Sail Drone acoustic survey to estimate pollock in the eastern Bering Sea
- Gulf of Alaska (GOA) SST
- Gulf Watch Surveys : Temperature, Prey
- Long-line survey for sablefish in GOA
- Age 0 Pacific cod surveys in the GOA
- Summary of GOA ecosystem indicators

Acknowledgements for the report from Alaska: Alisa Abookire, Nick Bond, Alex De Robertis, Janet Duffy-Anderson, Lauren Rogers, Carol Ladd, Ben Laurel, Pat Malecha, Lauren Rogers, Elizabeth Siddon, Rob Suryan, Rick Thoman, Jordan Watson, Ellen Yasumiishi, Stephani Zador

National Ocean and Atmospheric Administration Survey Monitoring Efforts 2019-2020

There are three NOAA surveys that collect data from physics through lower trophic levels, seasonally to bi-weekly, depending upon the program, off Washington, Oregon and California. An additional three ecosystem projects sample annually for oceanographic conditions, lower trophics and fish, of different target species. These transects and the location of the stationary sea lion monitoring site at San Miguel Island, California are shown in Figure 1. Each of these projects exceed ten years of sampling. Results are summarized in the annual State of the California Current (cited below) and/or the California Current Integrated Ecosystem Assessment Report (https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-publications-reports).

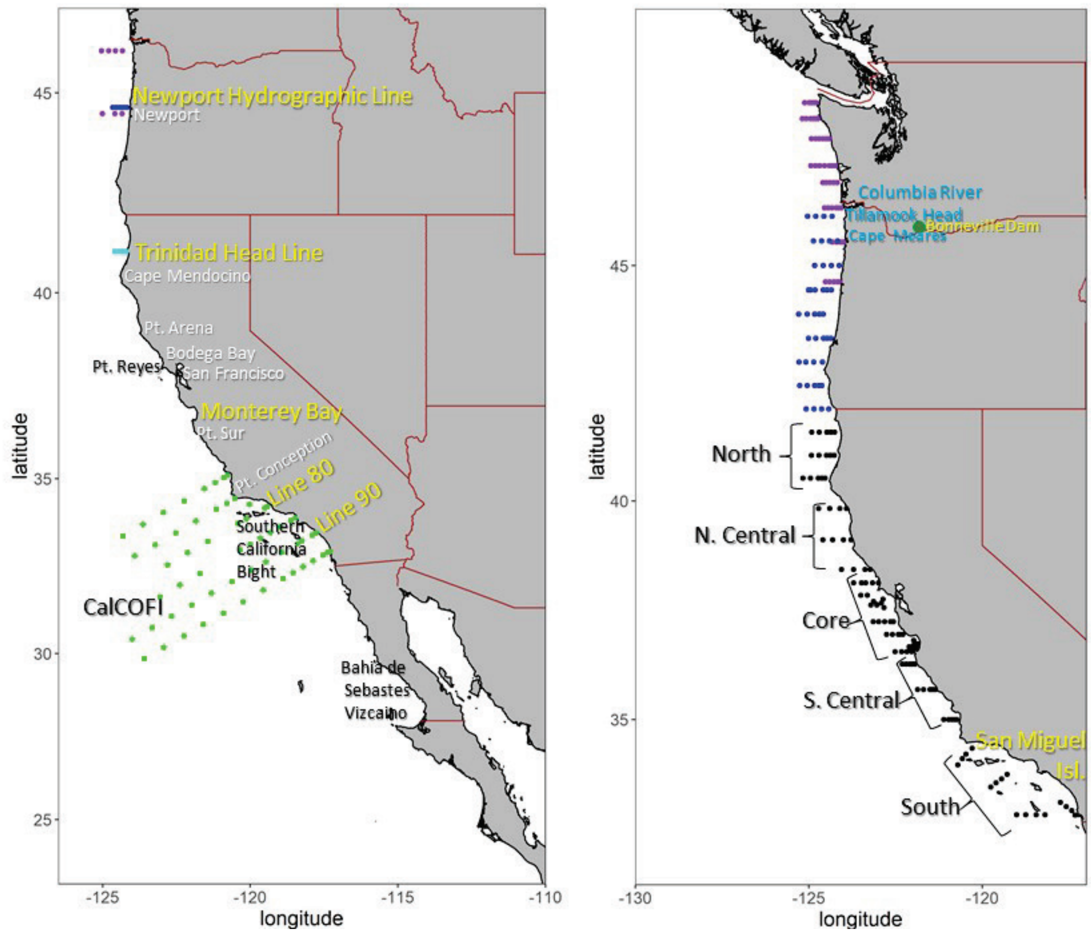


Figure 1. Maps depicting NOAA Fisheries surveys that included bongo tows (left) versus rope trawls and fixed observations for marine mammals (right). Left) Maps where bongo tows were conducted. From north, purple) pre-larval surveys taken in summer, blue) Newport Hydrographic Line, cyan) Trinidad Head Line, green) core CalCOFI stations sampled quarterly. Right) from north: purple) Juvenile salmon and Ocean Ecosystem Survey (JSOES) in the upper 20 m, blue) Pre-Recruit mid- water trawl, black) Rockfish Recruitment and Ecosystem Assessment Survey (RREAS); bracket define the five regions of the RREAS. Yellow diamonds define land-based locations of sea lion (San Miguel Island) surveys. Figure modified from Thompson, *et al*., 2019.

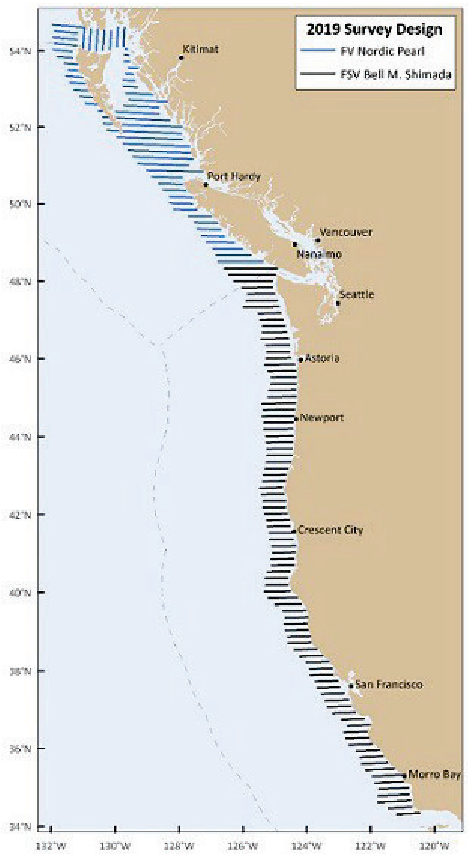


Figure 2. Acoustic-trawl survey transects for the NOAA Ship Bell M. Shimada (black, NWFSC) and the chartered vessel Nordic Pearl (blue, DFO)

In addition to these surveys there are several coastwide surveys designed to provide data for stock assessments: the NOAA Fisheries Northwest Fisheries Science Center (NWFSC) of NOAA in collaboration with Canada's DFO conducted their semi-annual Pacific Hake survey in 2019 (**Figure 2**). Saildrones surveyed the same transects as the R/V Shimada. The initial NWFSC hake survey was conducted in 2003. Groundfish surveys have also been conducted over the shelf and slope (55 – 1,280 m) annually by the NWFSC since 2003 from the border with Mexico to Canada. In addition, the NOAA Fisheries Southwest Fisheries Science Center conducts an annual Acoustic-Trawl Method Coastal Pelagics Survey that samples from off northern Vancouver Island, British Columbia to San Diego, California.

The following highlights (and select figures) of conditions observed from these surveys in 2019 is published in the State of the California Current Report (STATE OF THE CALIFORNIA CURRENT 2018–19: A NOVEL ANCHOVY REGIME AND A NEW MARINE HEATWAVE? CalCOFI Rep., Vol. 60, 2019) available at https://calcofi.org/publications/calcofireports/v60/Vol60-SOTC2019.pdf

- The CCE experienced a mild El Niño from late 2018 into 2019. Despite the El Niño, spring upwelling was above average between southern California and Washington but below average in Baja California.
- Sea surface temperature (SST) was mostly near the long-term average between Washington and southern California, while surface chlorophyll a was above average in Oregon/Washington and slightly below average in most of California in spring/ early summer 2019. SST changed dramatically by fall 2019, however, as a marine heat wave (MHW) that formed in May 2019 in the Gulf of Alaska impinged upon the West Coast of the United States. The expansion of the 2019 MHW followed a similar pattern to the 2014–15 MHW. (See further information below and Figure 10 below).

- The copepod assemblage off Oregon was in a mixed state as southern copepods were close to average while northern copepod biomass was positively anomalous in 2019 (**Figure 3**). Off northern California, *Euphausia pacifica* body size was smaller than average. Euphausid abundances were well below average in both central and southern California in 2019.

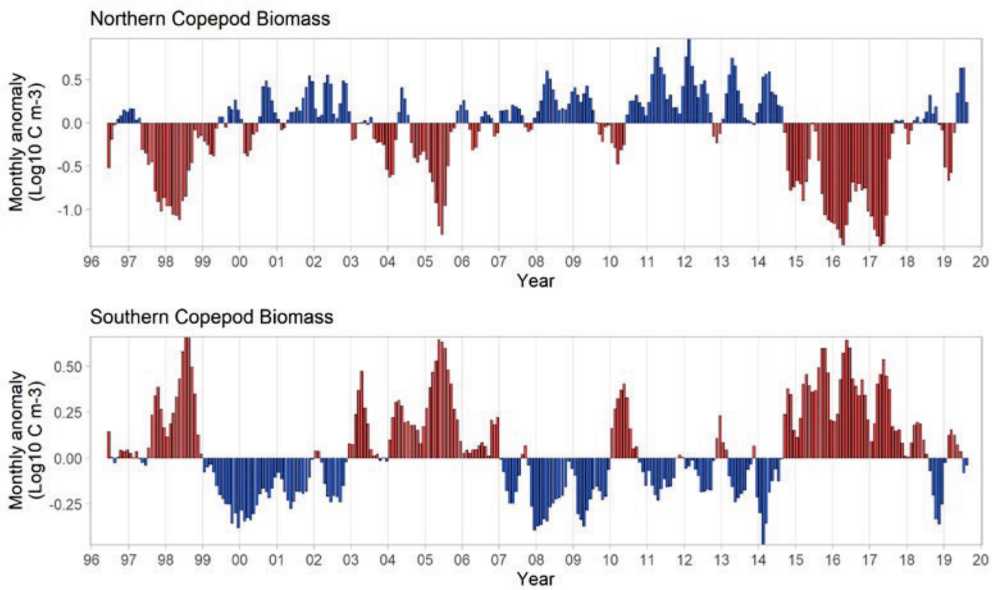


Figure 3. Three-month running mean of anomalies of biomass of northern and southern copepod taxa recorded off Newport, OR at NH05: Peterson Zooplankton Lab, NOAA, NMFS, Newport, OR.

- In the north, winter 2019 larval fish abundances were high and dominated by offshore taxa that are associated with warm conditions; spring larval and post-larval biomass were close to average and spring surface trawls observed record-high market squid (*Doryteuthis opalescens*) abundances.
- Northern anchovy (*Engraulis mordax*) adults and larvae were at record-high abundances in central and southern California in 2019. In central California, market squid and Pacific sardine (*Sardinops sagax*) were also abundant. In southern California warm-water mesopelagic fishes were very abundant, a trend since 2014 (**Figure 4**).
- Indicators for future salmon returns were mixed in 2019. Although the biomass of northern copepods, which correlate positively with returns, was high, abundances of yearling Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*), which also correlate positively with returns, were slightly below average. Winter ichthyoplankton was comprised mostly of southern or offshore taxa, which bodes poorly for future salmon returns.
- Seabird (common murre [*Uria aalge*]; Brandt's cormorant [*Phalacrocorax penicillatus*]; and pelagic cormorant [*Phalacrocorax pelagicus*]) productivity off Oregon was the highest in years in both 2018 and 2019.
- Humpback whale (*Megaptera novaeangliae*) sightings were very high in 2019, likely because humpback whales congregated near shore to feed on northern anchovy.

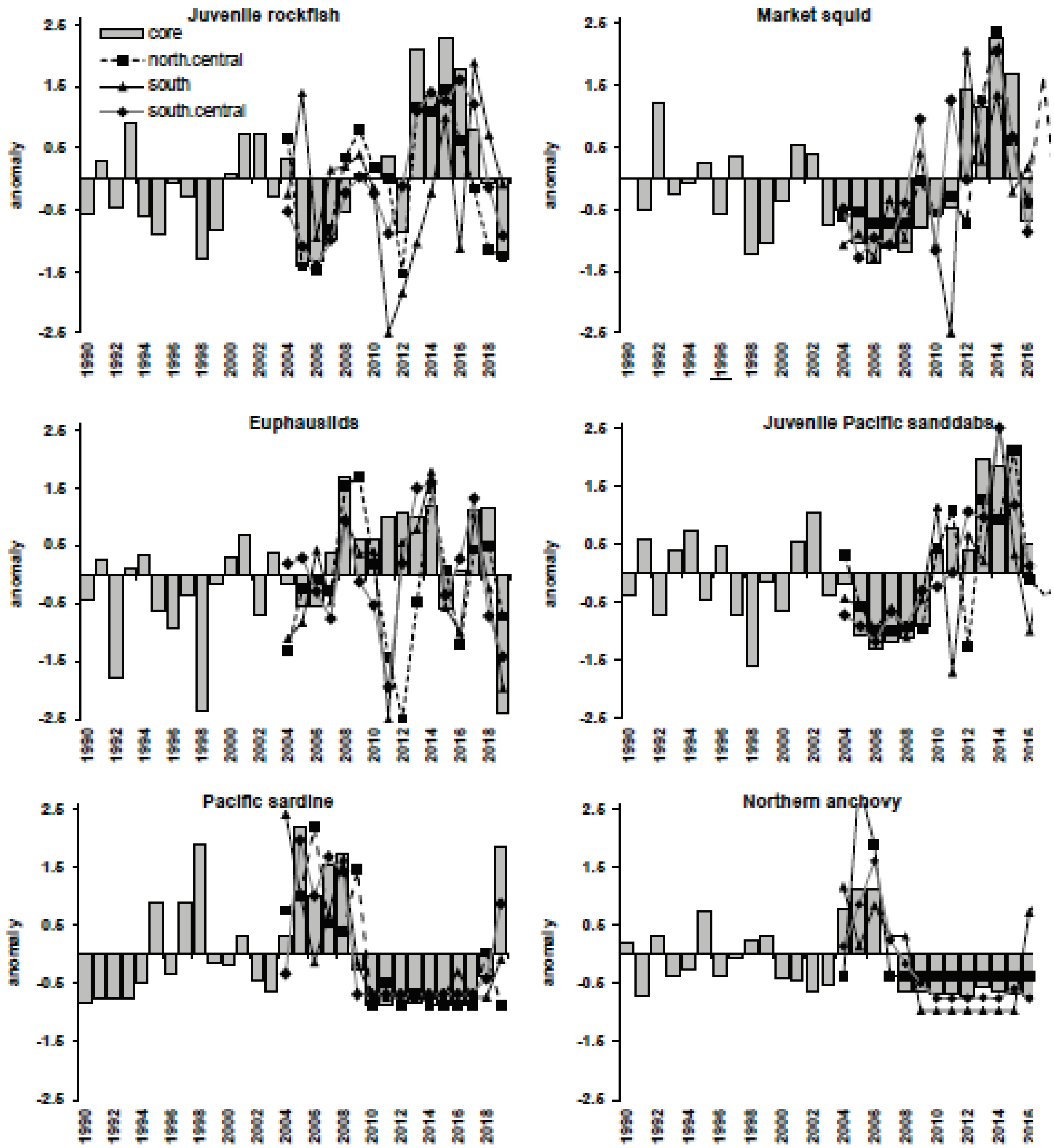


Figure 4: Standardized anomalies (of average (ln(catch+1)) catches) through 2019 for key forage taxa sampled by the Rockfish Recruitment and Ecosystem Assessment Survey.

Status of 2020 surveys due to COVID-19 pandemic:

Survey	Status	Comment
Northern California Current (NCC) Juvenile Salmon & Ocean Ecology	Yes	Charter conducted all efforts in June; Processing delayed
NCC Rockfish Recruitment & Ecosystem Assessment Survey (RREAS)	Cancelled	June
Newport Hydrographic Line: copepods	Reduced effort	Monthly instead of twice a month
Trinidad Line: krill	Reduced effort	Missed spring months and processing delayed
Central California Current RREAS	Reduced *and* *delayed* effort	From NOAA vessel to charter. And processing delayed. Sampling bias nearshore due to weather.
Southern California Current CalCOFI: ichthyoplankton	Reduced effort	Spring cancelled, summer only, processing delayed.
Pacific hake acoustic trawl biomass/distribution	Cancelled	Biennial-2020 research support.
Groundfish survey	Cancelled	Summer coastwide
Coastal Pelagics acoustic trawl biomass/distribution	Cancelled	Summer coastwide, also known as the CC Ecosystem survey

The US Integrated Ocean Observing System (IOOS)

The US Integrated Ocean Observing System (IOOS), run by NOAA's National Ocean Service, consists of national and regional components. The North Pacific region contains four IOOS regional associations (**Figure 5**).

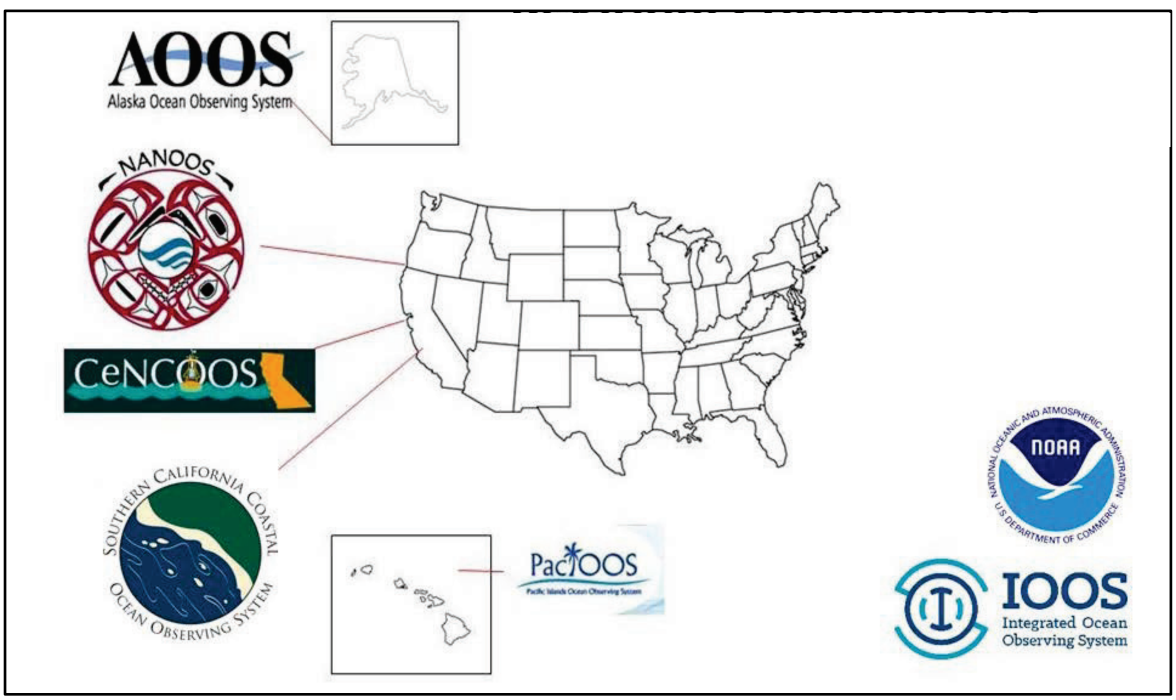


Figure 5. Map of the US west coast regional associations of the US Integrated Ocean Observing System (IOOS).

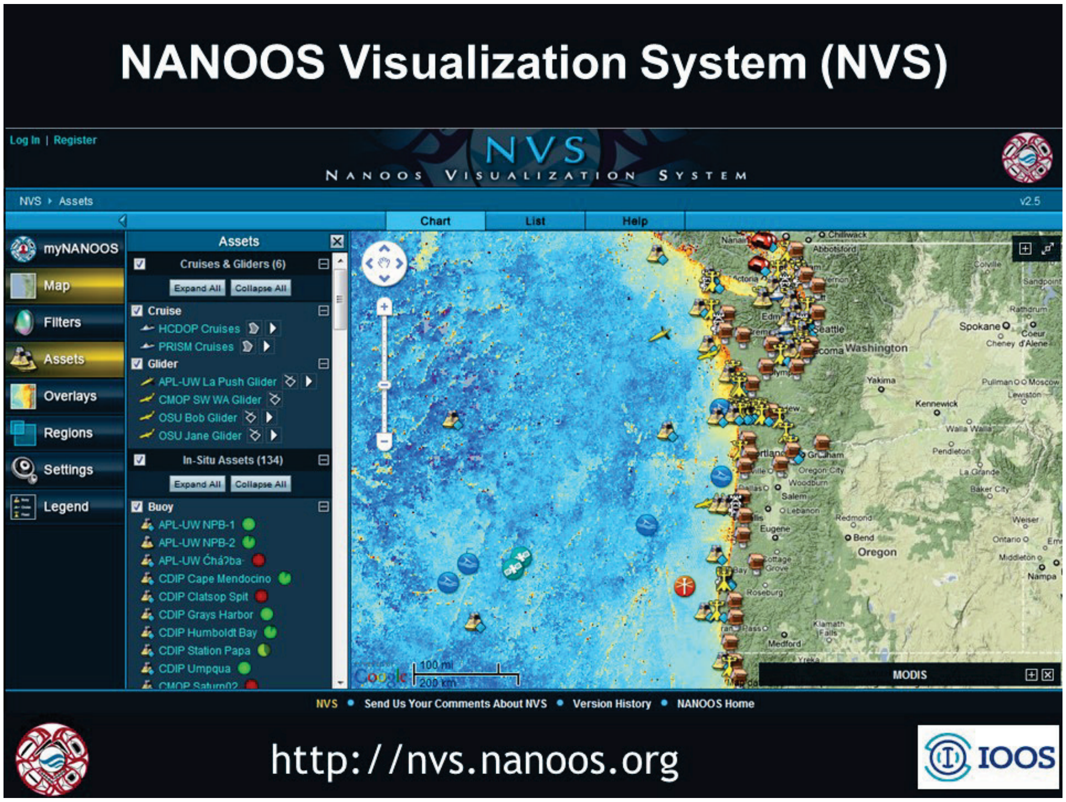


Figure 6. The NANOOS Visualization System showing the location of observing assets (buoys, glider, shore stations) off Oregon and Washington.

Each regional association has a web-based interface to display and download ocean observing data. The Alaska Ocean Observing System (AOOS) is described elsewhere in this MONITOR report. An example for the Northwest Association of Networked Ocean Observing Systems (NANOOS) is shown in **Figure 6**.

As part of the OceanObs'19 meeting (http://www.oceanobs19.net/), several papers describing US ocean observing were published in the journal *Frontiers in Marine Science*. As one example, Barth et al. (2019) described the cross-national cooperation in observing the northeast Pacific. This map shows the coastal observing assets in the northeast Pacific (**Figure 7)**.

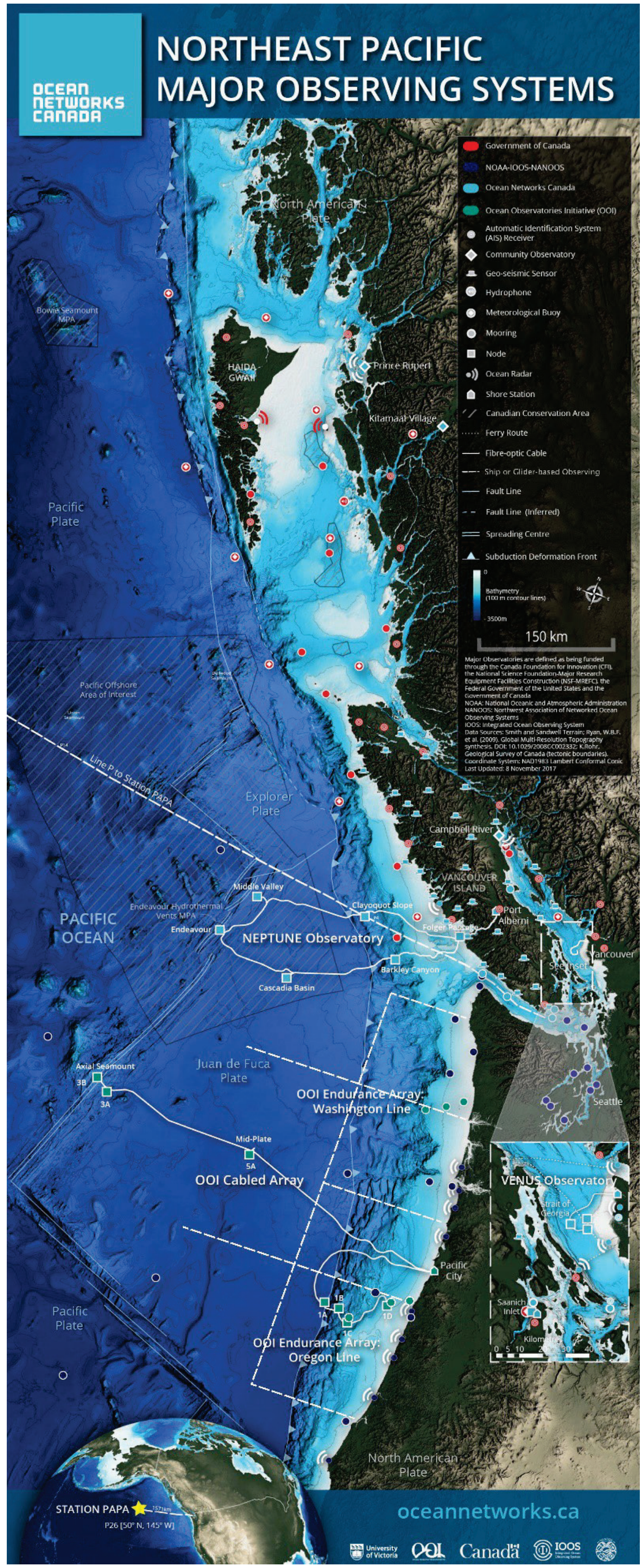


Figure 7. Map of the ocean observing assets in the Northeast Pacific. Colors indicate ocean observing assets funded by the Canadian (red) and United States governments (dark blue), by the private Hakai Institute (maroon), and by two major ocean observing programs: Ocean Networks Canada (light blue) and the Ocean Observatories Initiative (teal). Buoys and shore-side infrastructure are shown as distinct symbols, while ship or glider lines (dashed) and instrumented ferry routes (dotted) are shown as continuous curves. Seafloor cables are shown as curvy, solid lines. Bottom depth, in meters, is shaded in blue. Courtesy of Ocean Networks Canada as modified by C. Risien (OSU). [Reprinted from Barth *et al.*, 2019.]

The underwater glider network off the US west coast continues operations with many lines across the California Current (**Figure 8**). A line off Pt. Arena, California, was begun in 2020 to fill the gap in the existing network (yellow below). All glider data are reported to and available from the US IOOS Glider Data Acquisition Center (https://gliders.ioos.us/data/).

COVID-19 Impacts: Some gaps in glider coverage occurred from the inability to get to sea on vessels to do glider deployments and recoveries due to COVID-19 stay-at-home restrictions.

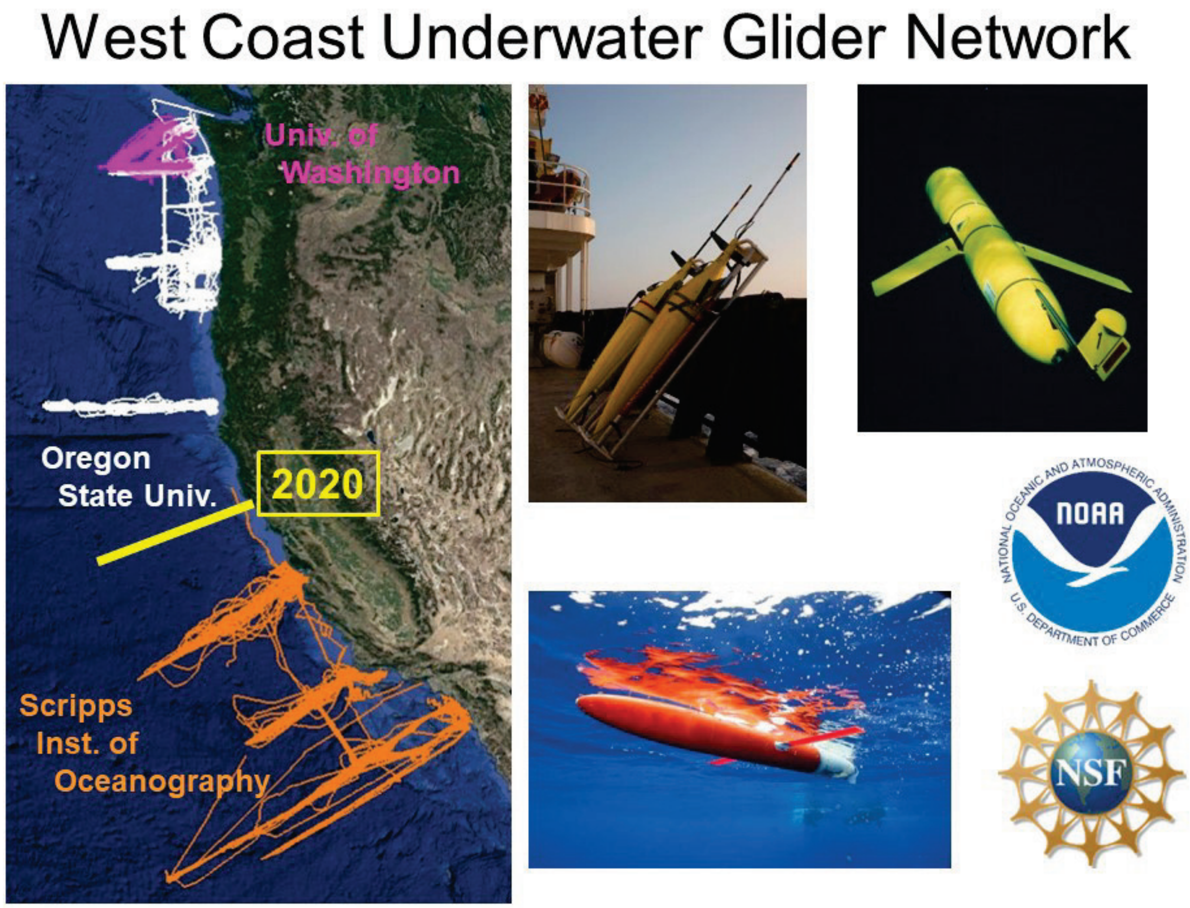


Figure 8. The U.S. west coast glider network operated by different academic institutions with funding from the U.S. National Science Foundation and National Oceanic and Atmospheric Administration.

Ocean Observatories Initiative (OOI)

The US National Science Foundation’s Ocean observatories Initiative (OOI) has been operational since 2014 (https://oceanobservataries.org). A schematic of the observatory is shown in **Figure 9**.

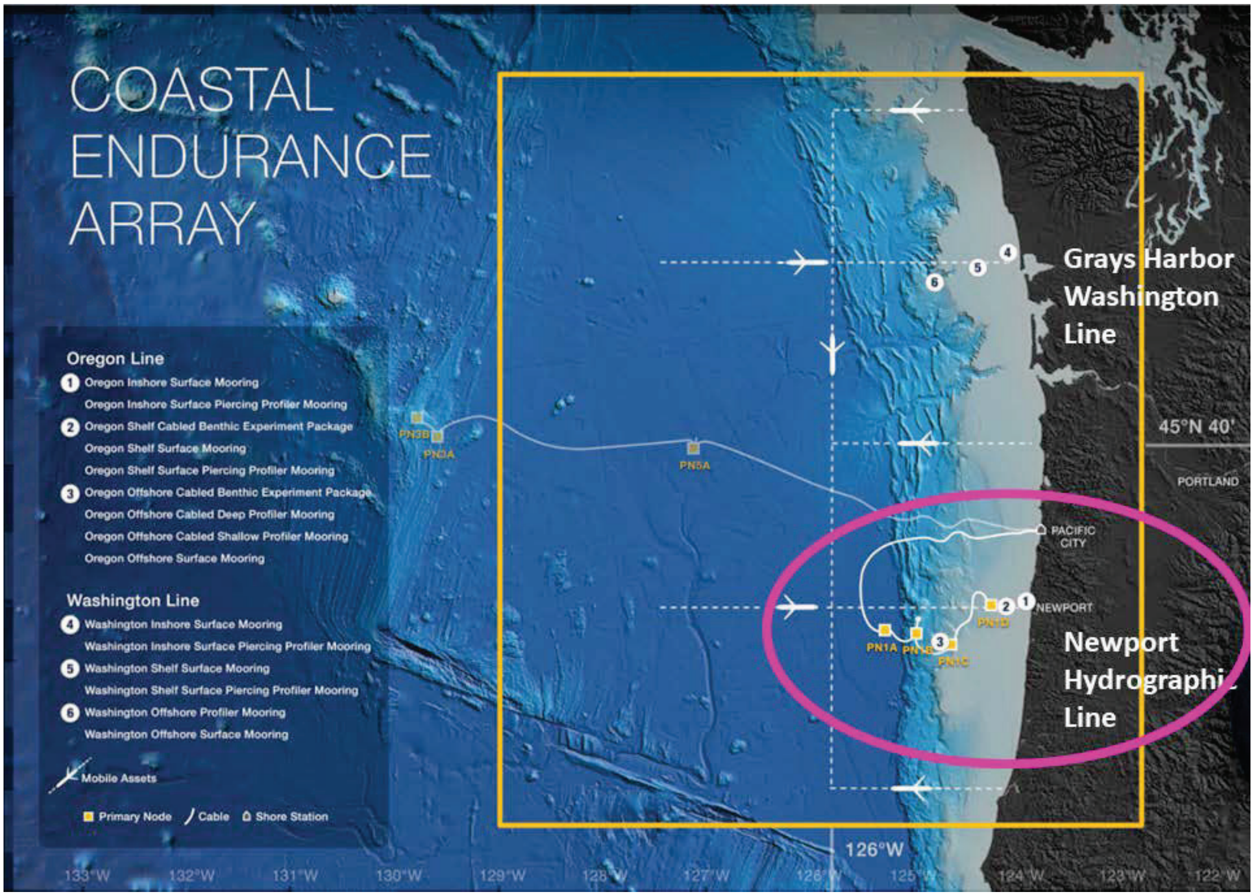


Figure 9. The Coastal Endurance Array of the U.S. Ocean Observatories Initiative.

Each OOI site consists of multiple observing platforms (surface-to-bottom moorings, bottom instrument platforms, profiling moorings). Some of the platforms are connected to shore via a submarine cable that provides power and telemetry, while others are powered autonomously and report data to shore via satellite and cellular modems. The parameters measured on each of the OOI platforms includes physical, chemical, bio-optical and bioacoustics variables, the details of which can be found at https://oceanobservatories.org/

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Recent Observations from the U.S. West Coast

Sea surface temperature in the Northeast Pacific has been anomalously warm the last five years, starting with the marine heatwave called "The Blob" in 2014 (**Figure 10**). While waters were warm in late summer 2019, the upper-layer warm anomaly was effectively erased by fall and winter storms. The Northeast Pacific remains anomalously warm, but coastal waters are anomalously cold due to coastal upwelling (**Figure 10**). The "California Current Marine Heatwave Tracker" is an experimental tool for tracking marine heatwaves, developed by Andrew Leising and Steven Bograd (SWFSC, NOAA) and available at https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-projects-blobtracker .

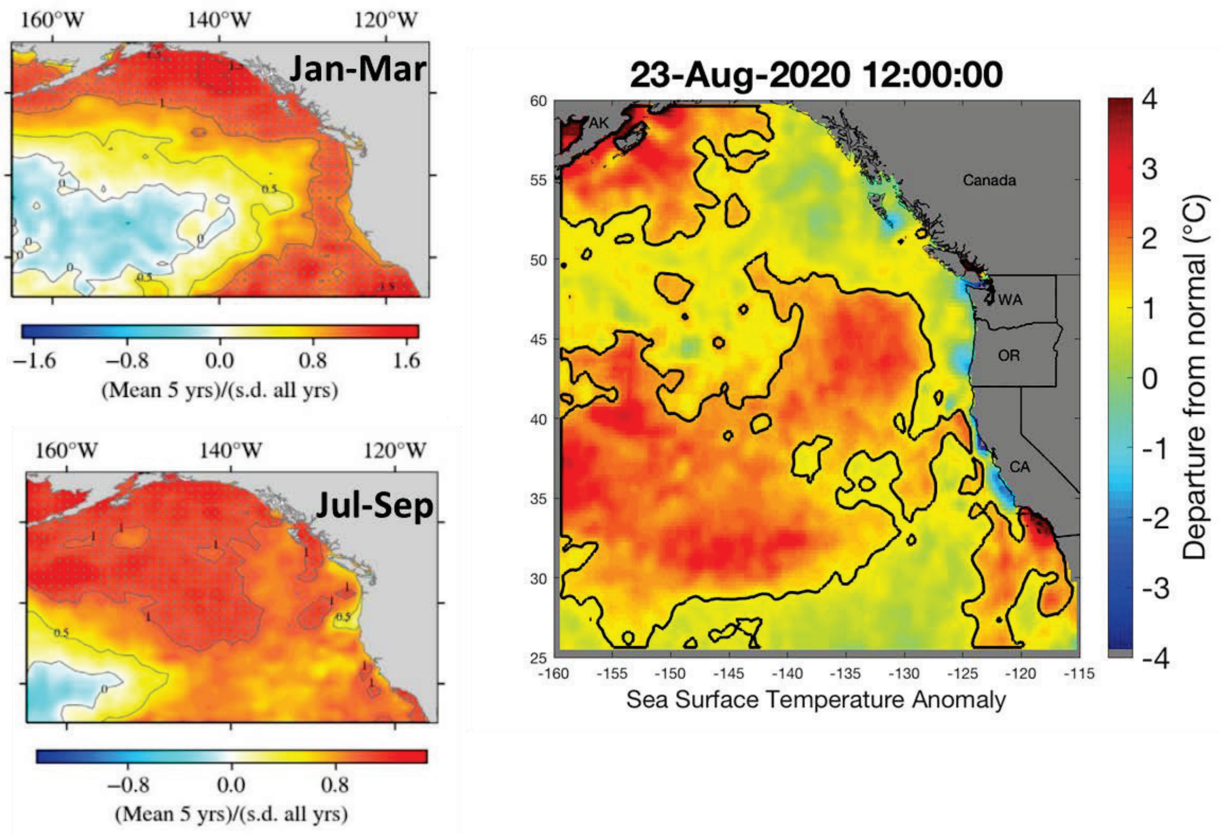

Figure 10. (left) 5-year mean Sea Surface Temperature anomalies in degrees Celsius for 2015-2019. https://www.pcouncil.org/documents/2020/02/g-1-a-iea-team-report-1.pdf/. (right) SST anomalies in late summer 2020 from https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-projects-blobtracker .

One ecosystem impact of increased upper-ocean warming is favorable conditions for the occurrence of Harmful Algal Blooms (HABs). HABs have been responsible for closures of shellfish and crab fisheries in recent years, resulting in negative social and economic impacts for coastal communities and along the U.S. west coast from California to Washington (**Figure 11**).

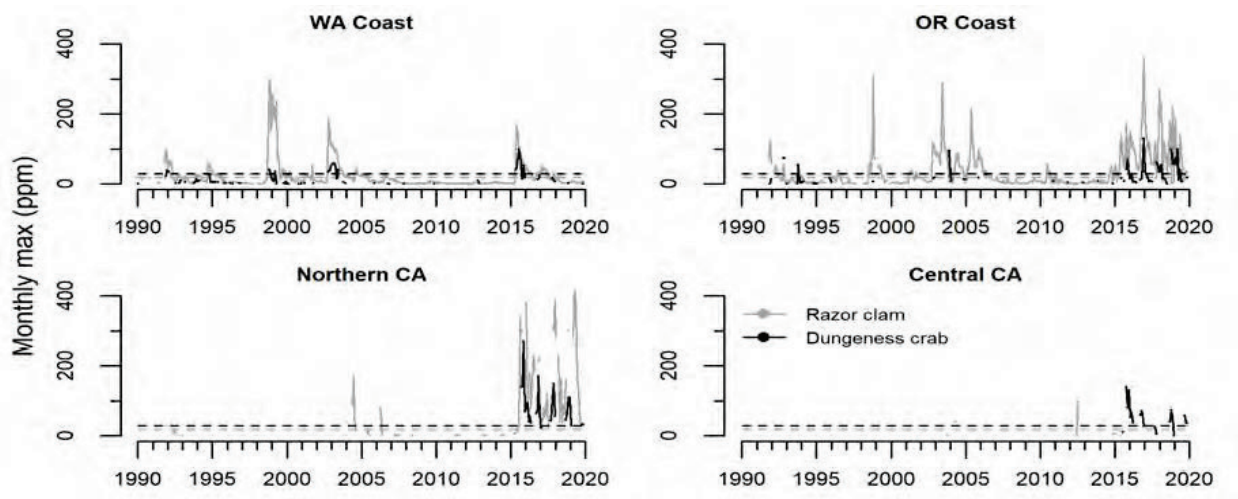

Figure 11. Monthly maximum domoic acid concentration (ppm) in razor clams (gray) and Dungeness crab viscera (black) through 2019 for WA, OR, northern CA (Del Norte to Humboldt counties), and central CA (Sonoma to San Luis Obispo counties). Horizontal dashed lines are the management thresholds of 20 ppm (clams in gray) and 30 ppm (crabs in black). https://www.pcouncil.org/documents/2020/02/g-1-a-iea-team- report-1.pdf/.

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Harvey, C., T. Garfield, G. Williams, and N. Tolimieri, eds., 2020. California Current Integrated Ecosystem Assessment (CCIEA) California Current Ecosystem Ecosystem Status Report, 2020. https://www.pcouncil.org/documents/2020/02/g-1-a-iea-team-report-1.pdf/

Thompson, et al., 2019. State of the California Current 2018–19: A Novel Anchovy Regime and a New Marine Heatwave? CalCOFI Rep., Vol. 60, 2019. https://www.calcofi.org/ccpublications/ccreports.html

Alaska fisheries oceanography surveys and observations for 2019-2020

Many of the NOAA Alaska Fisheries Science Center (AFSC) and Pacific Marine Environmental Lab (PMEL) surveys scheduled for 2020 were canceled due to COVID-related issues. Canceled surveys include: Aleutian Islands bottom trawl survey, the eastern Bering Sea bottom trawl survey, the northern Bering Sea bottom trawl survey, the Bering Sea pollock acoustics survey, the northern and southern Bering Sea ecosystem and pelagic fish surveys, the spring Bering Sea larval survey, the spring 70 m isobath and mooring survey, and the fall 70m isobath survey.

- N Pacific Climate

Sea level pressure (SLP) and sea surface temperature (SST) anomalies from the NCEP/NCAR Reanalysis project were compiled by Nick Bond (NOAA PMEL). In autumn 2019, SLP were positive in central Gulf of Alaska (GOA) with warm SSTs and upwelling-favorable winds (Fig. 12). In winter 2019/20, there was a large positive anomaly, suppressed storminess, and equatorward transport. In spring 2020, the positive SLP continued with westerly winds in the central GOA, upwelling-favorable in the eastern GOA and southerly winds in eastern Bering Sea (EBS). In summer 2020, there was low pressure over the GOA; northerly winds brought warm/dry air from mainland to the western and central GOA.

In autumn 2019, SST anomalies were warmer than normal across the region (EBS and western GOA); moderate temperatures in eastern GOA due to upwelling (Fig. 13). In winter 2019/20, there was a moderation of warmth in GOA and considerable cooling in EBS. A weak El Niño developed. In spring 2020, it was warm across the region with increased SSTs in the south EBS and rapid ice retreat, and the weak El Niño faded. In summer 2020, it was warm east of the dateline; with cooling west of the dateline. There were negative anomalies in the western Aleutian Islands, perhaps suggesting a La Niña.

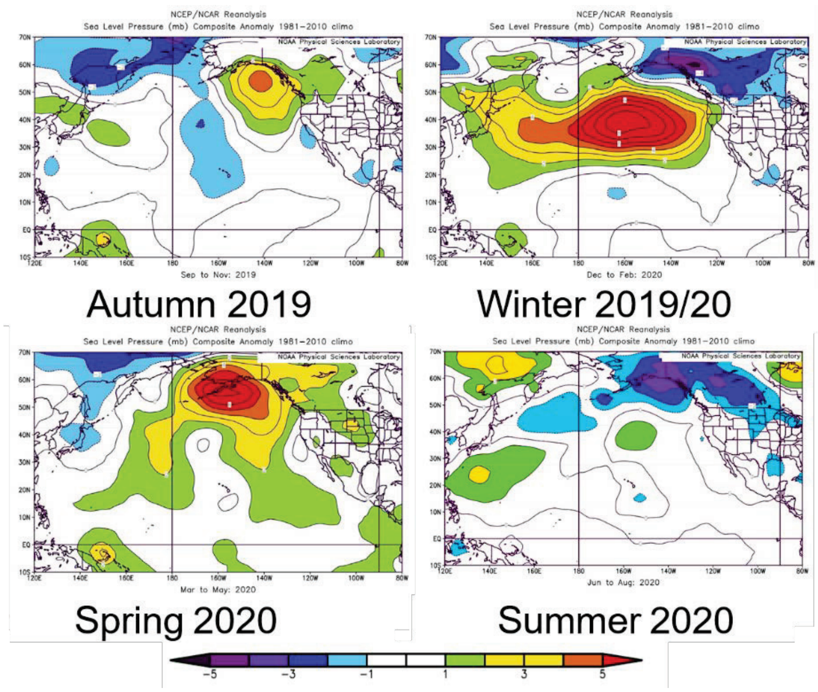

Figure 12. Sea Level Pressure (SLP) anomalies.

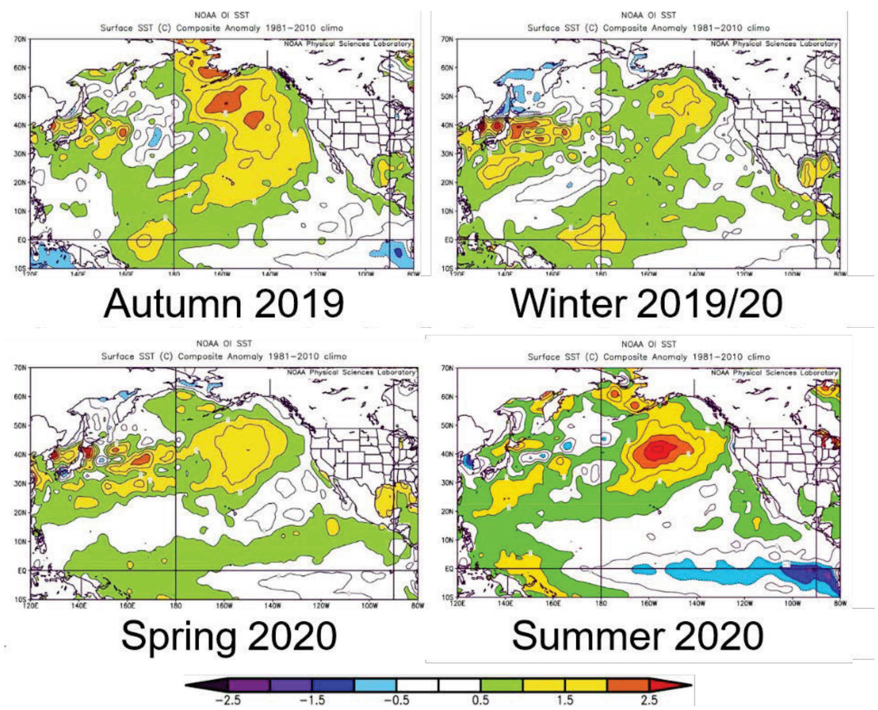

Figure 13. Sea Surface Temperature (SST) anomalies.

- Bering Sea

Bering Sea ice extent in 2020 in March (typical month of highest southerly extent) was similar to the median long term average (Fig. 14 pink line, left panel), but thin ice was observed in many areas (Fig. 15). In 2019/20, residual warmth delayed the freezer-up into winter and cooling in late water resulted in a rapid build-up of sea ice which exceeded the median in Feb/March. Southerly (warm) winds in spring promoted rapid ice retreat (Fig. 16).

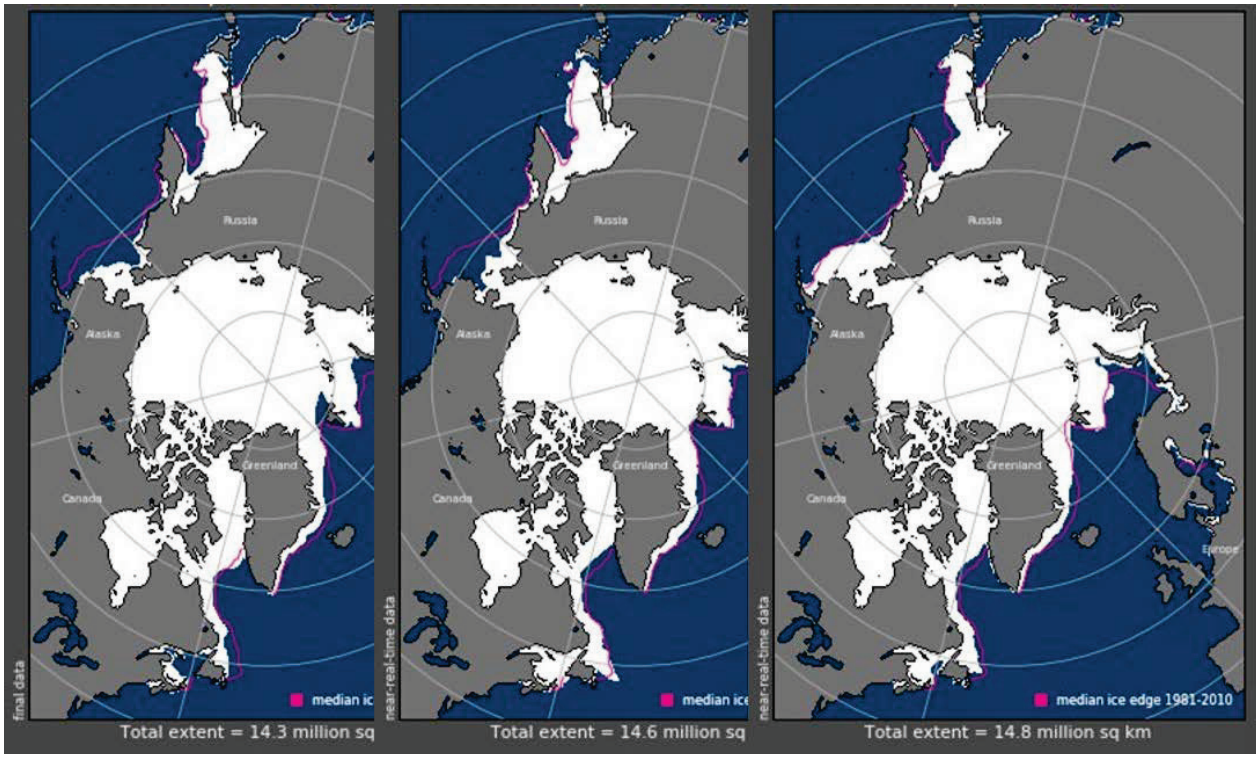

Figure 14. Arctic Sea Ice extent for March 2018, 2019, 2020 (left, center and right panels) from the National Snow and Ice Data Center.

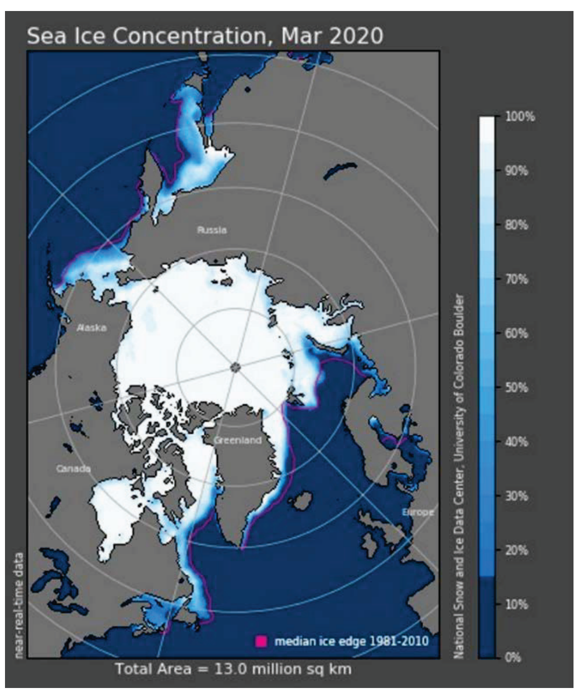

Figure 15. Arctic Sea Ice concentration for March 2020 from the National Snow and Ice Data Center.

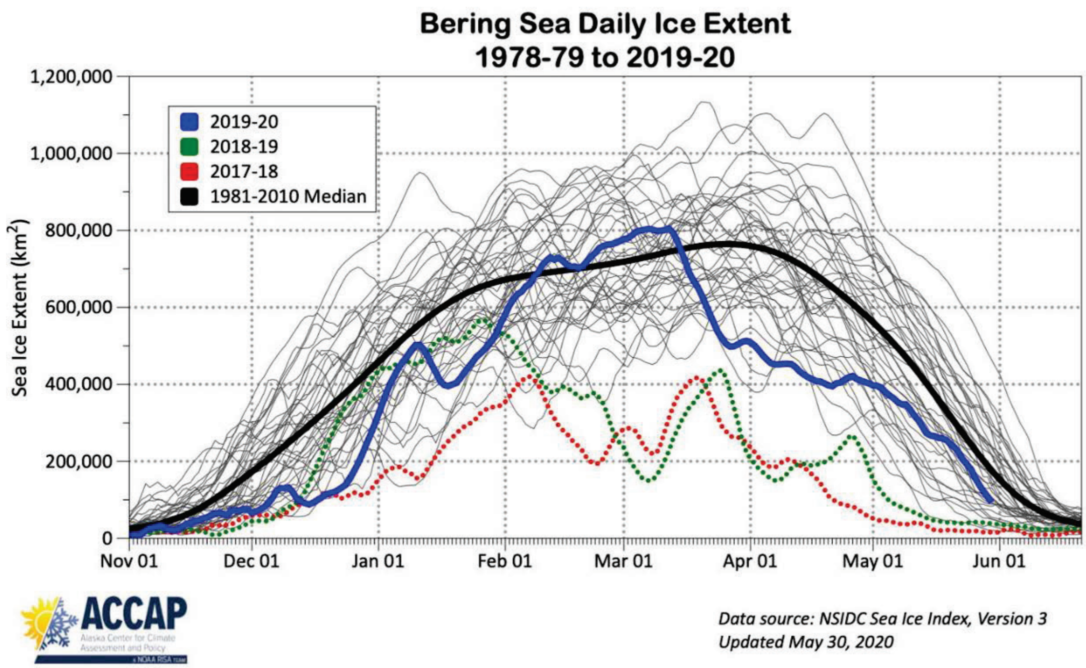

Figure 16. Bering Sea daily ice extent for 1978/79 to 2019/20 from ACCAP (courtesy of Rick Thoman).

SST data for the EBS indicates that 2020 late winter temperatures were closer to the long-term mean; above-average temperatures returned in spring and summer, especially over the southeastern shelf; and late summer temperatures (red circle) remain above average, similar to 2019. The time series can be updated daily using code available at the link below. The code also provides a comparison of temperatures across the Gulf of Alaska.

https://github.com/jordanwatson/EcosystemStatusReports/tree/master/SST

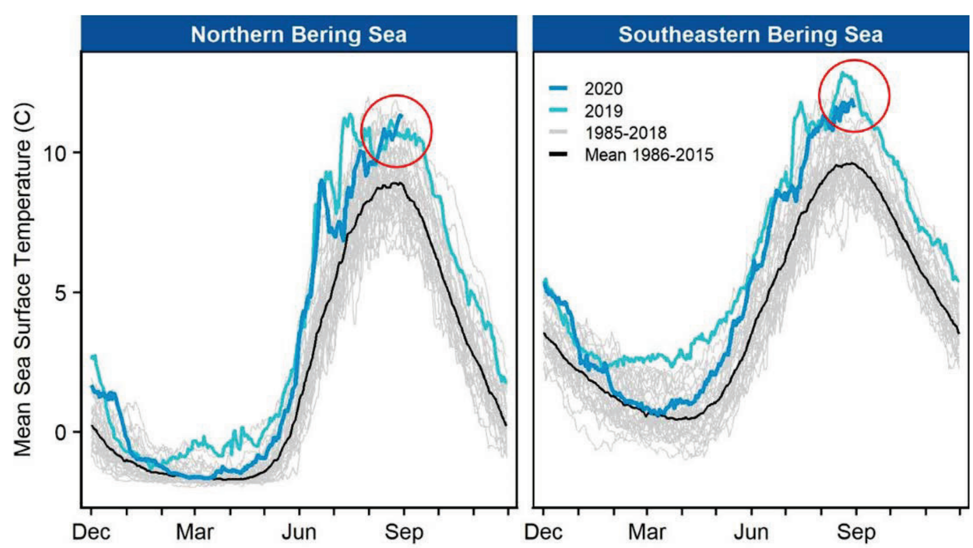

Figure 17. Eastern Bering Sea daily mean SST for 2020 and 2019 compared to means for 1986-2015 for the northern Bering Sea (north of 60°N) and southeastern Bering Sea (south of 60ºN) from satellite analysis. Courtesy of Jordan Watson, NOAA AFSC.

A coccolithophore phytoplankton bloom started in the EBS in late August 2020 (Fig. 18). These blooms can be detrimental to fish and seabirds. For example, a large bloom in 1997 was associated with a die-off of short-tailed shearwaters. These blooms are thought to reduce foraging success for visual predators.

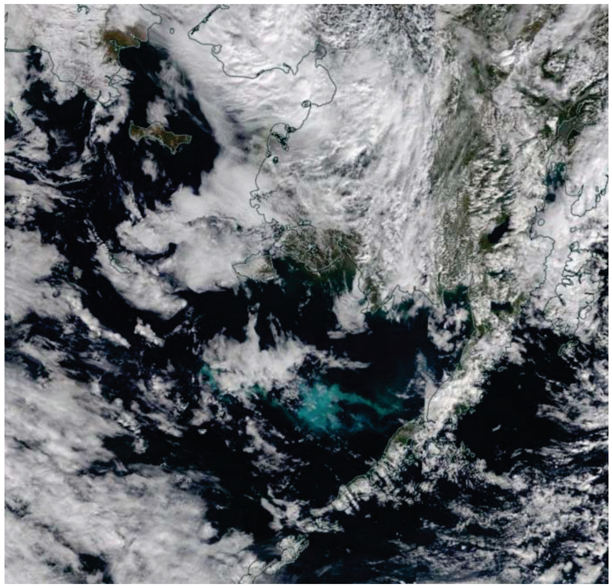

Figure 18. Coccolithophore bloom (aqua color water) in the eastern Bering Sea observed on August 27, 2020. Image provided by Carol Ladd (NOAA PMEL). We acknowledge the use of imagery from the NASA Worldview application (https://worldview.earthdata.nasa.gov), part of the NASA Earth Observing System Data and Information System (EOSDIS).

A combined Distributed Biological Observatory (DBO) and mooring survey onboard the NOAA ship *Oscar Dyson* in late August-September 2020 is currently ongoing (Fig. 19). This survey will turn around PMEL moorings (*e.g.* M2, mammal moorings) and sample DBO stations. Operations include surface and subsurface moorings and instrumentation (including Prawler-profiling mooring), CTDs, Bongos, Pop-up floats. Oceanographic sampling also includes discrete samples for nutrients and chlorophyll a and zooplankton bongo tows. Contact Janet Duffy-Anderson (NOAA AFSC) for details.

A new project, Pop-up floats and Pacific cod spawning habitat, deployed pop-up floats in the eastern Bering Sea (Fig. 20). Deployment of floats in 2020 was a collaborative effort by Industry, USCG, and the NOAA ship *Oscar Dyson*. Pop-up floats (PMEL) record bottom temps for ~1 year, then pop-up to transmit data. There is a lack of spatially-resolved bottom temperature measurements, especially in winter/spring. This lack of temperature data hinders our understanding of cold-pool dynamics in general, and specifically how changes in bottom temperatures are affecting distribution and availability of spawning habitat for Pacific cod. Data will be used to refine ROMS and model spatio-temporal changes in Pacific cod spawning habitat. Eventually this data can be used for fisheries ESPs (Ecosystem and Socioeconomic Profiles), risk tables, and climate-informed reference points (via CEATTLE model). Contacts for this project include Lauren Rogers (AFSC) and Phyllis Stabeno (PMEL).

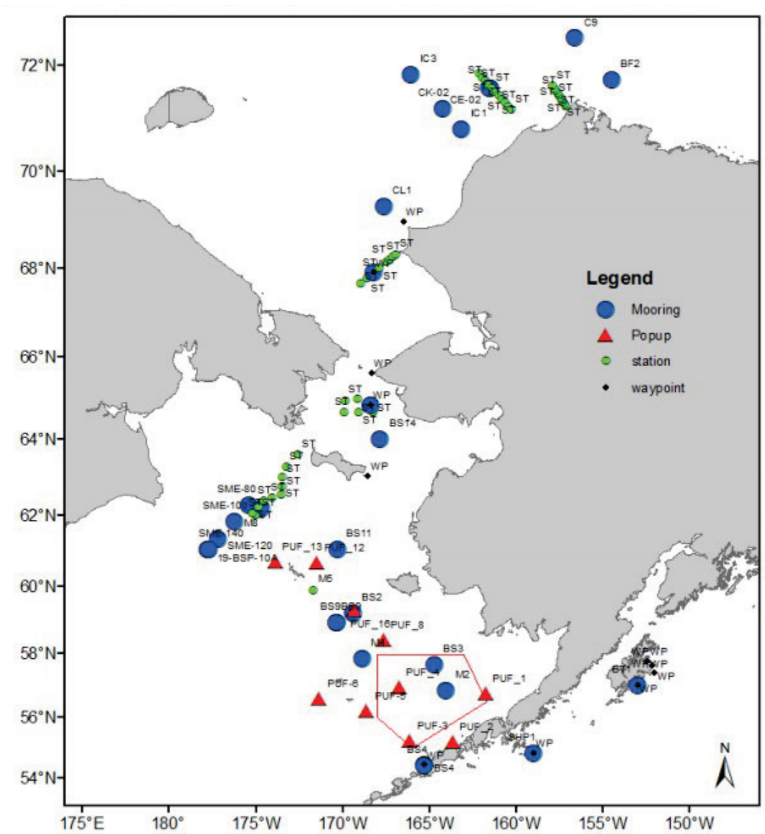

Figure 19. Distributed Biological Observatory (DBO) and mooring stations to be sampled on the NOAA ship *Oscar Dyson* in the eastern Bering Sea, late August- September 2020.

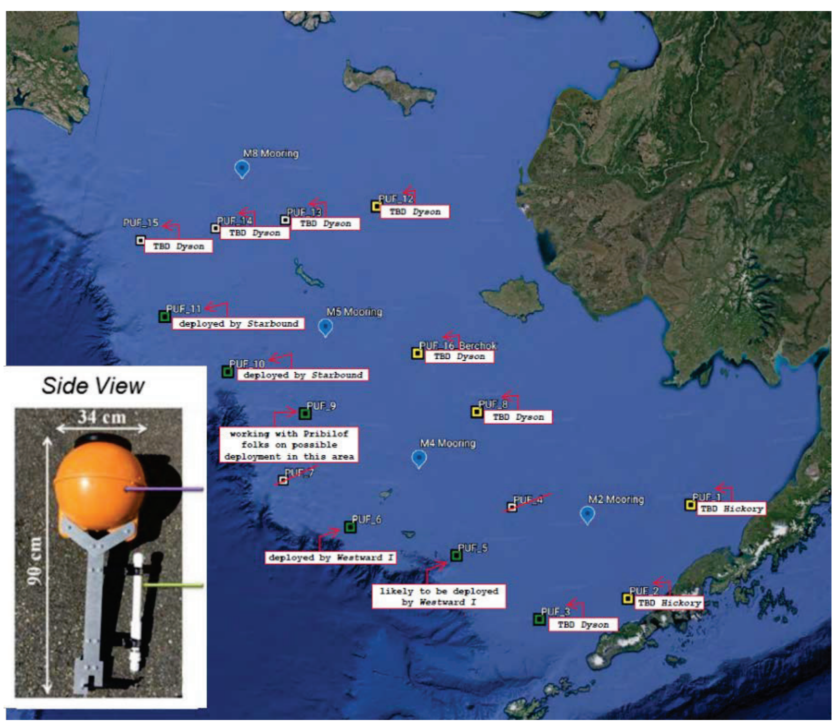

Figure 20. Locations of pop-up floats for Pop-up floats and Pacific cod spawning habitat project.

Due to cancellation of the NOAA AFSC groundfish bottom trawl and acoustic ship-board surveys (used for NOAA fisheries stock assessments of pollock), a rapid response project, AFSC Saildrone Pollock Acoustic Survey, was developed as a contingency plan (Fig. 21). Saildrones are wind and solar powered robots with calibrated 38/200 kHz echosounder, oceanographic, and meteorological sensors. The goal was to use unmanned surface vehicles to add a data point to existing acoustic time series of walleye pollock abundance. Fish backscatter on the EBS shelf is dominated by pollock, and there has been recent research and development efforts to make this project feasible.. The approach was to use 3 saildrones to sail to/from the eastern Bering Sea from California (where the saildrones are based). Spacing for transects was 40 nmi. The survey occurred 4Jul to 20Aug, 2020 with recovery planned for mid-October. Limitations (compared to ship survey) include no size/age composition, lower sampling density, and no data until vehicles are recovered. Contact Alex DeRobertis (NOAA AFSC) for details.

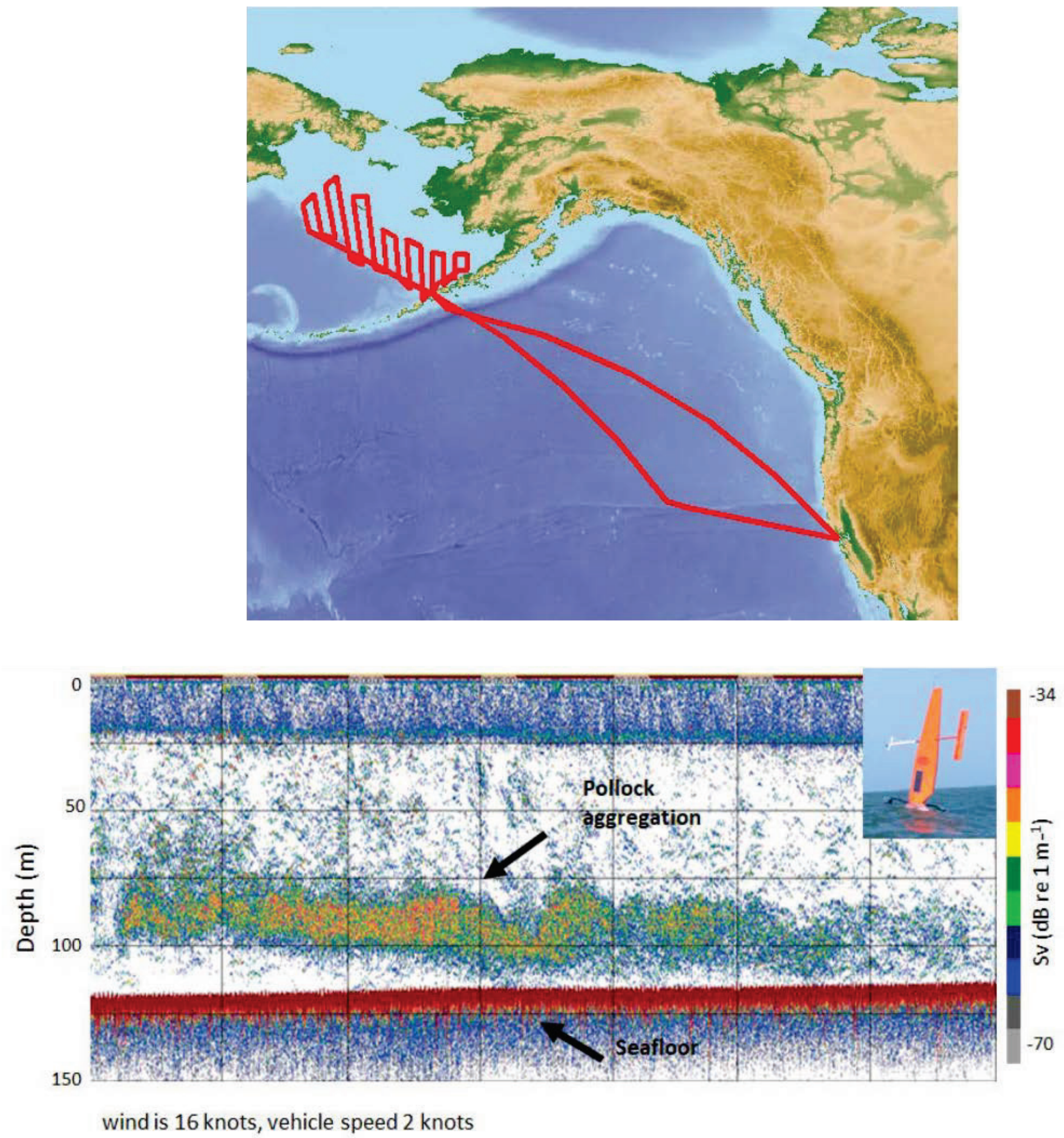

Figure 21. AFSC Saildrone Pollock acoustic survey in the Bering Sea 04 July - 20 Aug, 2020.

- Gulf of Alaska

The Gulf of Alaska (GOA) SST data for 2020 indicate the late winter temperatures cooled to the long-term mean through April (Fig. 22). The western GOA then warmed above the mean, near the marine heat wave threshold, for much of summer. The eastern GOA temperatures remained near-normal through present.

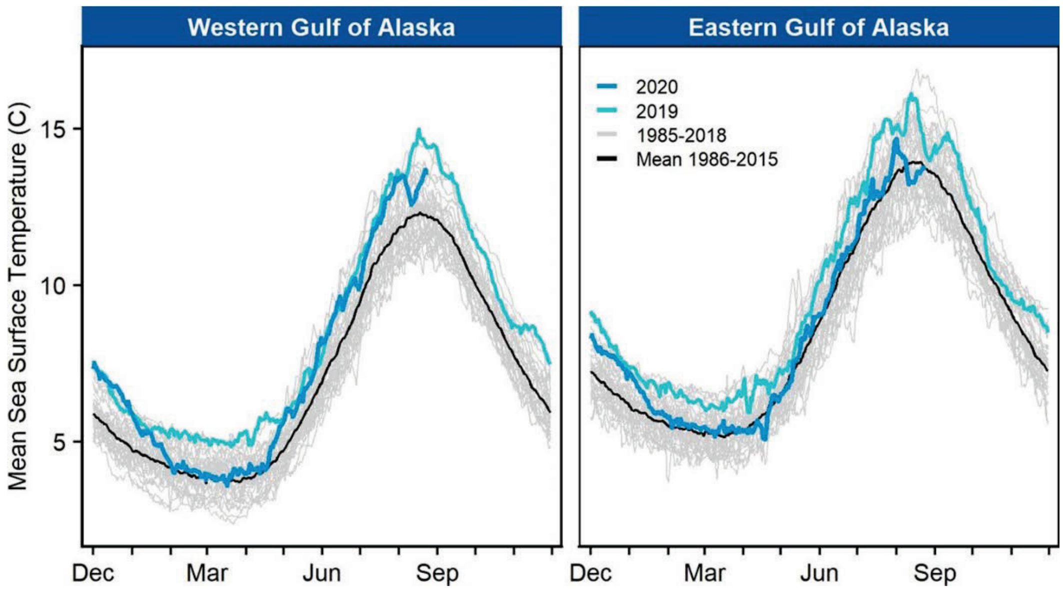

Figure 22. GOA SST for the western and eastern GOA for 2020 and 2019 compared to means for 1986-2015 from satellite analysis. Courtesy of Jordan Watson, NOAA AFSC.

Gulf Watch Alaska & Northern GOA Long Term Ecological Research (LTER) programs conduct surveys in the northern GOA (Fig. 23). Temperature timeseries in Prince William Sound and at GAK1 indicate above average temperatures in recent years at the surface and at depth (200-250m) (Fig. 24 top). Along the Seward line, a warm pool of water was observed at depths of ~150-200m in May, July and September (Fig. 24 bottom). Prey for seabird (sablefish, capelin and other fish) from Middleton Island are evaluated annually by USGS (Scott Hatch and Y. Arimitsu). In 2020 (warm year) sablefish age-0 fish had a high summer growth index, while capelin biomass was decreased (Fig. 25). Contact Rob Suryan (NOAA AFSC) for details on Coast Watch.

A longline survey for sablefish in the GOA was conducted by NOAA AFSC, May 28-August 31, 2020 (Fig. 26 top) to provide data for the sablefish stock assessment. For this survey sablefish CPUE, length, weight, sex, maturity, and otoliths are recorded. Other species where longline survey data is used for stock assessments include: GOA cod, Bering Sea Aleutian Islands turbot, GOA rougheye and blackspotted rockfish, GOA shortraker, shortspine thornyhead, sharks and giant grenadier– these species are catch per unit effort (CPUE) and lengths only. Researchers tag and release a subsample of sablefish, G. turbot, shortspine thornyhead, and sharks. Sablefish Relative Population Number (RPN) for all areas combined indicates that sablefish numbers were very high in summer 2020 (Fig. 26 bottom). Contact Pat Malecha (NOO AFSC) for details.

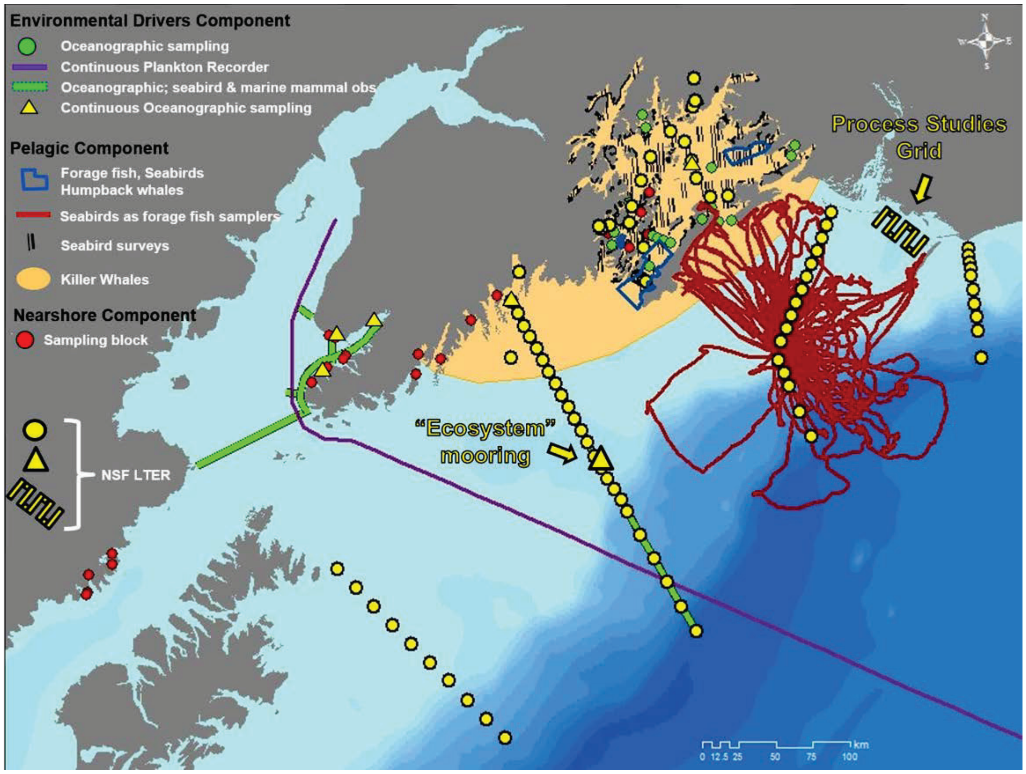

Figure 23. Gulf Watch Alaska and N. GOA Long Term Ecological Research (LTER) Surveys.

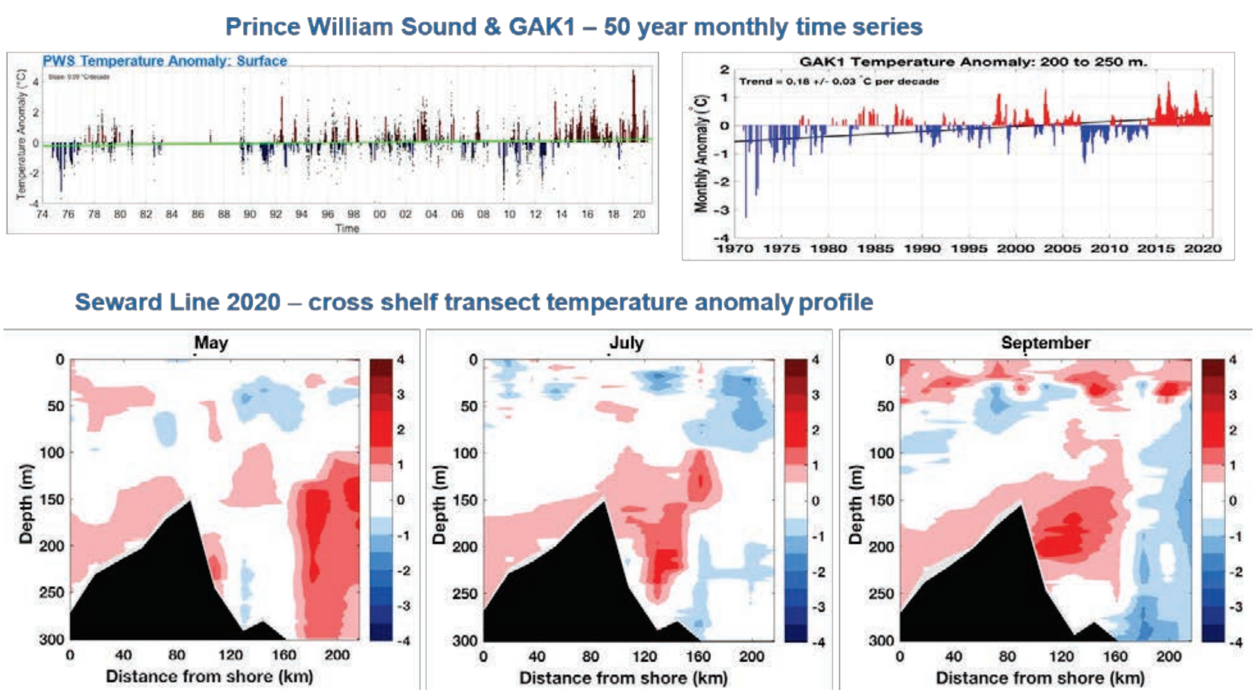

Figure 24. Temperature times series and 2020 observations in the northern GOA from Gulf Watch and the N.GOA LTER (contributed by S. Daneilson, R. Hopcroft, R. Campbell).

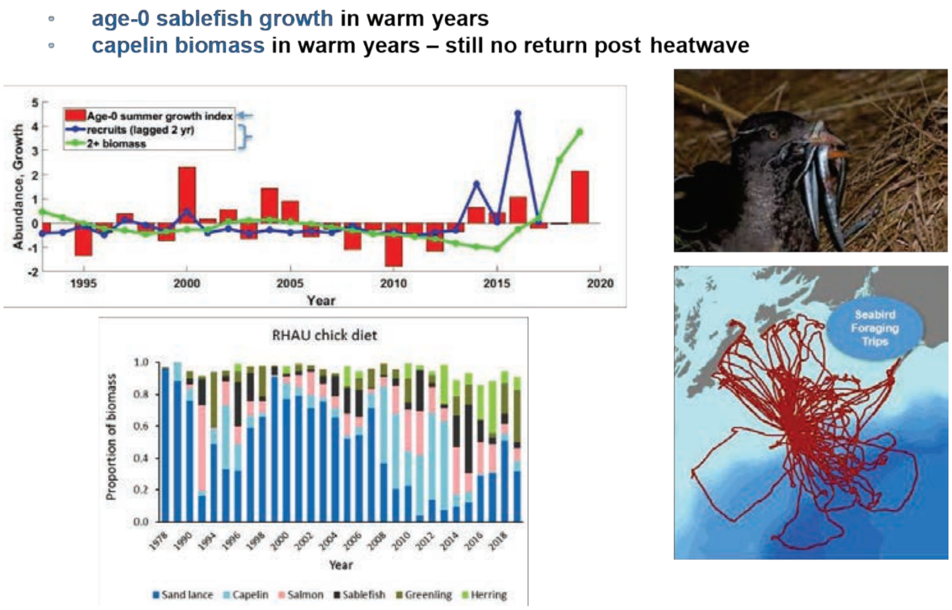

Figure 25. Northern GOA annual time series of age-0 sablefish growth index and recruits, and seabird chick diets at Middleton Island (S. Hatch and Y. Arimitsu). This is a Gulf Watch project.

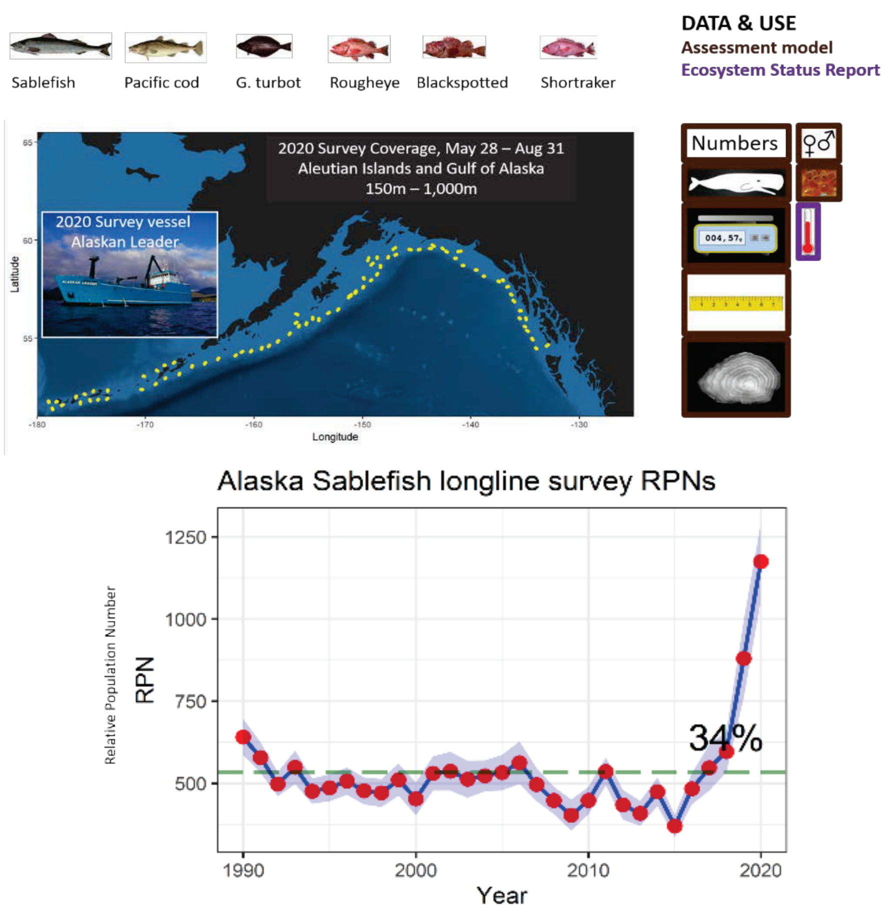

Figure 26. GOA longline survey locations (top) and relative population number (RPN) for sablefish 1990-2020 (bottom). Figures courtesy of P. Malecha.

Surveys for age-0 Pacific cod and walleye pollock were conducted by NOAA AFSC in summer 2020 (Fig. 27). Data indicate high abundances of these fish throughout the sampling area.

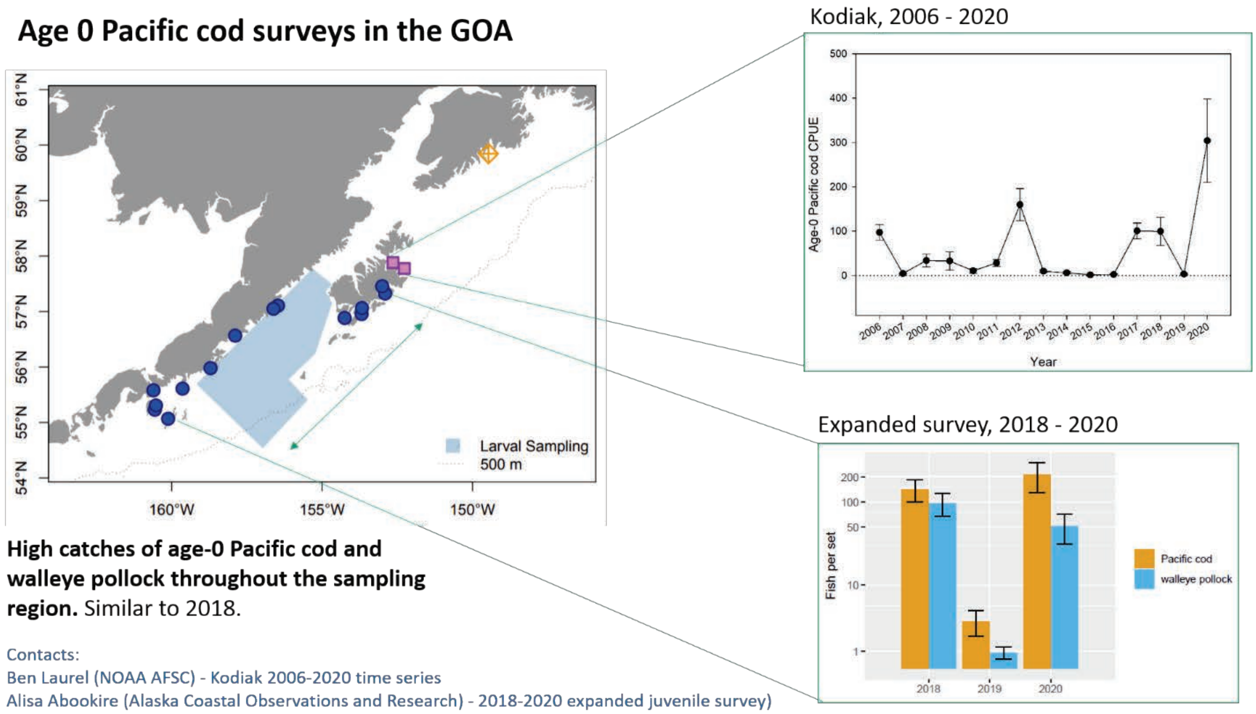

Figure 27. Age 0 Pacific cod surveys in the GOA by NOAA AFSC. Contacts include Ben Laurel (NOAA AFSC) and Alisa Abookire (ACOR).

Gulf of Alaska ecosystem summary

No return of the Blob (marine heatwave)

- Water Temperature: Inshore = warm; Shelf = spring and summer upper water column near long-term mean, but warm in fall; Bottom water over shelf warm summer and fall
- Average zooplankton densities for 2020 – but southern (warm) species still prevalent in fall (through 2019 – Seward Line)
- Prey abundance (e.g., sable fish) appears improved from recent years
- Strong Pacific cod age-0 year class
- Average to below average juvenile salmon catches
- Still consider potential recruitment carry-over effects of 2019 heatwave

Implications: Near average conditions for feeding and growth.

A member asked when the Blob was expected again. Dr. Barth answered that it came back in winter 2019, but the winds reduced it; it is still there (just deeper).