2023 Report of MONITOR Committee

Virtual and Seattle, USA
September 20/21 and October 22, 2023

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MEETING INFORMATION

Business meetings for the MONITOR Technical Committee will be held for two days as an online and hybrid meeting.

1st-day session September 20, 2023, Wednesday Monday 1700-1840 (US/Canada PDT) and September 21, 2023, Thursday 0800-0940 (Beijing, China), 0900-1040 (Korea/Japan), 1000-1140 (Vladivostok, Russia) Topic: 2023 PICES MONITOR Business Meeting (Day 1) Time: Sep 21, 2023 09:00 AM Seoul Join Zoom Meeting https://kaist.zoom.us/j/85170410042 Meeting ID: 851 7041 0042 Find your local number: https://kaist.zoom.us/u/kbDoThPb8N
2nd-day session October 22, 2023, Sunday 1800-2040 at Seattle, USA (Room Cascade I-B) and October 23, 2023, Monday 0900-1140 (Beijing, China), 1000-1240 (Korea/Japan), 1100-1340 (Vladivostok, Russia) Topic: 2023 PICES MONITOR Business Meeting (Day 2) Time: Oct 22, 2023 06:00 PM Pacific Time (US and Canada) Join Zoom Meeting https://kaist.zoom.us/j/82417017136 Meeting ID: 824 1701 7136 Find your local number: https://kaist.zoom.us/u/kck4MBLYEA

AGENDA

Day 1: September 21, 2023, 0900-1040 (KST; *Note: times may shift*)

1. 09:00-09:10 Welcome, Introductions, and Sign-in [10 mins]
2. 09:10-09:20 Updates [10 mins]
    a. Updates from ISB
    b. Activities of AP-CREAMS: Lovanov
3. 09:20-09:25 ECOP Presentation Award Judge volunteer [5 mins]
4. 09:25-09:40 PICES-2024 session/workshop proposals discussion [15 mins]
   09:40-09:45 Break [5 mins]
5. 09:45-10:50 National reports – Written and Oral [65 mins]
   Written: Please provide national reports before the PICES meeting. Include relevant monitoring activities for relevant years. Written reports will be posted to the PICES web page.
   Oral: Please include highlights and updates in national reports of relevant monitor/observation activities from the last year. PowerPoint presentations will be posted on the PICES web page.
   The presentation will be given in a random order this year:
    - Canada Boldt, Ross
    - Japan Kitamura, Tadokoro, Abe
    - Korea Kim, HK Jung, EH Jung
    - Russia Kulik, Lobanov
    - United States Barth, Eisner, Jacobson
    - China Zhao, Zhang, Cui, Zhou
6. 10:50-11:00 Other business – Annual report and Briefing book; Note on ranking the PICES-2024 session/workshop proposals [10 mins]

Day 2: October 22, 2023, 1800-2040 (PDT; *Note: times may shift*)

7. 18:00-18:10 Welcome, Introductions, and Sign-in [10 mins]
8. 18:10-18:20 Updates/Recap from the previous meeting [10 mins]
9. 18:20-18:50 Updates from PICES Groups [30 mins]
    a. 18:20-18:30 Activities of FUTURE: Boldt [10 mins]
    b. 18:30-18:40 Activities of AP-CREAMS: Lee [10 mins]
    c. 18:40-18:50 Activities of AP-NPCOOS: Kim [10 mins]
   18:50-19:00 Break [10 mins]
10. 19:00-20:10 Relations with international organizations [70 mins]
    a. 19:00-19:10 Activities of the CPR: Batten [10 mins]
    b. 19:10-19:20 Activities of the WGICA: Saitoh [10 mins]
    c. 19:20-19:30 Activities of the US IOOS/NANOOS: Newton [10 mins]
    d. 19:30-19:40 Activities of the OneArgo: Ross [10 mins]
    e. 19:40-19:50 Activities of the BECI: Brown [10 mins]
    f. 19:50-20:00 Activities of the AOOS: Janzen [10 mins]
    g. 20:00-20:10 Activities of the IOCCP: Telszewski [10 mins]
   20:10-20:20 Break [10 mins]
11. 20:20-20:40 Other business [20 mins]

LIST OF ACRONYMS

AP	Advisory Panel
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
CMT	Committee
ECOP	Early Career Ocean Professional
EG	Expert Group
ETSO	Environmental Time Series Observations
FUTURE	Forecasting and Understanding Trends, Uncertainty, and Responses of North Pacific Marine Ecosystems
ISB	Inter-sessional Science Board
POMA	PICES Ocean Monitoring Service Award
SEES	Social-Ecological-Environmental System
SG-NPSER	Study Group on North Pacific Ecosystem Status Report
TCODE	Technical Committee on Data Exchange
TOR	Terms of Reference
WG	Working Group
WG-35	Working Group on Third North Pacific Ecosystem Status Report (WG-NPESR3)
WG-38	Working Group on Mesoscale and Submesoscale Processes

AMAP	Arctic Monitoring and Assessment Programme
AOOS	Alaska Ocean Observing System
CeNCOOS	Central and Northern California Ocean Observing System
CPR	Continuous Plankton Recorder
GOOS	Global Ocean Observing System
IOOS	Integrated Ocean Observing System
IOCCP	International Ocean Carbon Coordination Project
NANOOS	Northwest Association of Networked Ocean Observing Systems.
NEAR-GOOS	North Eastern Asian-Global Ocean Observing System
NPRB	North Pacific Research Board
OOI	Ocean Observatories Initiative
POGO	Partnership for Observation of the Global Oceans
WOA	World Ocean Assessment

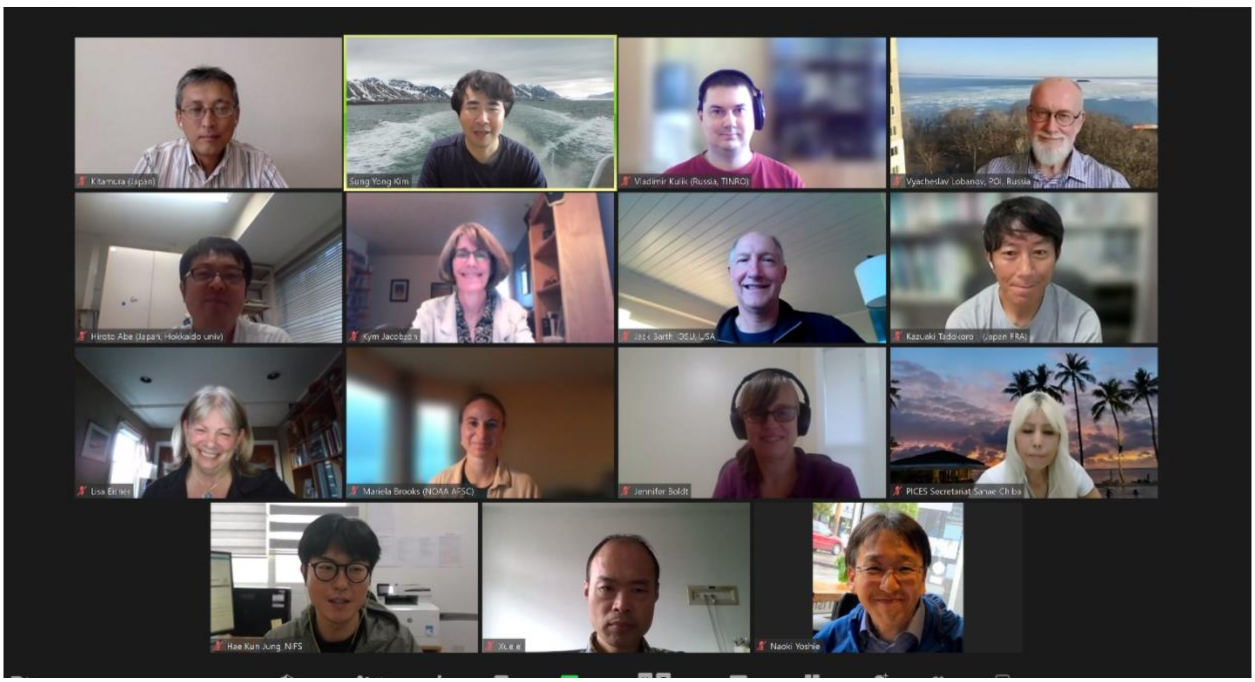
DAY 1

AGENDA ITEM 1: WELCOME AND INTRODUCTION

MONITOR Chair Prof. Sung Yong Kim called the online meeting to order, participants introduced themselves, and the agenda were reviewed and adopted.

Attendees:

At the beginning of the 1st-day meeting**: [members]** Vyacheslav B. Lobanov (Russia), Vladimir Kulik (Russia), Sung Yong Kim (MONITOR Chair, Korea), Hea-Kun Jung (Korea), Hiroto Abe (Japan), Kazuaki Tadokoro (Japan), Minoru Kitamura (Japan), Jack Barth (USA), Lisa Eisner (USA), Kym Jacobson (MONITOR Vice-Chair, USA), Jennifer Boldt (Canada) **[observers]** Marieal Brooks (USA), Naoki Yoshie (AP-NPCOOS Co-chair, Japan), Xuelei Zhang (AP-NPCOOS), Sanae Chiba (PICES Secretariat)



Note that the group photo was taken at the end of the 1st day meeting

AGENDA ITEM 2: UPDATES FROM THE ISB AND UPDATES FROM EGS

1. Updates from ISB
    a. Policy Expert Groups/Committee business meetings
        i. EG business online meetings are required a month prior to the annual meeting.
        ii. CMT business online meeting for reviewing EG reports and updates an in-person business meeting (MONITOR on Sunday 6 pm)
    b. New member(s): Drs. Zhengguo Cui and Feng Zhou (China)
    c. POMA/Zhu-Peterson Awards decisions
    d. PICES Annual Meeting 2024 @ Honolulu, HI USA (Oct. 26-Nov. 1)
        i. The FUTURE of PICES: Science for Sustainability in 2030
        ii. FUTURE 2nd OSM meeting will be held during the annual meeting (possibly one day)

2. Activities of AP-CREAMS: Slava Lobanov
    a. 30th year anniversary of AP-CREAMS - joint international studies of Asian Marginal Seas: from circulation and biogeochemistry to socio-economics research.
        i. 2-3 days in July 2024 in Korea or China
        ii. Acknowledge CREAMS founders, involve young scientists, discuss future of CREAMS, move closer to SEES
        iii. Request travel fund for invited speakers and young scientist
        iv. Sanae: put request through MONITOR

AGENDA ITEM 3: VOLUNTEER FOR ECOP PRESENTATION AWARD JUDGE

1. MONITOR judges will evaluate ECOPs' talks in S10
2. S10: Improved detection and understanding of factors affecting changes in North Pacific forage communities and implications to ecosystems (11 talks and three posters)
3. Dates
    a. Oral – Oct. 25 Wednesday 0900-1730 (Day 1)
       Oct. 27 Friday 0900-1230 (Day 2)
    b. Poster – Oct. 26 Thursday 1830-2100
4. Guidelines
    a. Each Committee will select ONE oral and ONE poster award from all Sessions/Workshops they judge. If you see no presentations are qualified, you don't need to choose any
        i. At least two-judge volunteers are recommended
5. Volunterrs: Jennifer Boldt and Lisa Einser (oral); Jack Barth (poster)

AGENDA ITEM 4: PICES-2024 SESSION/WORKSHOP PROPOSALS DISCUSSION

1. Title: The FUTURE of PICES: Science for Sustainability in 2030

2. Theme: PICES has provided leadership in developing a more thorough understanding of the structure, function, and changes of North Pacific marine ecosystems with the support of its flagship scientific programs. The current scientific program on 'Forecasting and Understanding Trends, Uncertainty, and Responses of North Pacific Marine Ecosystems' (FUTURE) promotes investigations of North Pacific ecosystems with an emphasis on the synergy of social, ecological, and environmental systems and processes. Within this framework, PICES is focused on developing a better understanding of the combined consequences of climate change and anthropogenic pressures on marine ecosystems, ecosystem services, and marine-dependent social systems. Building on these foundational results, we now embark on the "FUTURE" of PICES that will lead to better observations, improved awareness of mechanisms of change, and, ultimately, science for sustainability by 2030. Through our science, PICES will continue to provide leadership to the United Nations Decade of Ocean Science for Sustainable Development and the mission of developing "the science we need for the ocean we want." We welcome submissions associated with the "FUTURE" of PICES to explore progress already made and to steer our science towards identifying gaps and setting priorities.

3. Suggestions in the MONITOR CMT perspectives and discussion
    a. Status of ocean observational gaps in physics and bio-geochemistry (along with AP-NPCOOS)
    b. Any topics related to "better observations, improved awareness of mechanisms of change, and ultimately science for sustainability by 2030."
    c. Advanced and cutting-edge technology embracing physics, bio, biogeochemistry, and engineering; low-cost observations; feasibility and readiness of explored technology to operational observing system;

4. Submitted proposal
    a. Title: Observational frontier and new studies for the understanding of ocean and ecosystem
    b. Conveners:
        i. Sung Yong Kim, Korea Advanced Institute of Science and Technology, Republic of Korea, syongkim@kaist.ac.kr (corresponding)
        ii. Kiyoshi Tanaka, University of Tokyo, Japan, ktanaka@aori.u-tokyo.ac.jp
        iii. Akash Sastri, Fisheries and Oceans Canada, Canada, akash.sastri@dfo-mpo.gc.ca
        iv. Jack Bath, Oregon State University, USA, jack.barth@oregonstate.edu

    c. PICES Sponsors: MONITOR, AP-NPCOOS, BIO, TCODE
    d. Duration: 1 day - 1.5 days
    e. Abstract:

    Advanced technology has helped our sampling efforts and increased our understanding of oceanography and ecosystem processes over the last two decades. Various sampling sensors, platforms, and ways of sensor fabrication have been developed, such as physics, biology, biogeochemistry, underwater communication, bioacoustics, bio-optics, and autonomous vehicles. These observational frontiers and new studies can be combined with building a seamless data integration and sharing system, which can relay information to artificial intelligence technology. We invite contributions on recent ocean observational approaches to obtain primary ocean variables and unprecedented measurements for physical, biological, and biogeochemical ocean properties and integrated efforts using different platforms. We also welcome contributions of low-cost ocean observations and new approaches by citizen scientists using new and existing sensors and platforms. These advanced technology and accessible approaches will support our goal of understanding the ocean sustainably.

f. Potential invited speakers:
   i. Dave Kimmel, zooplankton CPICS and Plankton imager, david.kimmel@noaa.gov
   ii. Alex DeRobertis, DriX acoustics, Alex.derobertis@noaa.gov
   iii. Maria Kavanaugh, OSU, phytoplankton imaging, maria.kavanaugh@oregonstate.edu
   iv. Jeanette Gann, IFCB phytoplankton imager, Jeanette.Gann@noaa.gov
   v. Yasumasa Miyazawa, data assimilation model, miyazawa@jamstec.go.jp
   vi. Chris Rooper, DFO, underwater optics, Chris.Rooper@dfo-mpo.gc.ca
   vii. Kresimir Williams, NMFS, underwater optics, Kresimir.Williams@noaa.gov

AGENDA ITEM 5: NATIONAL REPORTS

1. Canada

I. Overview and Summary of 2022

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 on conditions in 2022 is available at here:

https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2022/technical-report-rapport-technique-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. (2023).

Below is the overview and summary from that report, with the same Figure and Section numbers as in the report (Boldt et al. 2023):

Climate change continues to be a dominant pressure acting on Northeast (NE) Pacific marine ecosystems, as 2022 was the fifth or sixth warmest year on record globally (depending on climatology used). B.C. air temperatures continued to increase (1950-2022) as daily mean air temperatures were above average (Curry et al., Section 6). Precipitation was below average in B.C., while snowpack was above-average well into June over most of B.C. In autumn, severe drought conditions were experienced nearly everywhere in B.C. accompanied by near-record warm temperatures (Curry et al., Section 6). In 2022, river discharge in southern B.C. was less than normal, but was close to average in northern B.C. (Curry et al, Section 6; Donnet, Section 33). Despite strong negative PDO and La Niña conditions throughout 2022 which should have led to an abnormally cool year, temperatures were near normal in the NE Pacific (Ross and Robert, Section 7). The relatively normal temperatures observed in the NE Pacific were likely due to the juxtaposition of cool climate oscillations on a background of long-term climate warming (Ross and Robert, Section 7; Figures 3-1 and 3-2). The 2022 average annual SST, collected at shore stations along the B.C. coast, was marginally cooler than 2021 and close to the mean calculated over the 1992-2020 period (Donnet et al., Section 10). Coast-wide SST in 2022 was much lower than conditions observed in 2015 during the marine heatwave (MHW) known as "the Blob" and perhaps signaling an end of the warm period that started in 2014 (Donnet et al., Section 10). Overlying multi-year oscillations in the annual SST, there is a long-term trend towards rising ocean temperatures of 0.9°C over the last 100 years (Figure 3-3; Donnet et al., Section 10). Surface waters in the NE Pacific were anomalously fresh in 2022 but slightly less than 2021;

this continues a freshening trend observed for the last six years (Ross and Robert, Section 7). Increasing CO_2 in the atmosphere has increased the acidification of the ocean, which will continue to intensify with the rise of anthropogenic carbon levels in the atmosphere (Evans, Section 36). In spring 2022, marine CO_2 conditions on the central B.C. coast and in the northern Salish Sea slightly improved compared to 2019-2020, but returned to more corrosive and low pH conditions for the remainder of the year (Evans, Section 36).

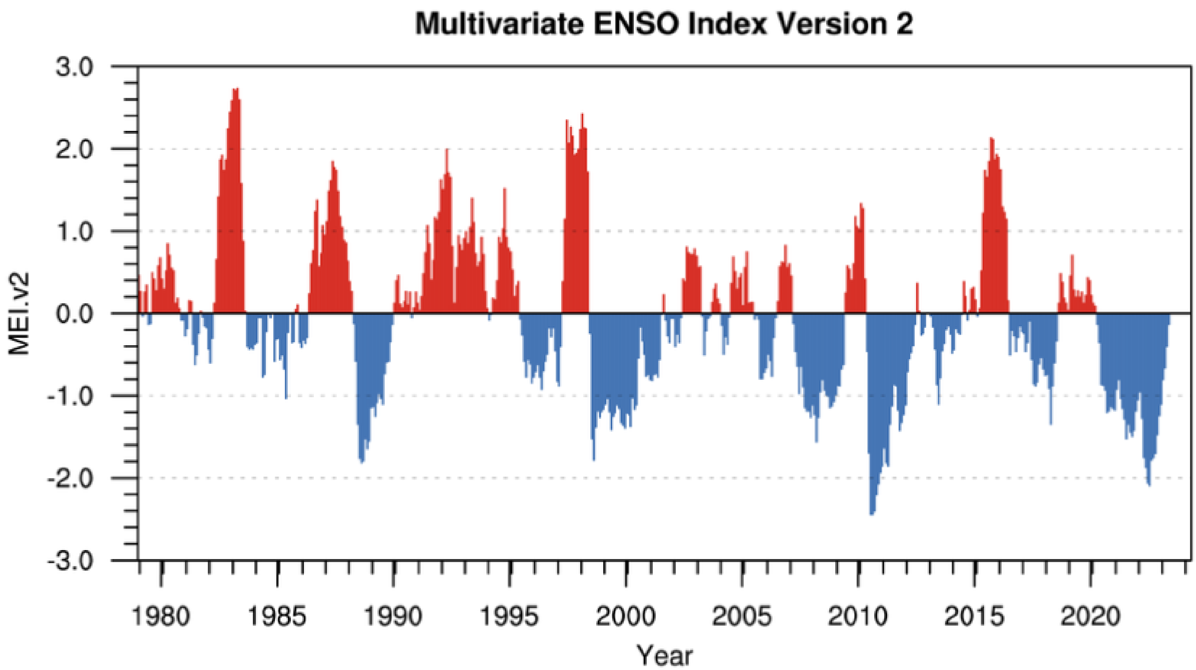


Figure 3-1. The multivariate ENSO Index. Data source: NOAA/ESRL/Physical Sciences Division – University of Colorado at Boulder/CIRES; https://psl.noaa.gov/enso/mei/

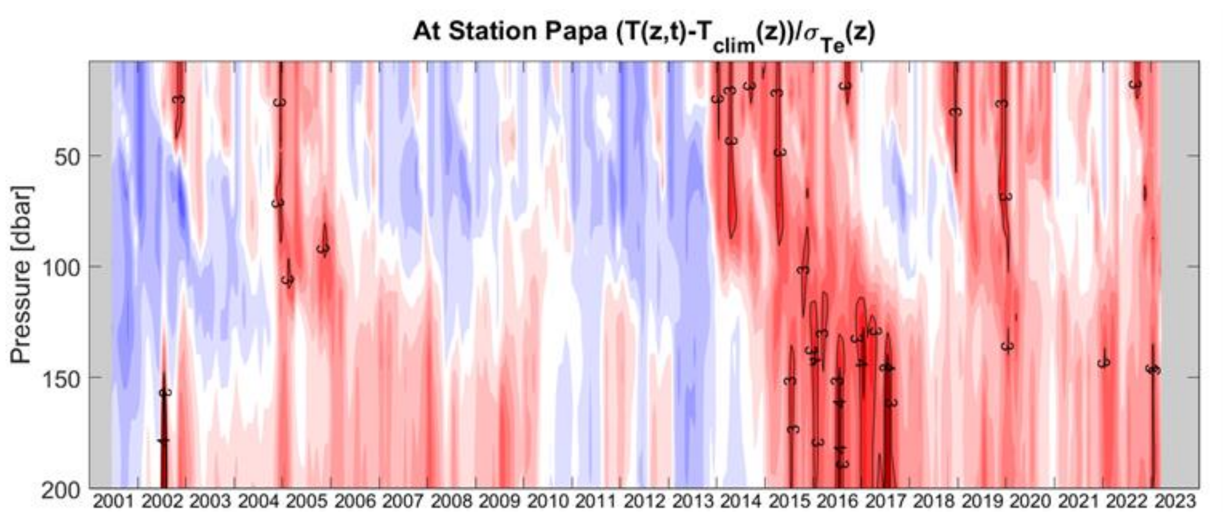


Figure 3-2. Plot of temperature, as observed by Argo floats near Ocean Station Papa, with anomalies calculated relative to the 1991-2020 seasonally-corrected mean and standard deviation (from the Line P time series). Cool colours indicate cooler than average temperatures and warm colours indicate warmer that

average temperatures. Dark colours indicate anomalies that are large compared with standard deviations from the climatology. The black lines highlight regions with anomalies that are 3 and 4 standard deviations above the mean. Source: Ross and Robert, Section 7.

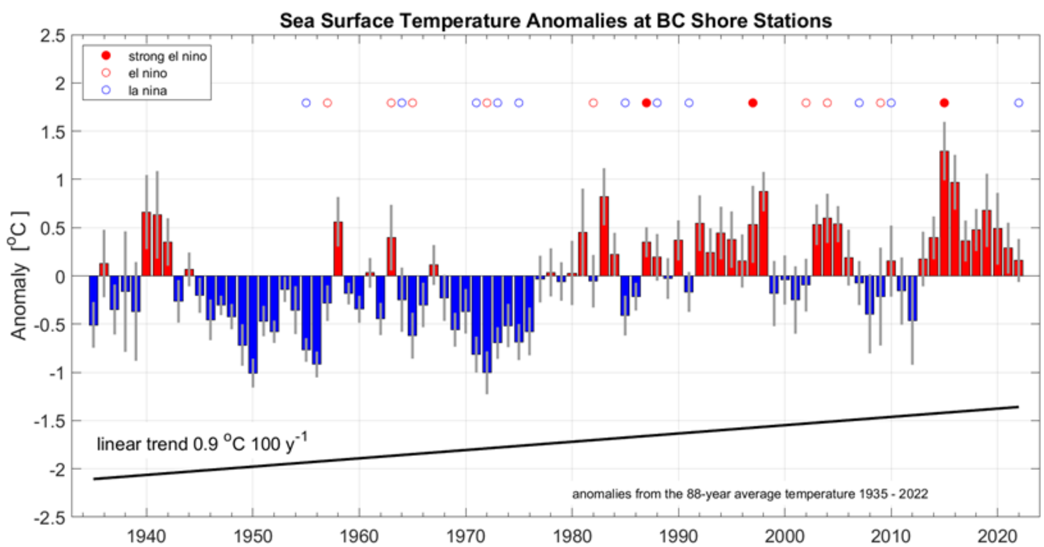


Figure 3-3. Trend in annual Sea Surface Temperature based on the observations of all lighthouses (black line). The bars represent the anomalies averaged over all stations (a coast wide indicator), (red – above average, blue – below average), the vertical grey lines show the variability (standard deviations) in the lighthouse data for each year (1935-2022). Important El Niño Southern Oscillation (ENSO) phases are indicated above as red (El Niño warm anomaly) and blue (La Niña cold anomaly) circles and dots (strong phase). Source: Donnet et al., Section 10.

Multiple marine heatwaves (MHWs) were identified in the NE Pacific in 2022; the largest MHW areas remained offshore in the open ocean for the first half of the year (Hilborn et al., Section 11). Beginning in late August most of the B.C. Exclusive Economic Zone (EEZ) fell under MHW status with varying intensity until late October (Hilborn et al., Section 11). The size, intensity, and frequency of MHWs in the NE Pacific is increasing (Hilborn et al., Section 11).

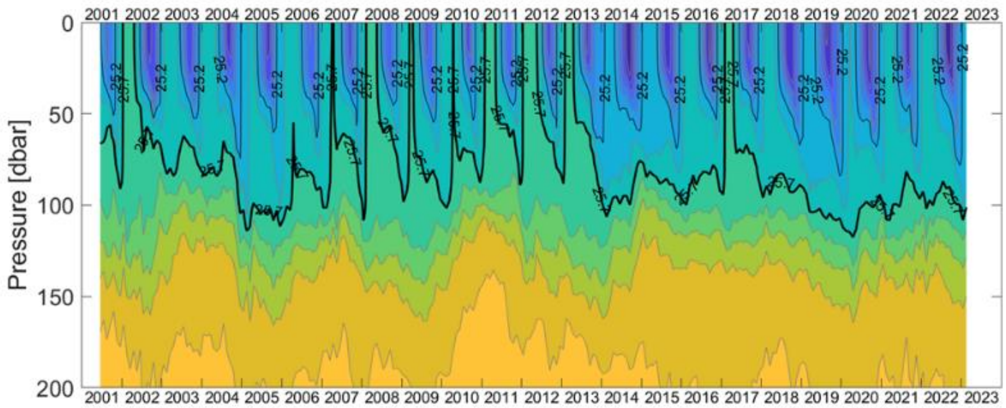


Figure 3-4. Coloured contour plot of density as observed by Argo floats near Station Papa (P26: 50° N, 145° W). The colours indicate potential density (yellow is denser and blue lighter). The black lines highlight the σ□=25.2 kg/m^3 (thin) and 25.7 kg/ m^3 (thick) isopycnals. Source: Ross and Robert, Section 7.

MHWs are associated with reduced vertical mixing, which causes increased winter stratification. This results in decreased nutrient supply from deep to surface offshore waters. The winter stratification was similar in 2021/22 and 2020/21, and both were stronger than during the 2007-2013 period preceding the first big MHW of the last decade (i.e. the 'Blob'), but not as strong as the 2018/19 and 2019/20 winters which showed extremely low winter mixing. Thus, the mixing of nutrients to the surface was likely normal in 2021/22 (Figure 3-4; 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 2022 spring transition timing of upwelling was very late relative to the 1991-2020 mean and the magnitude of summer upwelling was below the long-term average, resulting in an expectation of below-average upwelling-based coastal productivity (Hourston and Thomson, Section 8; Dewey et al., Section 38; Figure 3-5). After a late (June) start to upwelling, persistent upwelling, particularly along the southern Vancouver Island continental slope, brought California undercurrent source waters onto the shelf, supplying nutrients and saline water to surface waters and extending deep, oxygen-poor waters over the shelf eastward (Sastri et al., Section 15; Dewey et al., Section 38).

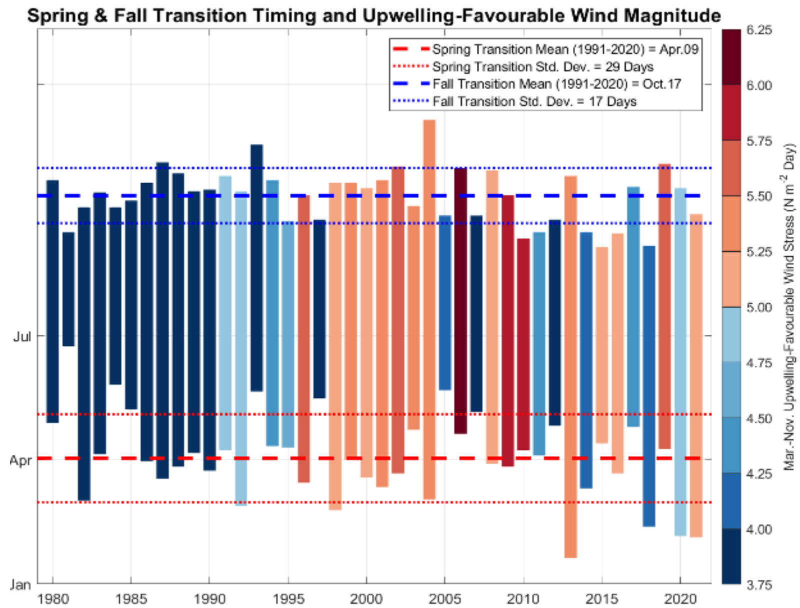


Figure 3-5. Annual spring and fall transition timing and March-November upwelling-favourable wind stress magnitude, 1980-2021. Bold dashed lines indicate the average spring (red) and fall (blue) transition dates. Light-dashed lines indicate standard deviations of the spring (red) and fall (blue) transition dates. Source: Hourston and Thomson, Section 8.

Phytoplankton and zooplankton communities appear to be returning to average status after the MHW (2014-2016) in the shelf region (Ostle and Batten, Section 21; Galbraith and Young, Section 20). In 2022, southern copepod species continued to decline in abundance compared to MHW years (Ostle and Batten, Section 21; Galbraith and Young, Section 20). Southern copepods were more prevalent in offshore compared to shelf waters of the south Vancouver Island and Hecate Strait regions (Figure 3-6). Boreal shelf and subarctic copepod biomass was above or near- average in all areas (Galbraith and Young, Section 20). Large subarctic and boreal copepods are more favourable for fish growth than small, southern copepod species. Changes to the physical environment, phytoplankton, and zooplankton communities can have impacts on higher trophic levels. Extreme heat events, such as the atmospheric heat dome of 2021, may have a long-term effect on Olympia Oyster survival and reproduction; however, no evidence of decrease in density was observed at index sites in 2022 (Herder and Bureau, Section 22). There was an increase in the biomass of shelf rockfish, some slope rockfish, and many flatfish species in the recent 5-10 years. In contrast, Arrowtooth Flounder and Pacific Spiny Dogfish biomass declined (Anderson et al., Section 29).

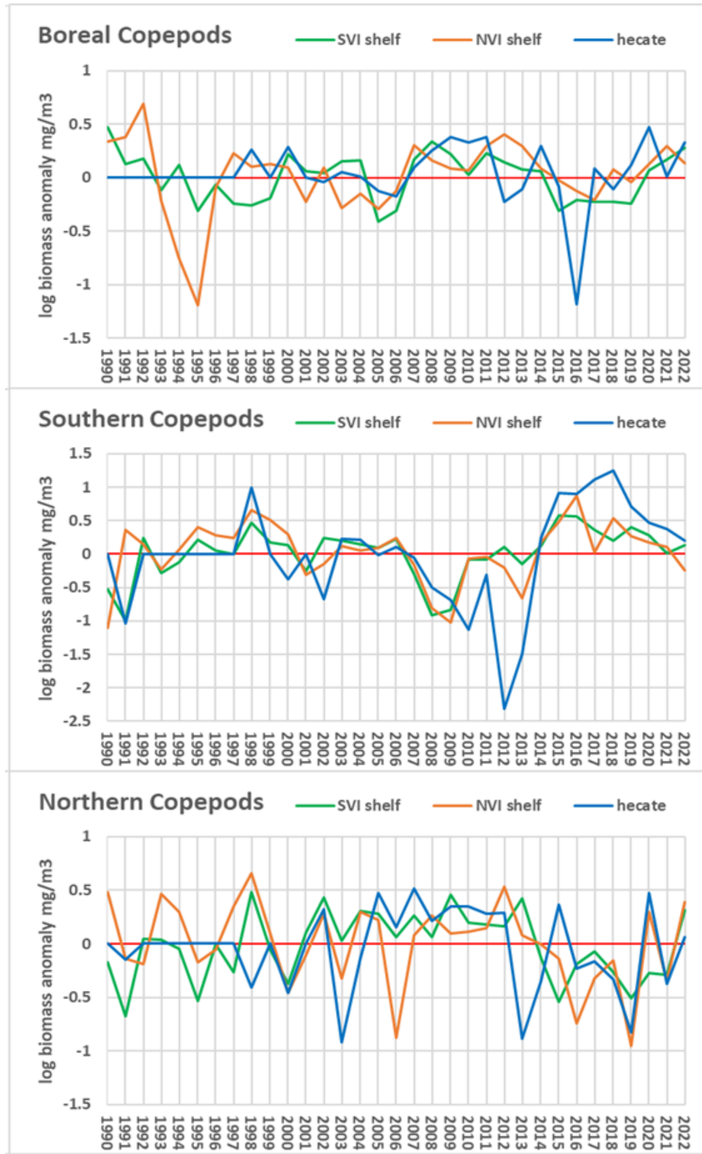


Figure 3-6. Zooplankton species-group anomaly time series. Line graphs are annual log scale anomalies. Southern Vancouver Island (SVI) green; Northern Vancouver Island (NVI) orange; Hecate Strait blue. Blank years mean no samples were collected. Source: Galbraith and Young, Section 20.

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). As in 2021, the representation of *N. cristatus* in Cassin's auklet nestling diets on Triangle Island in 2022 was well below what would be expected based on PDO conditions (Hipfner, Section 30). Diets fed to nestling Rhinoceros Auklets on Pine and Lucy islands included normal amounts of Pacific Sand Lance and Pacific Herring in 2022, continuing the trend towards favourable conditions that existed prior to the Blob (Hipfner, Section 30).

Several populations of marine mammals have shown strong recovery trends (notably humpback whales) after commercial whaling ended in 1967, and are once again important components of marine ecosystems, resulting in increased overlap with human activities and potential conflicts with fisheries and marine traffic. Sei Whale sightings in Canada's EEZ have increased, indicating increasing abundance or changing distribution patterns, and/or increasing observation efforts in offshore waters (Doniol-Valcroze et al., Section 32). The population of Harbour Seals is considered stable or slightly declining, while the abundance of California Sea Lions in 2020-21 was a threefold increase since 2009-10, with no significant increase since 2017 (Tucker et al., Section 31).

In the Salish Sea, there are trends of increasing temperature and decreasing oxygen at all depths, and waters are generally becoming fresher at surface and saltier at depth (Donnet and Chandler, Section 37). During the spring of 2022, conditions were cooler, saltier, and less oxygenated than normal. These conditions continued through the summer at depth but surface waters were warmer, fresher and more oxygenated than normal. Thus, stronger than normal summer stratification occurred in 2022. In the fall, conditions were notably warmer at the surface, as well as saltier (Juan de Fuca) and less oxygenated than normal at most depths. In 2022, the Fraser River annual discharge was near-normal overall but below normal in the fall; the peak discharge was late (~1 month; Donnet and Chandler, Section 37; Figure 3-7).

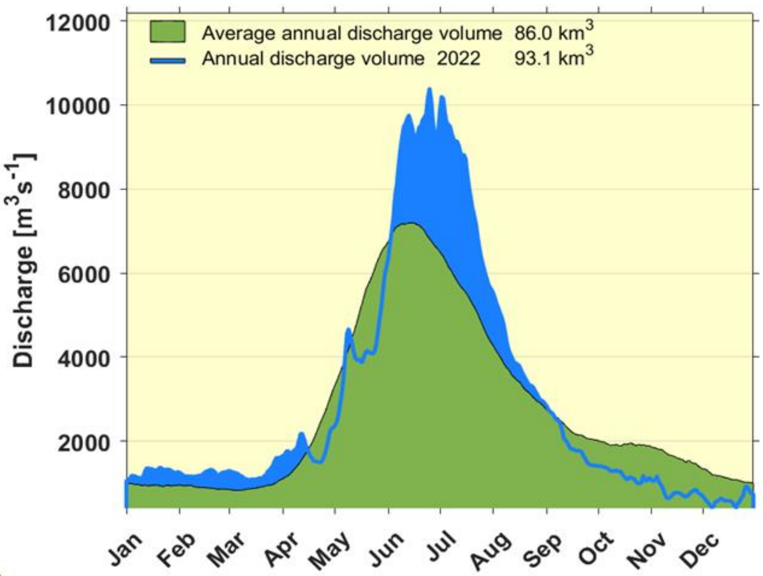


Figure 3-7. Fraser River discharge at Hope B.C.; 2022 (blue), 111 year average (green). Extracted from the Environment and Climate Change Canada Real-time Hydrometric Data web site, station number 08MF005, "FRASER RIVER AT HOPE" (https://wateroffice.ec.gc.ca/mainmenu/real_time_data_index_e.html) on 30 Jan 2023. Source: Donnet and Chandler, Section 37.

In the Strait of Georgia (SOG), 2022 was the first year since 2015 when all five harmful algal bloom taxa formed dense but localized blooms. In summer, there were dense blooms of *Heterosigma akashiwo, Dictyocha, Noctiluca scintillans, Rhizosolenia setigera,* and *Pseudo-nitzschia* in some areas (Esenkulova et al., Section 42). Harmful algal blooms can cause finfish and shellfish mortalities, impacts to human health, and economic losses. Marine Aquatic Invasive Species (AIS) are increasing in both range and abundance in B.C. For example, there has been an expansion of European Green Crab around Haida Gwaii and the Salish Sea (Gale et al., Section 48). This high-impact invader that negatively affects eelgrass, an important fish habitat, was detected for the first time on Haida Gwaii in July 2020 (Gale et al., Section 48). Preventing the spread of AIS requires management and monitoring of anthropogenic pathways and vectors as early detection of AIS can inform management and policy. Other anthropogenic stressors include oil spills, vessel traffic and underwater noise. For example, in 2022, there were 1054 oil spills reported to DFO; the most significant was the Fishing Vessel Aleutian Isle which sank with 15000 L of diesel on the U.S. side of the Juan de Fuca Strait (Herborg et al., Section 34).

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 early compared to the long-term average (Allen and Latornell, Section 40; Dewey et al., Section 38; Esenkulova et al., Section 42). In fact two spring blooms occurred, one in February followed by another one in April (Esenkulova et al., Section 42); the implications for feeding conditions for juvenile fish are unclear. In 2022, the SOG zooplankton biomass decreased but was still higher than the time series average since 1996 (Young et al., Section 43). Medium and large-sized copepods, important juvenile salmon prey, dominated the biomass (Young et al., Section 43).

Coastwide Pacific Herring biomass has been increasing since 2010, dominated by the SOG stock; however, in some assessed areas, such as Haida Gwaii, there have been prolonged periods of low biomass (Cleary et al., Section 24; Figure 3-8).

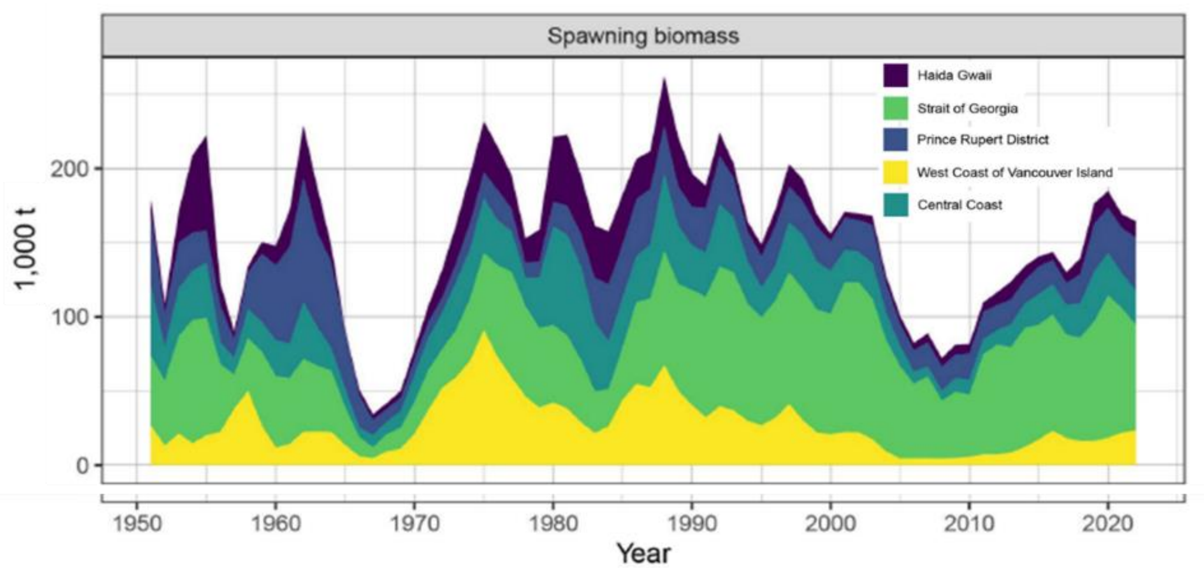


Figure 3-8. Pacific Herring spawning biomass of five assessed areas, 1951- 2022. Source: Cleary et al., Section 24.

In summer 2022, Pacific Herring biomass and CPUE in continental shelf waters off the WCVI (mixed stocks) were the highest in the 2006-2022 time series (Boldt et al., Section 25). In the SOG in the fall of 2022, the relative biomass of age-0 Pacific Herring was higher than that observed in 2021, but still below the time series mean; a very low biomass estimate of age-0 may indicate low recruitment to the adult SOG population (Boldt et al., Section 44). In 2022, Northern Anchovy were present in 48% of the SOG age-0 Pacific Herring survey sets; this is the third highest percentage in the time series (Boldt et al., Section 44). In 2022, the index of Fraser River Eulachon spawning stock biomass was estimated to be one of the lowest in the time series (~10 tonnes; Flostrand and Ens, Section 23). However, mean Eulachon catch per unit effort from a WCVI multispecies bottom trawl survey was moderately high (Flostrand and Ens, Section 23).

In the fall of 2022 in the SOG, juvenile salmon survey index of Coho Salmon abundance (catch per unit effort) was above average, Chinook Salmon was average, Sockeye and Chum Salmon were below average, while Pink Salmon was the highest observed since 2010 (Neville, Section 45). Also, juvenile Coho Salmon remained bigger than average (Neville, Section 45). Chum and Pink Salmon were the dominant juvenile salmon species encountered in summer and fall on the continental shelf of the northern and western coast of Vancouver Island (King et al, Section 25). Chum Salmon relative abundance in summer was below average. Pink Salmon relative abundance in fall was above average. These juvenile salmon, and those caught in summer, were in better condition than usual.
Many Canadian populations of Pacific salmon have exhibited significant declines in abundance coinciding with global climate change in the freshwater and marine ecosystems salmon inhabit (MacDonald et al., Section 27; Figure 3-9). The marine survival of B.C. Sockeye Salmon indicator stocks were generally below or near the long-term average for 2022; return abundances were below average for most populations except Francois and Osoyoos lakes, which had average to above average returns (Bailey and Freshwater, Section 28). Chinook Salmon returns in 2022 continued their trend of low abundances in many areas, with exceptions (examples: WCVI hatchery returns, east coast of Vancouver Island Fall returns). In 2022, Pink Salmon returns were average to above average in northern B.C. and on the east coast of Vancouver Island, and below average on the central coast and mainland inlets. Chum Salmon returns in 2022 were generally poor to extremely poor with some exceptions: Nass, enhanced Bella Coola, and lower SOG Chum Salmon. Coho Salmon returns to many systems were near average, while others were mixed (MacDonald et al., Section 27).

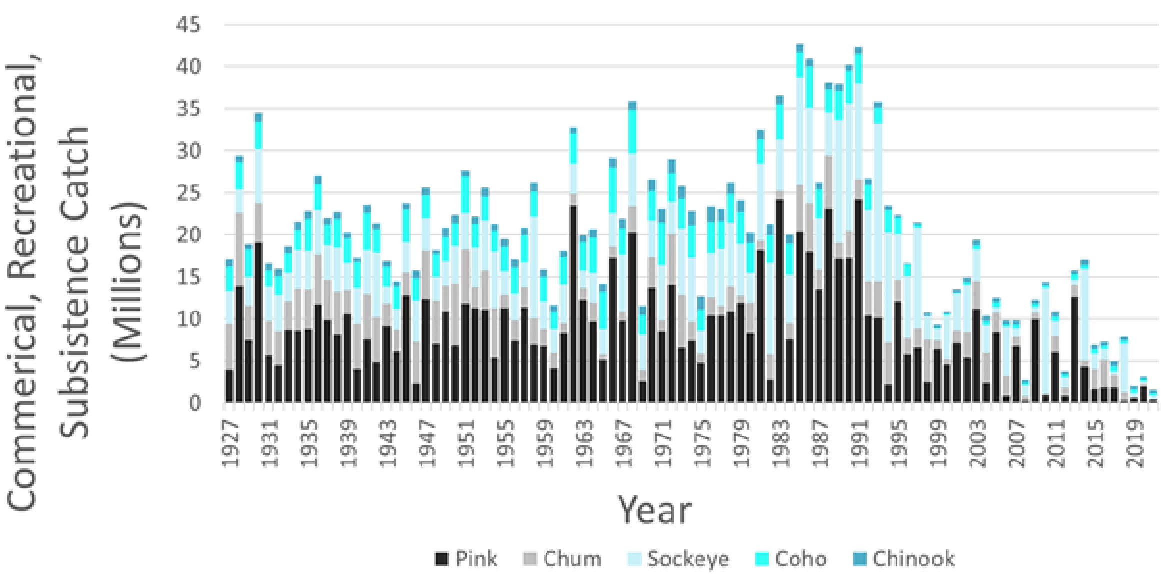


Figure 3-9. Commercial, recreational and Indigenous subsistence catch of Canadian Pink, Chum, Sockeye, Coho and Chinook Salmon (Grant et al. 2019; NPAFC statistics: https://npafc.org/statistics/). Average catch from 1925-1993 was 24.2 million, and from 1994-2014 was 13.4 million. Catch since 2015 has averaged 4.8 million, with the lowest catch on record occurring in 2021 (1.6 million). Source: Grant et al., Section 27.

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II. Observational programs

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

Ongoing:

1. Line P: nominally continuing at 3 surveys/year (February, May/June, August/September), starting in the 1950s (spring 2022 survey cancelled); 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 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 2021), with intensified sampling in

2010 and 2011. Areas of emphasis: hydrography and circulation, nutrients, phytoplankton, vertical flux of organic matter & contaminants.

4. Strait of Georgia zooplankton survey (is 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. In 2020, stations in Toba Inlet and Burke Channel were added. 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, DO13C, dissolved inorganic carbon, chlorophyll, HPLC, phytoplankton composition, viral and bacterial abundance, and zooplankton (biomass, composition, fatty acids and isotopes). Areas of emphasis include ocean climate, ocean acidification, marine food webs, watershed to oceans, and salmon.
6. Discovery Islands near Quadra Island (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, DO13C, 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 (except 2020), 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 and 2021) 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
    a. 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*).

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

e.) 2019 - Fisheries and Oceans Canada in partnership with the Nuu-chan-nulth Tribal Council and Ocean Networks Canada completed an offshore Drop Camera Survey. 4 seamounts were visually surveyed with the deep sea drop camera. This survey also heights of 13 other seamounts. During this survey we launched 2 ocean gliders and collected oceanographic samples at 25 sites.

f.) 2021 - Fisheries and Oceans Canada in partnership with an onshore team from the Nuu-chan-nulth Tribal Council and the Council of the Haida Nations, and Ocean Networks Canada completed an offshore Drop Camera Survey focusing in Deeper seamounts. This survey has been able to confirm the locations and depths of 30 (21 before 2021 and +9 during 2021) unnamed seamounts and collected accurate mapping of 15 (13 <2021 and +2 during 2021) well known seamounts (in total, 45 seamounts at least partially mapped). This work has increased the number of known seamounts in the Canada Pacific offshore from the 24 known in 2017 to 65 (62 <2021 and +3 during 2021). We have been able to visually survey 17 seamounts, (12 <2021 and +5 during 2021) [bonus: plus an bathyal plane, a knoll, and a cold seep field].

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

d) In 2018, 2019, 2021 DFO completed ROV surveys in the deep water inlets and Channels in the Central Coast of BC. These surveys examined coral and sponge distribution in these unexplored habitats. New sponge and coral habitats were discovered on all surveys.

F. Autonomous monitoring with gliders and Argo profiling drifters. Canada has been very active in the successful international Argo program. Since the start of the program, Canada has deployed many floats (see https://www.ocean-ops.org/board?t=argo), including 13 in the NE Pacific. 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). Over the course of 2022, Canadian gliders logged ~10,000 kilometers, ~12,000 CTD profiles and flew ~430 days at sea in the NE Pacific. 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 Clare Ostle on some of the analyses and publications (see http://pices.int/projects/tcprsotnp/).

H. Ocean observatory networks (Ocean Networks Canada)

The coastal component of Ocean Networks Canada's observing system consists of:

i. Cabled undersea oceanographic sensor and benthic camera installations in Saanich Inlet (since 2006), the Strait of Georgia (since 2008), outer Barkley Sound (since 2011), together with seven community-based cabled observatories on Vancouver Island, the British Columbia mainland, in the Canadian Arctic at (Cambridge Bay, Nunavut), and in Conception Bay, Newfoundland.
ii. Data delivery from partner Smart Atlantic buoys around Newfoundland, New Brunswick and Nova Scotia

iii. Sensor platforms on ferries on three routes between Vancouver and Vancouver Island was completed in 2015.
iv. 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 that provide real-time information on surface ocean conditions and vessel traffic.
v. A growing Community Fisheries program where coastal community members conduct regular CTD profiles at fixed locations in coastal waters of British Columbia, Nunavut and Atlantic Canada.
vi. Autonomous oceanographic moorings (since 2012) in the Salish Sea provide continuity between Salish Sea and offshore observing systems.

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.

ONC began hosting the Pacific node of the Canadian Integrated Ocean Observing System in early 2019.

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 (https://www.dfo-mpo.gc.ca/science/data-donnees/lightstations-phares/index-eng.html).

J. Hakai Institute autonomous instrumentation

Hakai Institute’s supported oceanographic activities

Wiley Evans, Hakai Institute, Lead Oceanographer

1. 12 autonomous monitoring initiatives running, dis-continued, or planned during the 2022-2024 period:
    a. Canadian-Pacific Robotic Ocean Observing Facility (C-PROOF) glider line maintained from Calvert Island running since 2019.
    b. Burke-o-Lator pCO2/TCO2 analyzer continuously monitoring ocean acidification conditions adjacent to the Quadra Island Ecological Observatory running since 2014.
    c. KC (Kwakshua Channel) buoy monitoring ocean acidification conditions at the mouth of Kwakshua Channel running since 2018.

d. Burke-o-Lator pCO2/TCO2 analyzer continuously monitoring ocean acidification conditions adjacent to the Bamfield Marine Sciences Centre running since 2023.
e. Moored thermistor string in Pruth Bay running since 2017.
f. Moored ocean acidification monitoring station in Discovery Passage running since 2020.
g. Ship-of-opportunity surface ocean acidification monitoring from Seaspan tug M/V Seaspan Royal running since 2022.
h. Moored ocean acidification monitoring station in Owen Bay from 2021 to 2022 (discontinued).
i. Sub-surface mooring in Rivers Inlet from 2020 to 2023 (discontinued).
j. Ship-of-opportunity surface ocean acidification monitoring from Alaska state ferry M/V Columbia from 2017 to 2019, planned to be reinstated in 2023.
k. Surface mooring in Bute Inlet to monitor ocean acidification conditions; planned deployment in early 2024.
l. C-PROOF Wirewalkers (2) deployed in Bute Inlet; planned deployments in 2024.

2. 56 oceanographic stations sampled with varying frequency (weekly to 1x/year)
   a. 2 oceanographic stations, KC10 on the central coast and QU39 in the Salish Sea, include detailed chemical and biological sampling to track the implications of marine stressors (e.g., ocean acidification, hypoxia, marine heatwaves) on ecosystem function.

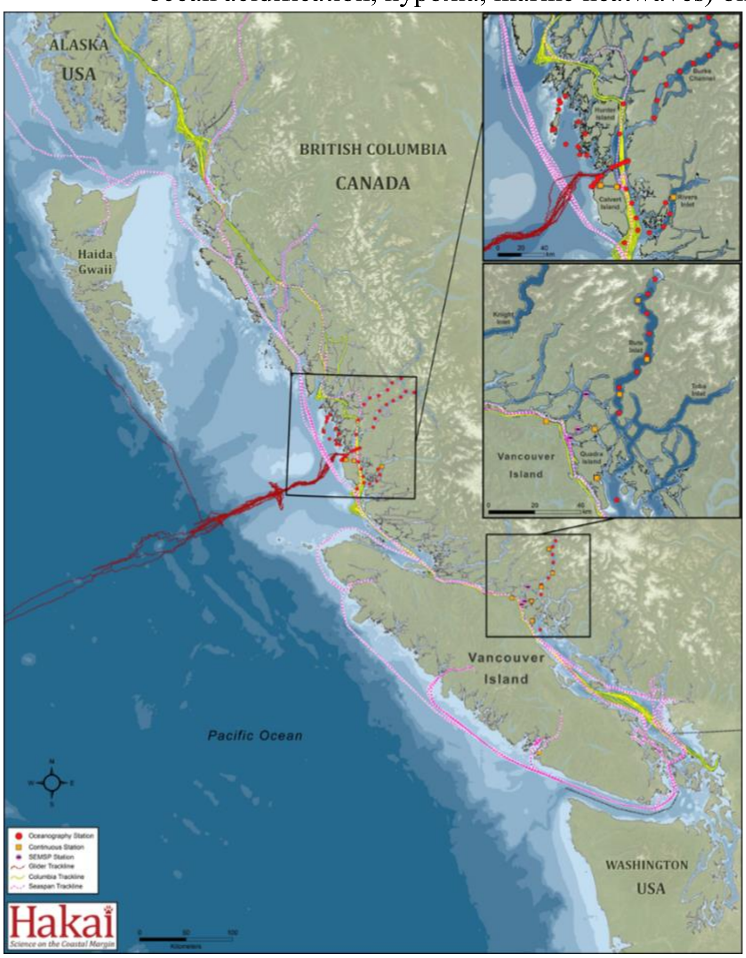

Figure 2. Locations of Hakai Institute supported oceanographic activities either running, discontinued, or planned during the 2022-2024 period.

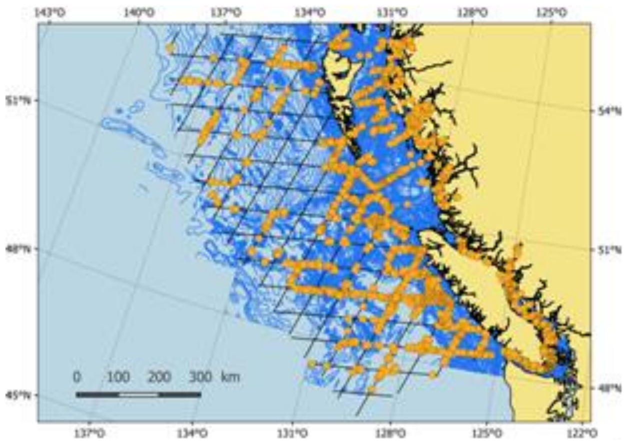

Figure 3. 2018 Pacific Region International Survey of Marine Megafauna (PRISMM). Visual and acoustic detections were made along 17,000 km of pre-determined systematic line transects. The survey resulted in over 2800 sightings of marine mammals, mostly concentrated in inshore passages and inlets, on the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

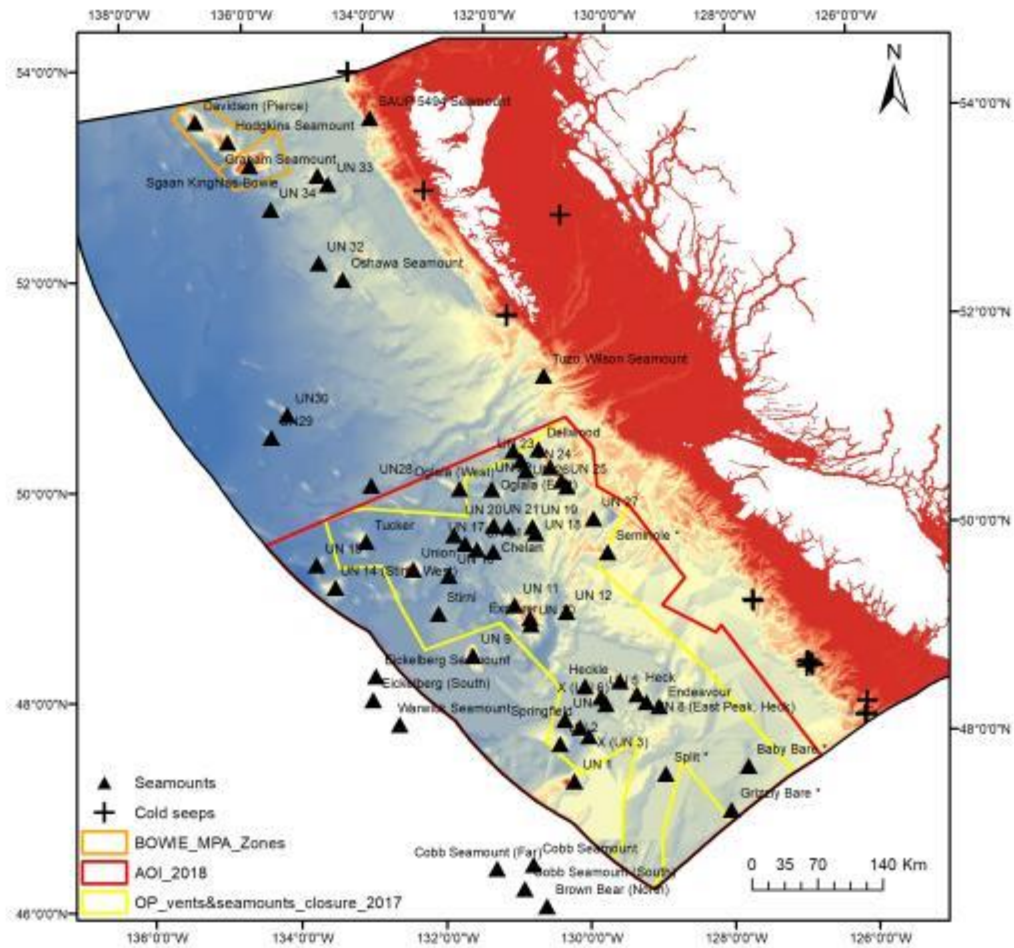

Figure 4. 2019 Survey of the Offshore Area of Interest (AOI). Source: Tammy Norgard (DFO).

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2. United States of America

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

USA National Report to MONITOR, 2022-2023

Jack Barth (Oregon State University), Kym Jacobson (Northwest Fisheries Science Center, NMFS, NOAA) and Lisa Eisner (Alaska 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, coastal pelagics)
- Long-term hydrographic and zooplankton lines: CalCOFI (California), Newport Hydrographic (Oregon), Trinidad Head (California)
- Juvenile salmon and rockfish recruitment surveys
- 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
- Bird and marine mammal observations
- Harmful Algal Bloom monitoring

Alaska oceanography and fisheries surveys and observations for 2022-2023 include:

- North Pacific Ocean
  - Sea Level Pressure (SLP) by season
  - Sea Surface Temperature (SST) by season
- Bering Sea and Arctic
  - Ice Extent
  - SST (northern and southeastern)
  - Phytoplankton
    - Spring bloom
    - Coccolithophores
  - 2023 surveys
    - Oceanographic biophysical mooring and hydrographic
    - Arctic Distributed Biological Observatory (ecosystem)
    - Ground Fish Bottom Trawl
    - North Bering Sea surface trawl and ecosystem
    - Harbor Seal Aerial Surveys

- Gulf of Alaska (GOA)
    - SST (GOA and Aleutian Islands)
    - 2023 surveys
        - Ground Fish Bottom Trawl (biennial)
        - Winter and Summer Acoustic-Trawl
        - Sablefish Longline
        - Spring Ichthyoplankton (biennial)
        - Juvenile Groundfish and Forage Fish
        - Southeast Coastal Monitoring (SECM) surface trawl and eocsystem
        - Western GOA Summer Beach Seine for Pacific cod
        - Marine mammal surveys (5 listed)

<u>Survey Monitoring Efforts</u> <u>on the</u> *<u>US West Coast, 2022-2023:</u>*

There are three NOAA surveys that collect physical data through lower trophics seasonally to bi-weekly

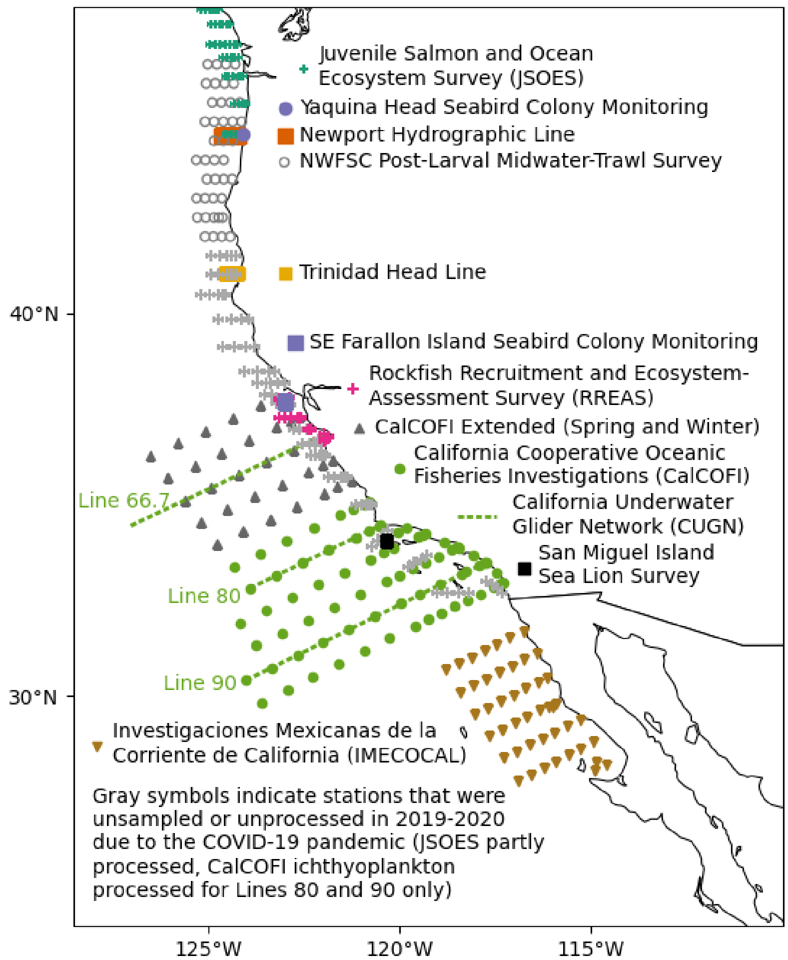

Figure 1. Hydrological and biological surveys used to assess the state of the California Current ecosystem. From the 2021 State of the California Current Report by E. Weber, NOAA Fisheries, SWFSC.

(depending upon the program) off Washington, Oregon and California. These include research and monitoring programs on the Newport Hydrographic Line in Oregon, the Trinidad Head Line in Northern California, and the California Cooperative Fisheries Investigations (CalCOFI) in Southern 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 seabird colonies and 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 to the Pacific Fisheries Management Council (PFMC) each March: https://www.pcouncil.org/documents/2023/02/h-1-a-cciea-team-report-1-electronic-only-2022-2023-california-current-ecosystem-status-report-and-appendices.pdf/

In addition to these surveys there are several coastwide fisheries surveys designed to provide data for stock assessments: the NOAA Fisheries Northwest Fisheries Science Center (NWFSC) in collaboration with Canada's Department of Fisheries and Oceans conduct semi-annual Pacific hake surveys. The most recent survey (2023) is still underway (Figure 2) The initial NWFSC hake survey was conducted in 2003. Transect spacing was expected to be 10 nmi from Point Conception (34.5°N) to the north end of Vancouver Island (50.5°N) and 20 nmi spacing north of Vancouver Island to Dixon Entrance (54.5°N). To cover the entire survey area with the above constraints, the survey returned to the 1500 m offshore limit protocol used in the pre-SaKe survey period (1995-2011), and also skipping every eighth transect from the starting point to the north end of Vancouver Island.

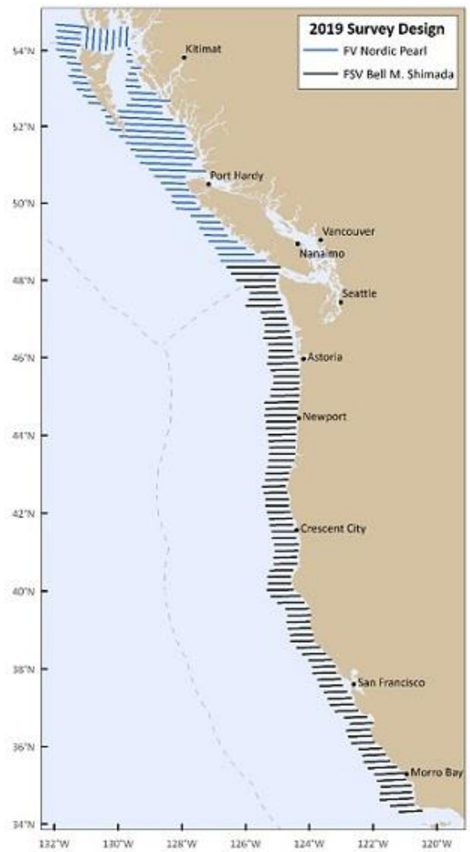

Figure 2. Acoustic-trawl survey transects for the NOAA Ship Bell M. Shimada (black, NWFSC) and the chartered vessel Nordic Pearl (blue, DFO).

Groundfish surveys have also been conducted over the shelf and slope (55 – 1280 m) annually by the NWFSC since 2003 (except in 2020) from the border with Mexico to Canada. The summer-fall 2022 (Figure 3) consistsed of Pass 1 from May 16 – July 26: 294 stations from US/Canada to US/Mexico with some sites not sampled due to delays caused by COVID-19 and the remainder not sampled due to a high number of cells with untrawlable bottom when searched. The second half of the survey began with Aug. 27, 2022 with plans to sample 376 sites and again cover the entire area from US/Canada to US/Mexico at depths of 55 -1280 m. The 2023 survey is still underway and scheduled to end near the end of October.

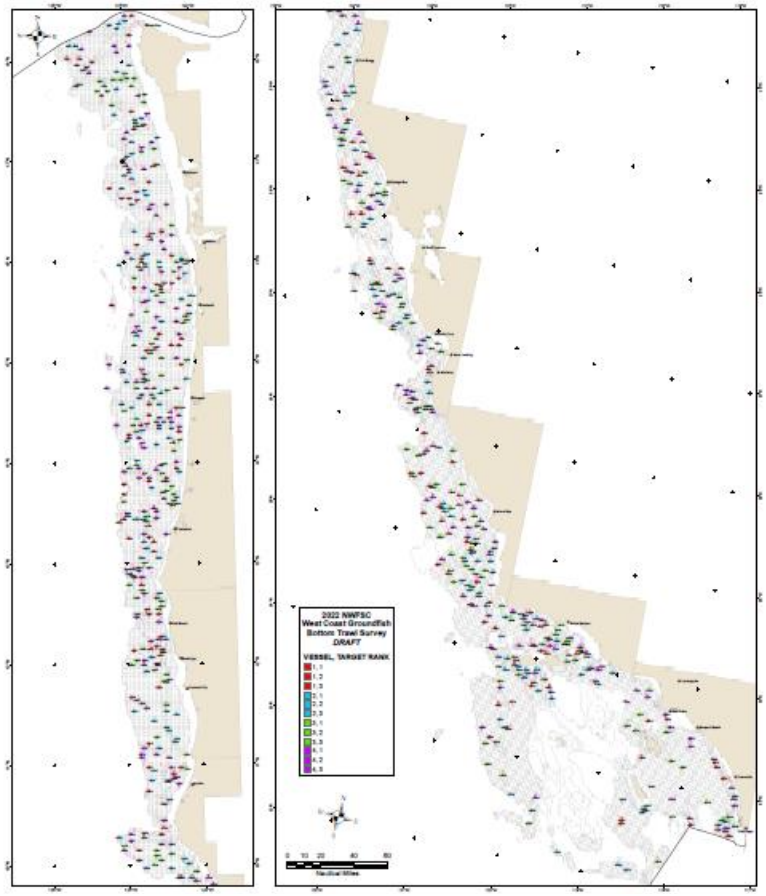

Figure 3. Target stations for 2023 NOAA groundfish survey off U.S. west coast. Left panel = northern Washington State through northern California. Right panel = northern California through southern California. *Aimee Keller NOAA Fisheries*

The NOAA Fisheries Southwest Fisheries Science Center conducts an annual Acoustic-Trawl Method Coastal Pelagics Survey that samples annually from off northern Vancouver Island, British Columbia to San Diego, California. Sampling this year and in 2022 included sampling off Mexico and nearshore sampling in collaboration with the industry (Figure 4).

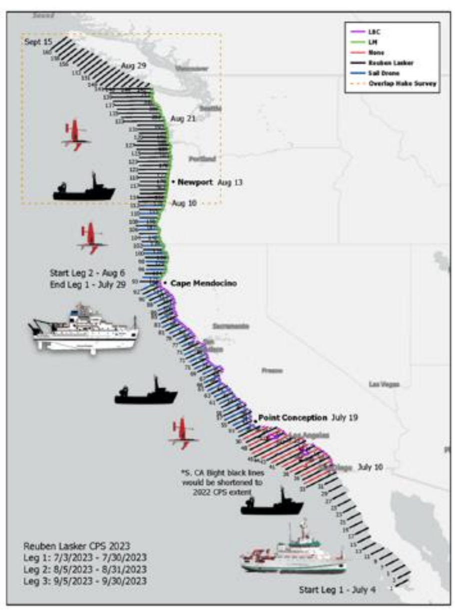

Figure 4. Planned sampling for the 2023 NOAA SWFSC survey for coastal pelagic species. SWFSC

Rockfish Recruitment and Ecosystem Assessment Survey (RREAS): Catches of YOY groundfish have been enumerated from central California in late Spring since 1983 from the, with catches of most other forage taxa reliably estimated from 1990 onward. The survey was expanded to sample most California marine waters starting in 2004 (Sakuma et al. 2016, Santora et al. 2021), and a comprehensive list of additional forage taxa that are also encountered is available in either of those manuscripts. The NWFSC Pre-recruit/NCC survey has included a nighttime trawling component using identical gear and methods since 2011. The taxa reported here are both among the most frequently encountered forage species in this survey, and among the most important forage taxa for higher trophic level predators. Catches were standardized by using a Bayesian delta-GLM to estimate year effects while accounting for spatial and temporal covariates, and to estimate approximate 95% confidence limits (see Ralston et al. 2013, Santora et al. 2021b).

The 2022 survey suffered from numerous logistical setbacks related primarily to staffing issues on the NOAA ship Reuben Lasker, and the need to impose health and safety protocols due to COVID-19, resulting in the loss of essentially all Leg 1 sea days, and a considerable fraction of the leg 2 sea days. Consequently, survey effort was reduced to 60 trawls, very few north of the core survey area, conducted during 17 operational sea days out of a scheduled 44. An additional 12 trawls were conducted in late June in conjunction with a National Marine Sanctuary survey, for a total of 72 trawls in California waters, far less than the 2004-2021 (excluding 2020) average of approximately 150 trawls per year. An additional 26 trawls were conducted off Oregon waters by the NCC survey.

Summary: Standardized anomalies of log-transformed catch indices of key forage taxa (Figure 5) suggest relative abundance shifts in the forage base within central California, with continued high abundance in the face of declines in young-of-the-year (YOY) and adult northern anchovies from recent record high levels, and close to long-term average abundance levels of YOY groundfish (rockfish, sanddabs and Pacific hake). Krill abundance continued a steady increase observed in recent years from the low levels observed in 2019, and myctophids (lanternfishes) were more abundant, but close to long-term average levels. Market squid and octopus were slightly less abundant in 2022 relative to recent years. Very few Pacific sardine were encountered in the central region in 2022, and catches in recent years of sardine are insufficient to say anything meaningful about abundance other than that it is very low. The cumulative results of these trends indicate a fairly productive ecosystem, with anchovy continuing to dominate the forage community but with a greater abundance of alternative forage, and with very few taxa being at low abundance levels.

Catches in other regions of the California Current: Catches of the same suite of taxa were generally consistent with those in the core area for southern California waters, with the exceptions of YOY northern anchovy were more abundant relative to the long-term trend, while adult anchovy were less abundant compared to central California. Additionally, YOY rockfish and krill were slightly below long-term mean levels for that region, while pelagic octopus were slightly above long-term mean levels (rather than significantly below).

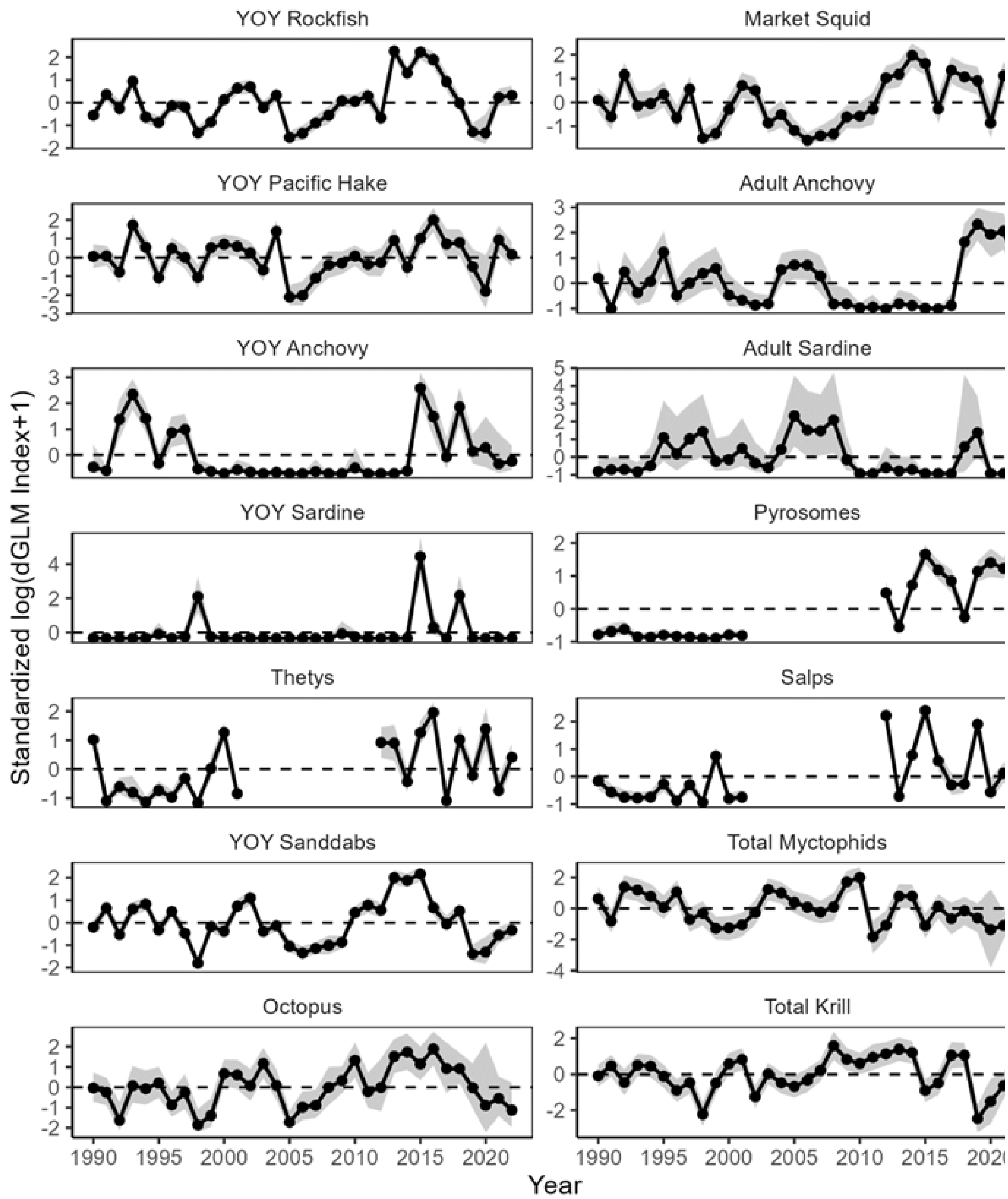

Fig 5. Standardized anomalies (based on ln transformed delta-glm model results) of key forage taxa sampled by the Rockfish Recruitment and Ecosystem Assessment Survey in the core survey region (Central California) 2022.

The following highlights (and select figures) of conditions observed from surveys in 2022 include information from the CCIEA report to the PFMC: https://www.pcouncil.org/documents/2023/02/h-1-a-cciea-team-report-1-electronic-only-2022-2023-california-current-ecosystem-status-report-and-appendices.pdf/

Additional highlights are included as are early season 2023 conditions.

- The 4th largest marine heatwave since 1982 observed in the North Pacific occurred in 2022, with more coastal influence than recent years.

- Blooms of the diatom *Pseudo-nitzschia* spp. can produce domoic acid, a toxin that can affect coastal food webs and lead to shellfish fishery closures when shellfish tissue levels exceed regulatory limits. An increase Domoic acid levels in late 2022 led to shellfish closures or delays.
- In 2022, northern copepods continued an overall positive trend since the extreme lows during the 2014-2016 heatwave. They were >1 s.d. above the mean in spring and early summer 2022 before dropping early in biomass before their regular seasonal transition in the fall (Figure 6).

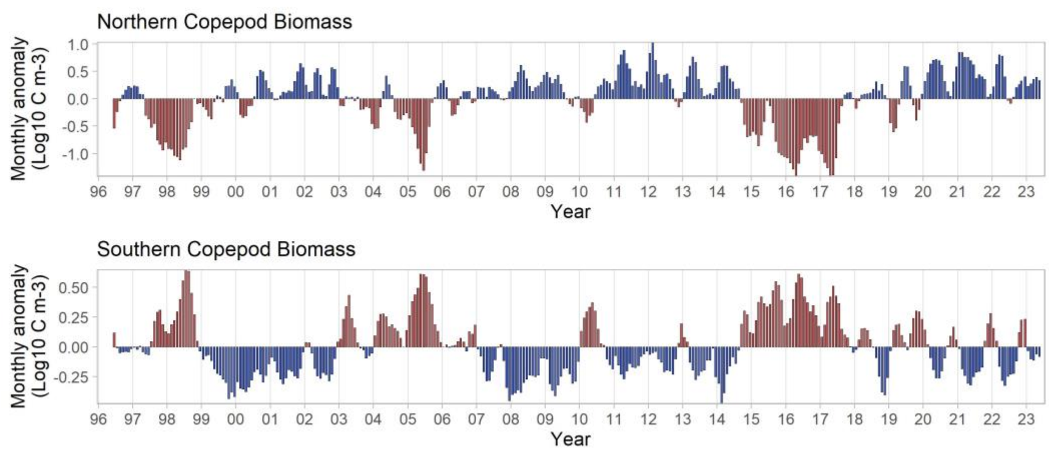

Figure 6. Three-month running mean of anomalies of biomass of northern and southern copepod taxa recorded off Newport, OR at NH05: Peterson Zooplankton Lab, NOAA, NMFS, Newport, OR

- *Euphausia pacifica*, a key krill species within the CCE, is sampled year-round along the Trinidad Head Line off northern California. Mean length of adult *E. pacifica* is an indicator of productivity at the base of the food web, krill condition, and energy content for predators. *E. pacifica* length was near-average during the second-half of 2021 and throughout 2022. With the onset of upwelling in 2023, length increased and was slightly above average by May (Figure 7a). For most of 2022, krill biomass was low to near-average (Figure 7b). In 2023, biomass increased to moderate levels during early spring, a pattern that reflects larger krill size and a greater density of adults (not shown). *Text and figure provided by Roxanne Robertson, NOAA Fisheries.*

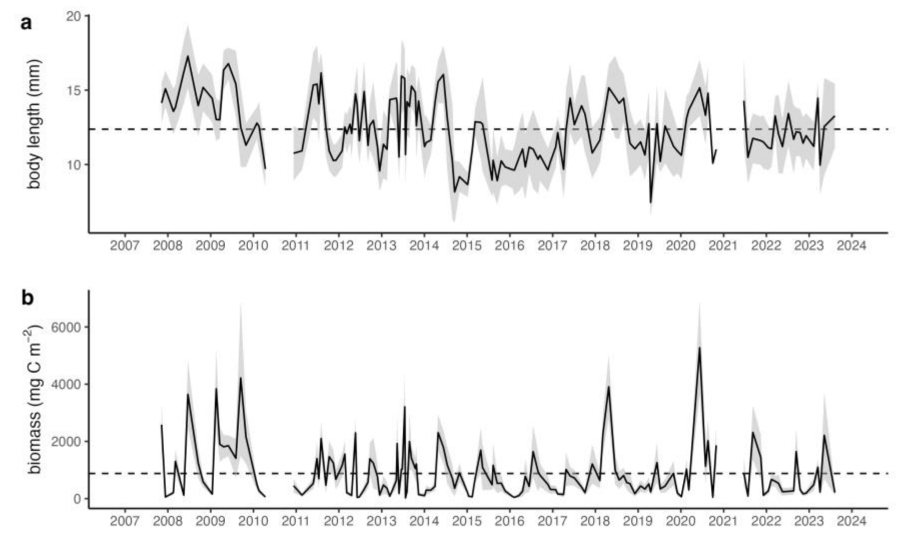

Figure 7. Krill observations along the Trinidad Head Line, 2007 – May 2023. a) Monthly mean length of *E. pacifica* and b) total biomass of *E. pacifica* . Gray envelopes indicate ± 1.0 s.d.

- The Northern CCE survey off Washington and Oregon targets juvenile salmon in surface waters, and also samples surface-oriented fishes, squid and jellies. Yearling Chinook salmon (*Oncorhynchus tshawytscha*) abundance during June surveys correlate positively with returning spring Chinook jack and adult salmon counts at the Bonneville Dam in the Columbia River (with 1 and 2 year lags, respectively), as do the abundance of yearling coho salmon (*O. kisutch*) to subsequent coho salmon smolt to adult survival (Morgan et al. 2019). Catch-per-unit effort of both yearling Chinook and coho salmon during the June 2022 survey was near average. Based solely on the correlations observed in previous years, this suggests that adult returns of spring Chinook salmon in 2024 and coho salmon returns in 2023 will be close to average, though other ecological factors will influence this relationship. California market squid (*Doryteuthis opalescens*) and Pacific pompano (*Peprilus simillimus*) were observed at higher than average densities since the beginning of the marine heat wave. In 2022, the density of market squid was above average and Pacific pompano densities were slightly higher than average.

- Anchovies remained abundant in surveys and predator diets in 2022 in the central and southern California Current and remain so in the south again in 2023.

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North Pacific climate and Alaska fisheries oceanography surveys and observations for 2022-2023

Compiled by Lisa Eisner, NOAA Alaska Fisheries Science Center (AFSC), USA

Acknowledgements: Nick Bond, Matthew Callahan, Lauren Rogers, Rob Suryan, Rick Thoman, Ellen Yasumiishi, Jens Nielsen, Elizabeth Siddon, Bridget Ferriss, David Kimmel, Ben Laurel, Alisa Abookire, Emily Fergusson, Sandy Parker-Stetter, Darin Jones

Time series of fisheries and oceanographic data and ecosytem evaluations (ecosystem status reports, ESR) can be found at https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands. Excerpts from the 2022 and 2023 ESR are included as indicated.

North Pacific Climate *(Excerpt, Bond 2023 ESR)*

Summary

The sea level pressure (SLP) over the mid-latitude North Pacific was generally greater than normal from autumn 2022 through summer 2023. The magnitude and position of the high pressure anomaly center varied seasonally but in general, the SLP anomaly pattern supported westerly wind anomalies for Alaskan waters. The positive SLP anomalies over the North Pacific were accompanied by warmer than normal sea surface temperatures (SSTs) between 30 and 50 ˚N across the western and central portion of the basin. This warmth extended eastward to near the coast of the Pacific Northwest, and moderated in its intensity in the western portion of the basin, during the summer of 2023. The relatively high SLP in an overall sense, i.e., weak Aleutian low, is consistent with co-occurring conditions in the tropical Pacific, which featured a long-lasting La Niña event ending in the late winter of 2023. The PDO was negative, in large part due to persistent positive SST anomalies in the western and central North Pacific. The climate models used for seasonal weather predictions indicate that El Niño is virtually certain to be present from late 2023 into 2024. In an ensemble sense, the models are also predicting that the first three months of 2024 will include near normal SSTs in the Bering Sea and Aleutian Island regions, and warmer than normal temperatures along the west coast of North America from northern California to the southeast GOA. The development of sea ice on the southeast Bering Sea shelf is liable to be delayed, as has been the rule over the past decade, with sea ice eventually expected to extend approximately as far south as St. Paul Island and Mooring 2

SLP and SST Anomalies
The state of the North Pacific climate from autumn 2022 through summer 2023 is summarized in terms of seasonal mean sea level pressure (SLP) and sea surface temperature (SST) anomaly maps. The SLP and SST anomalies are relative to mean conditions over the period of 1991-2020. The SLP data are from the NCEP/NCAR Reanalysis project; the SST data are from NOAA's Extended SST V5 (ERSST) analysis. Both data sets are made available by NOAA's Physical Sciences Laboratory (PSL) at https://www.psl.noaa.gov/cgi-bin/data/composites/printpage.pl.

<u>SLP</u>: The SLP pattern during autumn (Sep-Nov) of 2022 (Fig.1a) featured a band of strongly positive anomalies extending across the entire North Pacific north of about 35˚ N, with a center of about +4 millibars (mb) located south of the Alaska Peninsula. Negative SLP anomalies were present from eastern Siberia into the Chukchi Sea. This SLP distribution resulted in wind anomalies of ~ 2 m s-1 from the west across the Bering Sea, and easterly wind anomalies of 2-3 m s-1 between 35˚ and 45˚ N in the central and eastern North Pacific.

During winter (Dec-Feb) of 2022-23, there were positive SLP anomalies over the central North Pacific, with an anomaly center near 40˚ N, 150˚ W (Fig. 1b). Lower than normal SLP occurred over eastern Siberia into the western Bering Sea. The associated winds included westerly anomalies of 2 to 3.5 m s-1 from the southern Sea of Okhotsk through the eastern Aleutian Islands, and a clockwise sense of the anomalies in the GOA. These winds were accompanied by anomalous upwelling in the coastal GOA, and downwelling in the central, deep water portion of the GOA. Anomalous winds from the north were present off the coast of western North America.

Strongly positive SLP anomalies developed over the western and central North Pacific during the spring (Mar-May) of 2023 (Fig. 1c), with magnitudes exceeding 7 mb south of the Aleutian Islands. This SLP distribution resulted in westerly wind anomalies of roughly 2 m s-1 across most of the Bering Sea, northwesterly wind anomalies of 2-3 m s-1 in the western and central GOA, and easterly wind anomalies of 3-4 m s-1 in the central portion of the North Pacific between 35˚ and 45˚ N. Near normal winds occurred along the west coast of North America.

The summer (Jun-Aug) of 2023 reflected a transition from a prominent high SLP anomaly during the previous season to a dipole over the western North Pacific with lower than normal SLP extending from the Sea of Okhotsk to the west coast of mainland Alaska, and higher than normal SLP south of 40˚ N (Fig. 1d). The region between these two SLP anomaly centers experienced southwesterly wind anomalies of 2-3.5 m s-1. The positive SLP anomalies over the eastern GOA extending southward were accompanied by lower than normal precipitation for the coastal region from SE Alaska to the Pacific Northwest.

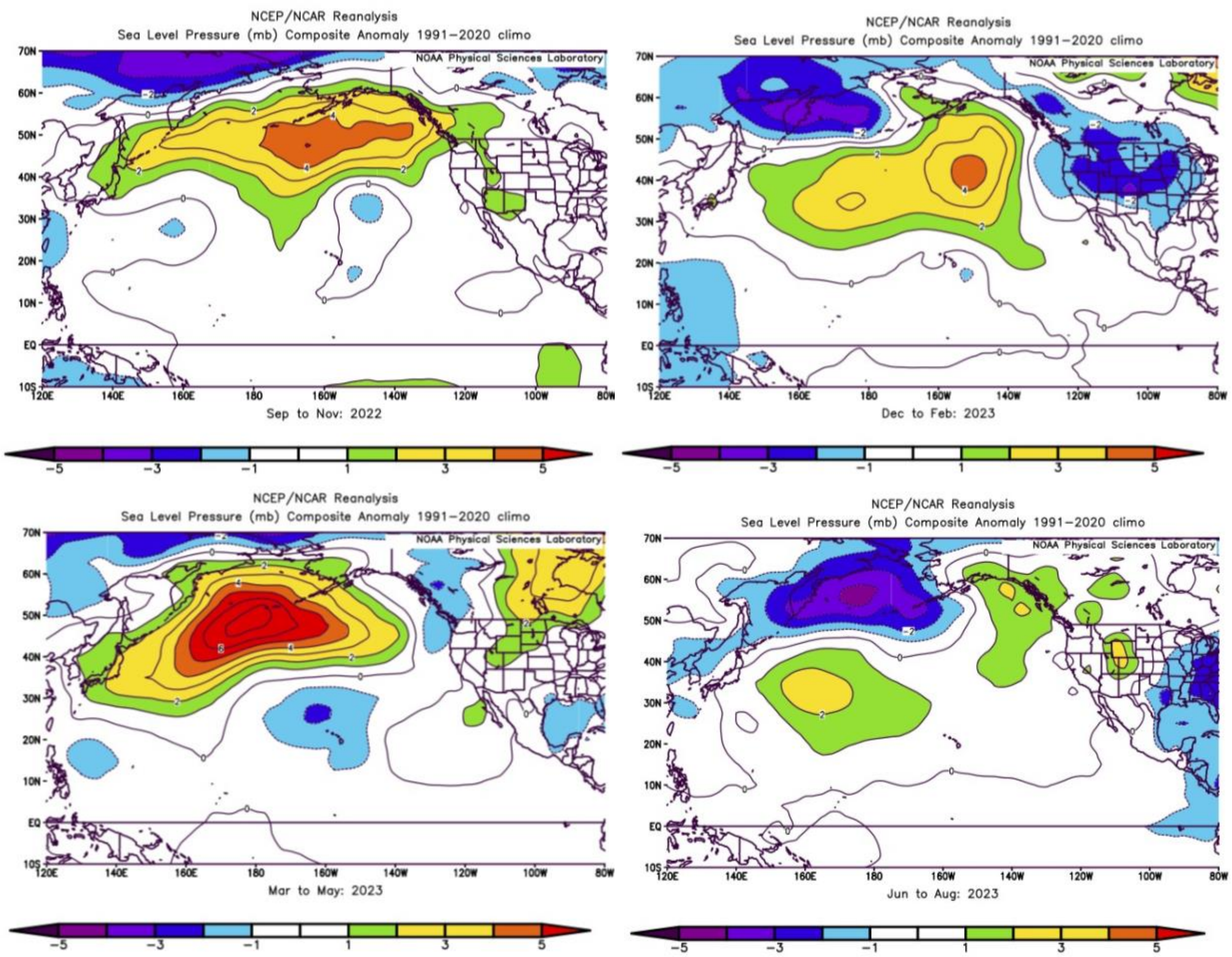

Figure 1. Mean sea level pressure (SLP) anomalies (hPa) for September-November 2022 (1a, top left), December 2022-February 2023 (1b, top right). March-May 2023 (1c, bottom left), and June-August 2023 (1d, bottom right). Figure courtesy of Nick Bond, University of Washington (UW)/ Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES).

<u>SST</u>*:* The autumn (Sep-Nov) of 2022 featured a broad band of warmer than normal SST that extended across the entire North Pacific (Fig. 2a), with anomalies exceeding 2.5 ˚C near 40˚ N and the dateline. Cooler water relative to seasonal norms was present in the Sea of Okhotsk and the eastern Bering Sea shelf. The central and eastern tropical Pacific was cooler than normal in association with moderate La Niña conditions.

The positive SST anomalies in the central North Pacific persisted through the winter (Dec-Feb) of 2022-23 (Fig. 2b), with moderation in the warm temperatures in the western North Pacific. During this season, Alaskan waters were mostly within 0.5 ˚C of normal. La Niña weakened, with only a small region of water 1 ˚C cooler than normal near the dateline in the equatorial Pacific.

A band of warm water centered along 40˚ N across all but the far eastern portion of the North Pacific was present during spring (Mar-May) of 2023 (Fig. 2c). Regions of cooler water reappeared in the Sea of Okhotsk and on the eastern Bering Sea shelf. The tropical Pacific had mostly near-normal SSTs with the exception of the immediate vicinity of the coast of South America, where positive anomalies began developing.

The summer (Jun-Aug) of 2023 brought marked moderation of the positive SST anomalies in the western North Pacific between 30˚ and 50˚ N but also an eastward extension of warm anomalies to the Pacific Northwest coast. This season also included a continuation of cool conditions in the eastern Bering Sea, the development of negative SST anomalies in the GOA, and cooling southwest of Baja California into the subtropical eastern North Pacific (Fig. 2d). The tropical Pacific featured strong warming east of 140 W, with the SSTs meeting the threshold for El Niño in June 2023, according to NOAA's Climate Prediction Center (CPC).

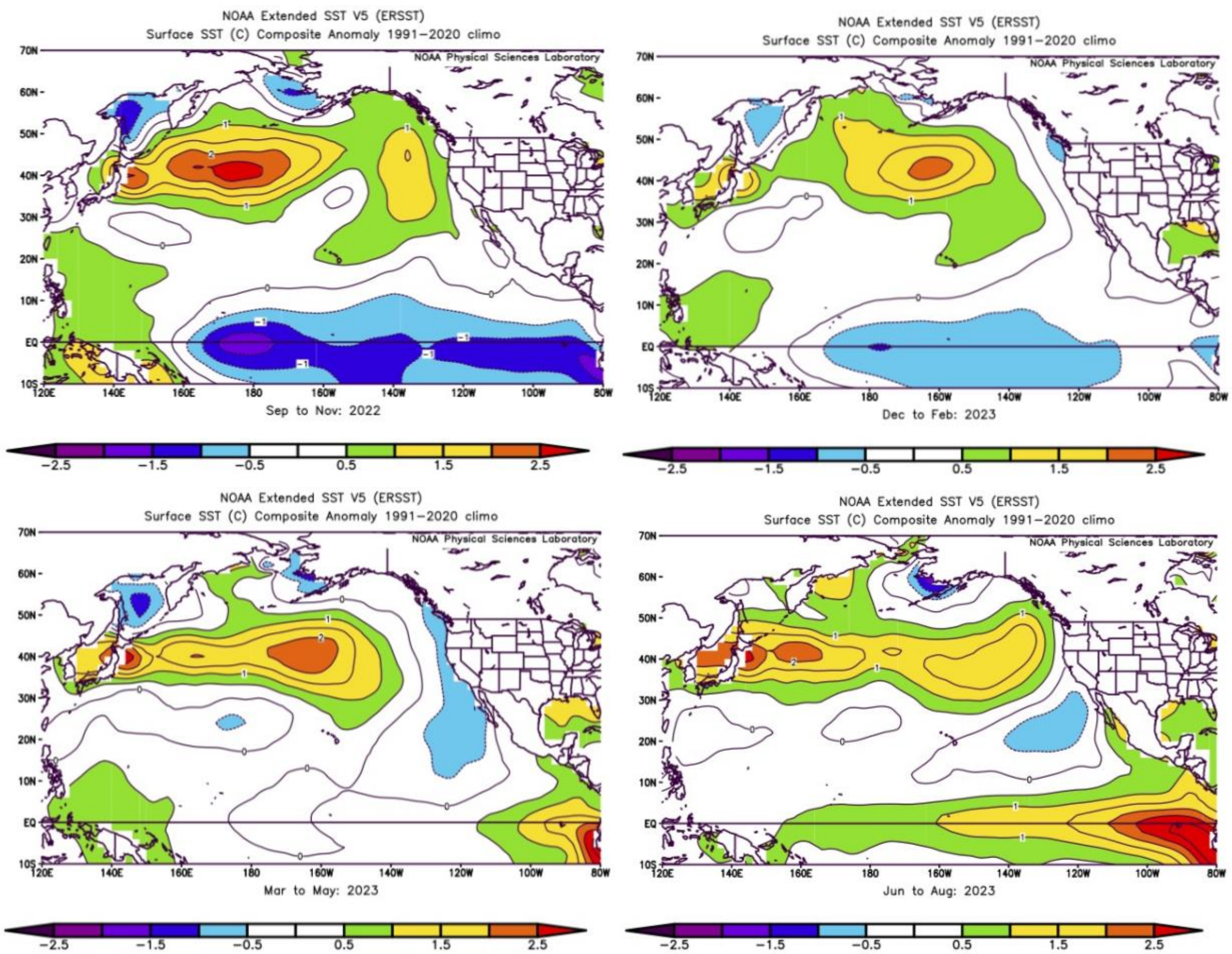

Figure 2. Mean sea surface temperature (SST) anomalies (˚C) for September – November 2022 (2a, top left), December 2022-February 2023 (2b, top right). March-May 2023 (2c, bottom left), and June-August 2023 (2d, bottom right).. Figure courtesy of Nick Bond (CICOES).

Bering Sea

Sea Surface Temperature (SST)

Satellite-derived estimates of SST for the Bering Sea were compiled by Matthew Callahan (NOAA AFSC). SSTs for December 2022 through mid-September 2023 in both the northern and southern Bering Sea were similar or slightly higher (southern Bering) than the long term mean/baseline value, with no heatwaves observed (Fig. 3). The time series graphs and SST data for the Bering Sea (and the Gulf of Alaska) can be updated daily at https://shinyfin.psmfc.org/ak-sst-mhw/

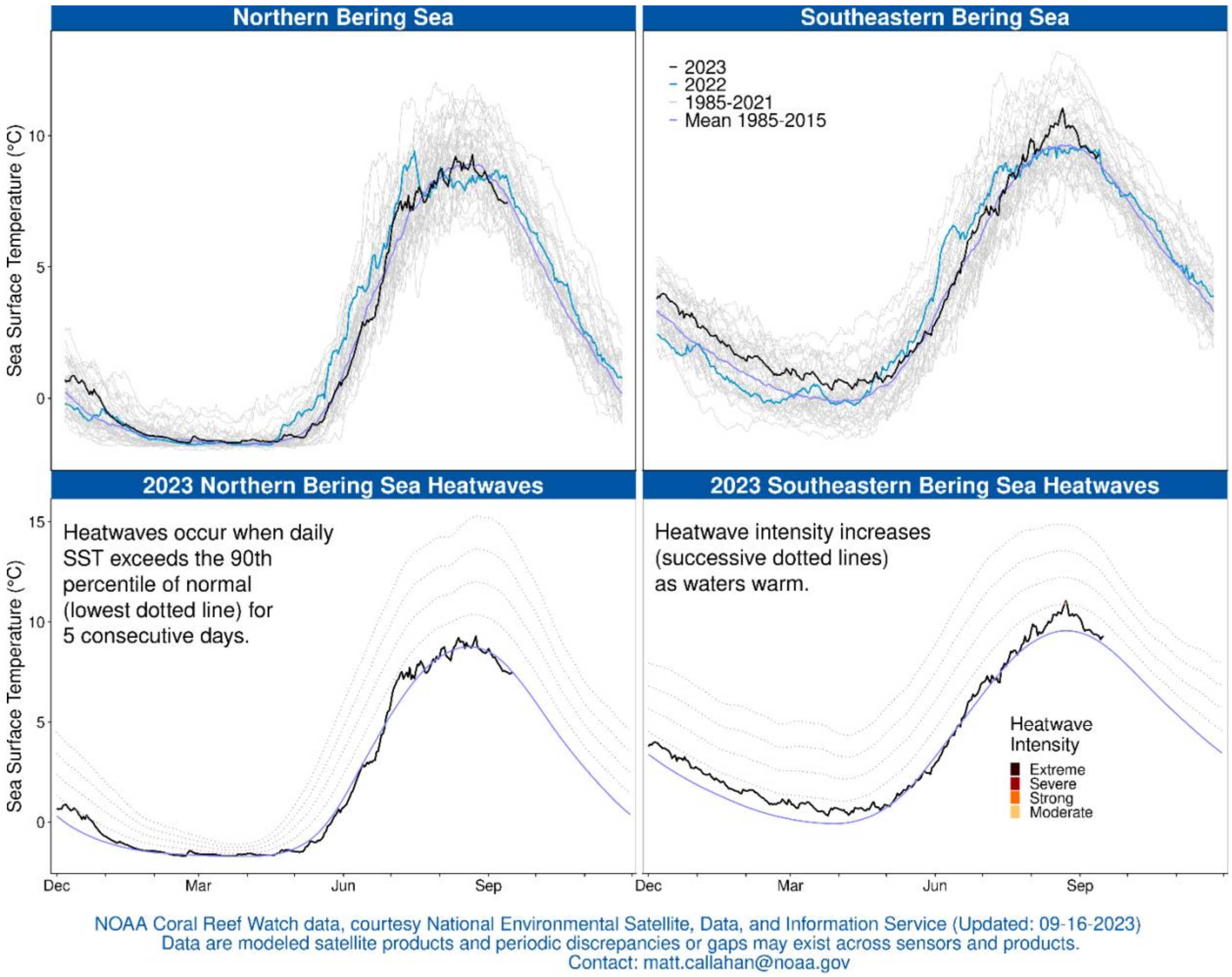

Figure 3. Daily mean SST for 2023 and 2022 compared to means for 1985-2015 for the northern Bering Sea (north of 60°N) and southeastern Bering Sea (south of 60ºN) from satellite analysis. Courtesy of Matt Callahan, NOAA AFSC.

Sea Ice Extent

Bering Sea ice extent was compiled by Rick Thoman (https://uaf-accap.org/). In the winter of 2022-23, sea ice formed late in much of the region and the extent was below average for much of the winter (with small periods of near average conditions); average extent was observed for mid-April onward (Fig. 4). However, in 2023, the eastern Bering Sea/Norton Sound sea ice was much thicker recent years (particularly compared to 2022), while the western Gulf of Anadyr was much thinner (Fig. 5). Two late March graphics below, top showing the sea ice thickness relative to the short 2011-2022 period of record, bottom showing the difference between 2023 vs the same week in 2022.

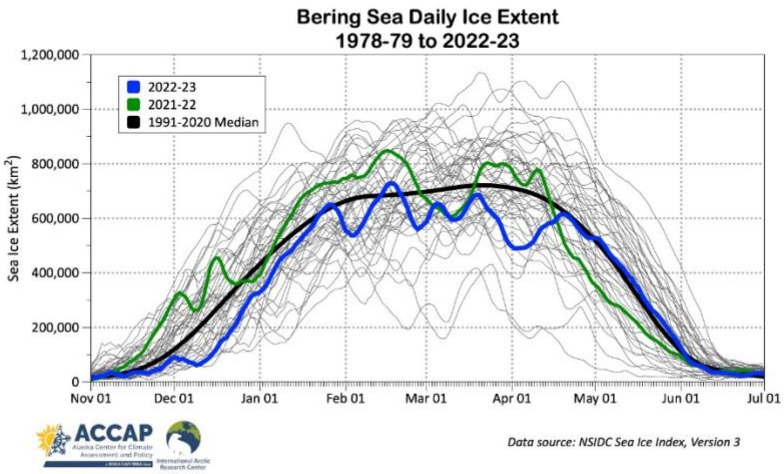

Figure 4. Sea ice daily extent over the Bering Sea. Figure courtesy of Rick Thoman, ACCAP.

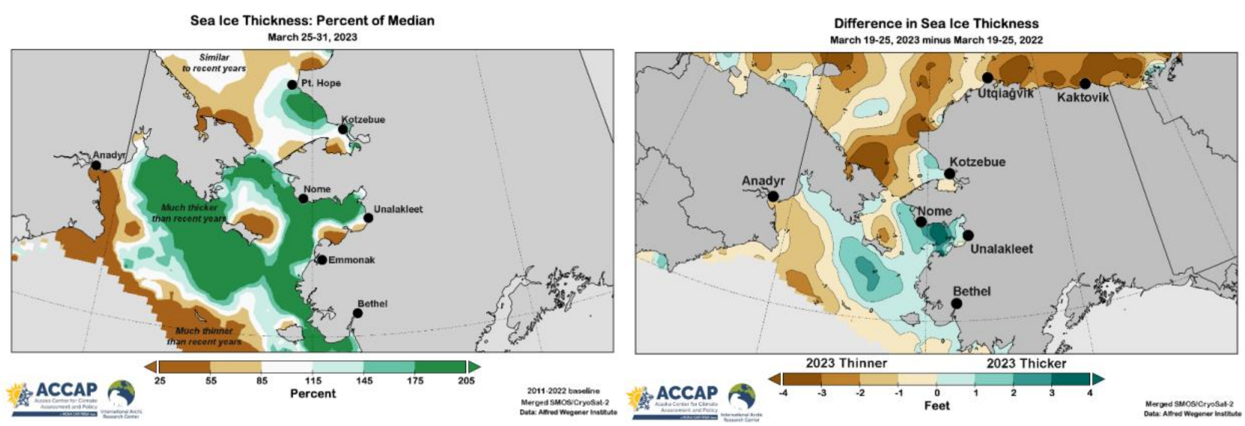

Figure 5. Sea ice thickness for late March 2023 as a percent of the median over 2011-2022 (left). Difference in sea ice thickness between late March 2022 and 2023 (right). Figures courtesy of Rick Thoman, ACCAP.

Phytoplankton

Spring phytoplankton blooms (excerpt Nielsen et al.2023, Bering Sea ESR):
In subarctic systems, such as the eastern Bering Sea, the timing and magnitude of the spring bloom can have large and long-lasting effects on biological production with subsequent impacts on higher trophic levels including commercial fish stocks. The fate of the spring bloom (pelagic grazing or sinking to benthos), and it's timing also impact benthic feeders in the Bering Sea. Recent climatic changes in the Bering Sea have included reduced sea ice and warming ocean temperatures, with consequent changes to the food web. Understanding annual changes in spring phytoplankton biomass and peak timing dynamics are thus important metrics for depicting ecosystem changes. We used ocean color satellite data from 2003--2022 available from the Gobcolour (includes satellite ocean color products from VIIRS, MODUS and SeaWIFS) at a 4x4 km resolution to estimate: 1) average spring (Apr-Jun) chlorophyll-a concentrations (chl-a, an estimate of phytoplankton biomass in the surface layer), and 2) peak timing of the spring open water bloom for major regions in the eastern Bering Sea. Preliminary conclusions for the

2023 spring bloom indicate that the Chl-a in 2023 was low in many regions (Fig. 6). Contact: Jens Nielsen (CICOES) and Matt Callahan (NOAA AFSC).

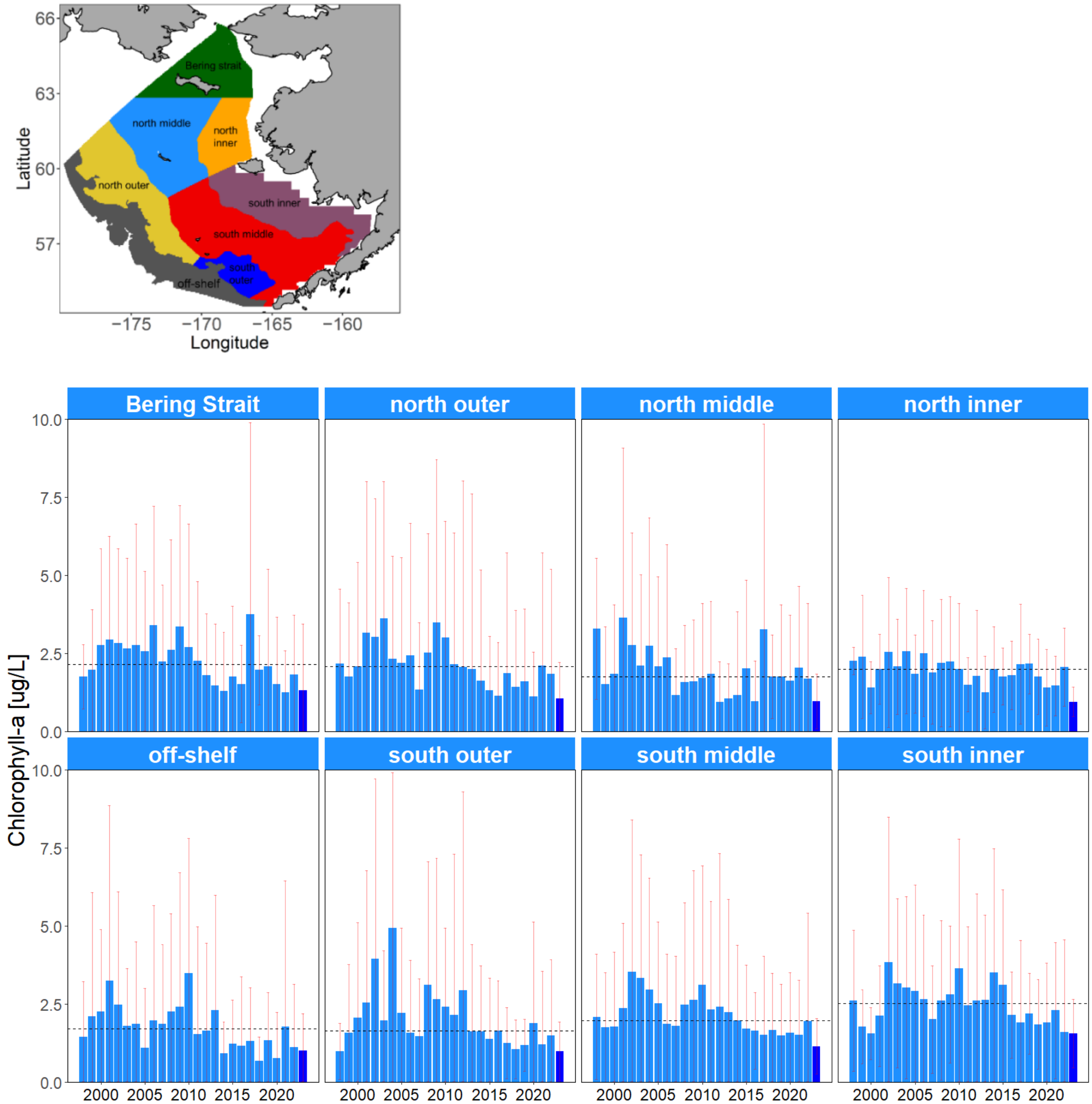

Figure 6. Map of regions used for satellite chl-a analyses (top). Average and standard deviation (SD) from spring (Apr--Jun) chl-a concentrations for 8 regions in the Bering Sea (bottom). Dotted black line denotes the long-term (2003--2023) median for each region. Courtesy of Jens Nielsen (CICOES).

<u>Late summer coccolithophore blooms</u> (excerpt Nielsen et al., 2022, Bering Sea ESR):
Blooms of coccolithophores, a unicellular calcium carbonate-producing phytoplanktonic organism, are easily observed by satellite ocean color instruments due to their high reflectivity. Coccolithophores produce calcium carbonate plates (coccoliths) that contribute to particulate inorganic carbon (PIC) in the

ocean (Matson et al., 2019). Blooms are most commonly observed and cloud cover is typically lower during September than other months allowing for better quantification (Iida et al., 2012). An interannual index of the average area (km2) covered by coccolithophores during the month of September is calculated with monthly average mapped PIC (Balch et al., 2005; Gordon et al., 2001) data from satellite.

Annual images (Fig. 7) show the spatial and temporal variability of coccolithophore blooms in September over the southeastern shelf. Annual indices are obtained from satellite data by averaging spatially over the inner and middle shelf (Fig. 8). Coccolithophore blooms were particularly large during the early part of the record, 1997, 1998 and 2000. The index was low and remained low (<80,000 km^2) through 2006. In 2007, the index rose to almost double that observed in 2006 (~125,000 km^2). A higher index (> 100,000 km^2) was observed in 2007, 2009, 2011, 2014, 2016, 2020, 2021 and 2022 for the middle shelf and in 2011, 2014 and 2022 (> 40,000 km^2) for the inner shelf. In 2022, the coccolithophore index for both the inner and middle shelf was among the highest ever observed in the timeseries (Figs. 7.8,). An image from late August indicates that there is also an extensive bloom over the SE Bering Sea in 2023 (Fig. 9).

Coccolithophore blooms can have important biogeochemical implications. The Bering Sea can be either a source or a sink of atmospheric CO_2, with the magnitude of coccolithophore blooms and the associated calcification playing a role (Iida et al., 2012). In addition, variability in the dominant phytoplankton (diatoms vs. coccolithophores) is likely to influence trophic connections with the smaller coccolithophores resulting in longer trophic chains. Coccolithophores may be a less desirable food source for microzooplankton in this region (Olson and Strom, 2002). The striking milky aquamarine color of the water during a coccolithophore bloom can also reduce foraging success for visual predators, such as surface-feeding seabirds and fish.

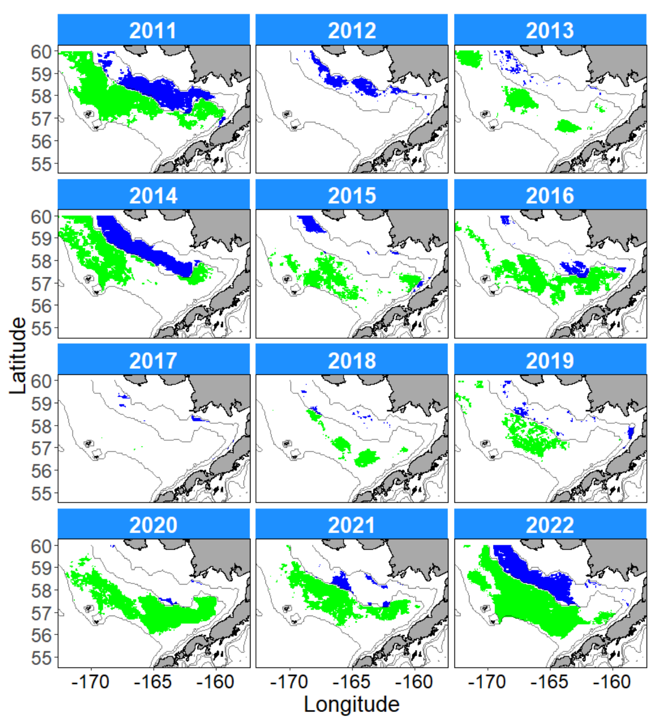

Figure 7. Maps illustrating the location and extent of coccolithophore blooms in September of each year from globcolour data. Color: satellite ocean color pixels exceeding the threshold (PIC>0.0011) indicating

coccolithophore bloom conditions. Blue: inner shelf (30 – 50 m depth), Green: middle shelf (50 – 100 m depth). These data are used to calculate the areal index in Fig. 6. Courtesy of Jens Nielsen (CICOES).

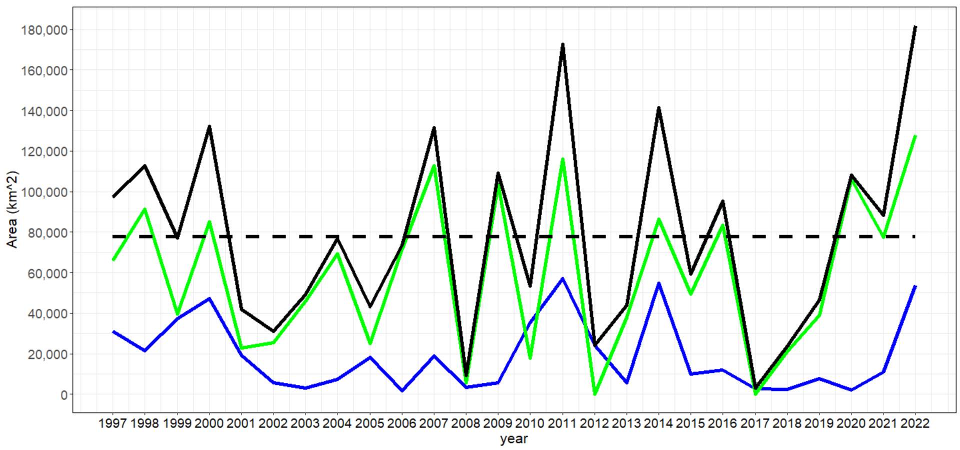

Figure 8. Coccolithophore Index for the southeastern Bering Sea shelf (south of 60°N) calculated from the GlobColour blended PIC product. Blue: average over the inner shelf (30 – 50 m depth), Green: average over the middle shelf (50 – 100 m depth), Black: total. The black dotted line is the longterm average. Courtesy of Jens Nielsen (CICOES).

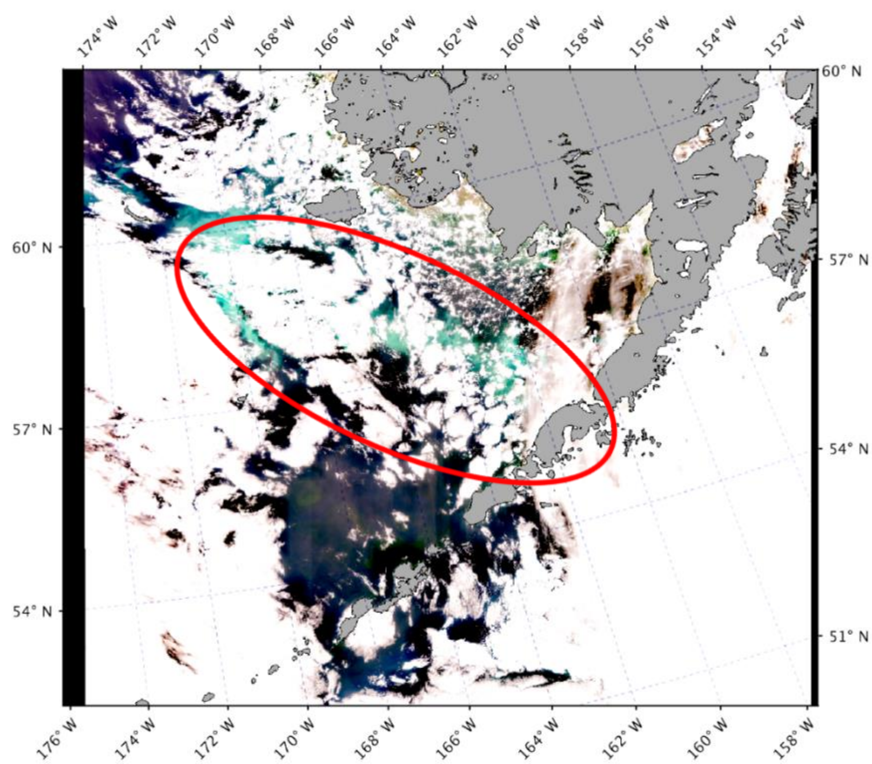

Figure 9. Satellite obsevations of a large coccolithophore bloom, shown in aqua (circled in red), 27August23.

2023 surveys in the Bering Sea

Many of the 2023 AFSC and Pacific Marine Environmental Lab (PMEL) surveys in the Bering (and Gulf of Alaska) are described (with maps) in the link https://www.fisheries.noaa.gov/alaska/science-data/2023-alaska-fisheries-science-center-field-season. Information and excerpts from this site are also included in the list below. Credit: NOAA Fisheries.

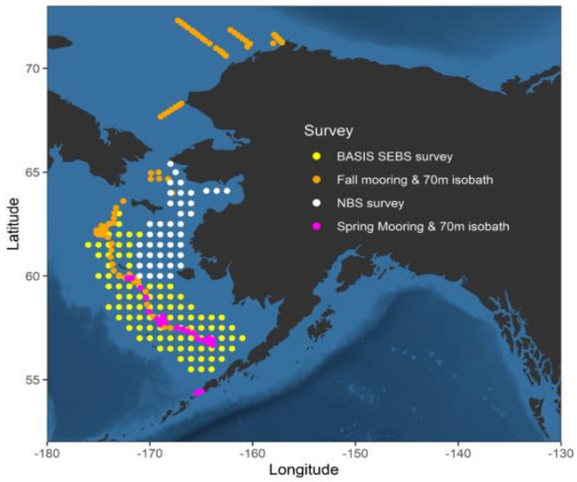

Figure 10. EcoFOCI oceanographic and mooring survey stations in spring (pink) and fall (orange), and northern Bering Sea surface trawl ecosystem survey stations in fall (white). BASIS southeastern Bering Sea.survey (yellow) not conducted in 2023.

<u>Oceanographic biophysical mooring and hydrographic spring and late summer/fall surveys</u> (PMEL/AFSC EcoFOCI) in the eastern Bering Sea on the R/V Oscar Dyson, 21April - 08 May and on the R/V Aquila, 15 August – 09 September, a month earlier than usual (Fig. 10). The overall research objective for both surveys is to determine how varying biological and physical factors influence the Bering Sea marine ecosystem. The objectives of the survey are: 1) service oceanographic and passive acoustic moorings that measure water column and sea ice properties and detect marine mammals and sounds from human activities; 2) sample the water column for phytoplankton, zooplankton, and larval fish; 3) deploy drifters to measure currents; and 4) deploy sonobouys to monitor marine mammal presence in real time.

Spring Survey: For the first time since 2012 (a very high ice year), researchers had to dodge sea ice to reach designated stations (Fig. 11; https://www.pmel.noaa.gov/news-story/annual-spring-survey-encounters-ice-bering-sea). Initial results for zooplankton (Fig. 12) include: 1) Overall RZA abundances were very low, it appears that the spring population increase has not started quite yet due to cold conditions.2) Large copepods were low, similar to cold years after warm periods. Cold temperatures reduced development times that result in higher large copepod numbers in warm years. 3) Small copepods were low, also similar to cold years where population numbers are reduced. The cold temperatures limit the population growth of small zooplankton by reducing development times and turnover rates. 4) Euphausiid numbers were very low, which is typical of the early spring. 5) Conditions appear favorable for *Calanus* population accumulation in summer/fall should the ice extent result in a large cold pool. Contact: Phyllis Stabeno (PMEL) and Julie Keister/Dave Kimmel (AFSC).

Figure 11. Left) photo of sea ice, and Right) sea ice coverage (colored regions) and stations (purple circles) on the 2023 Spring Mooring survey.

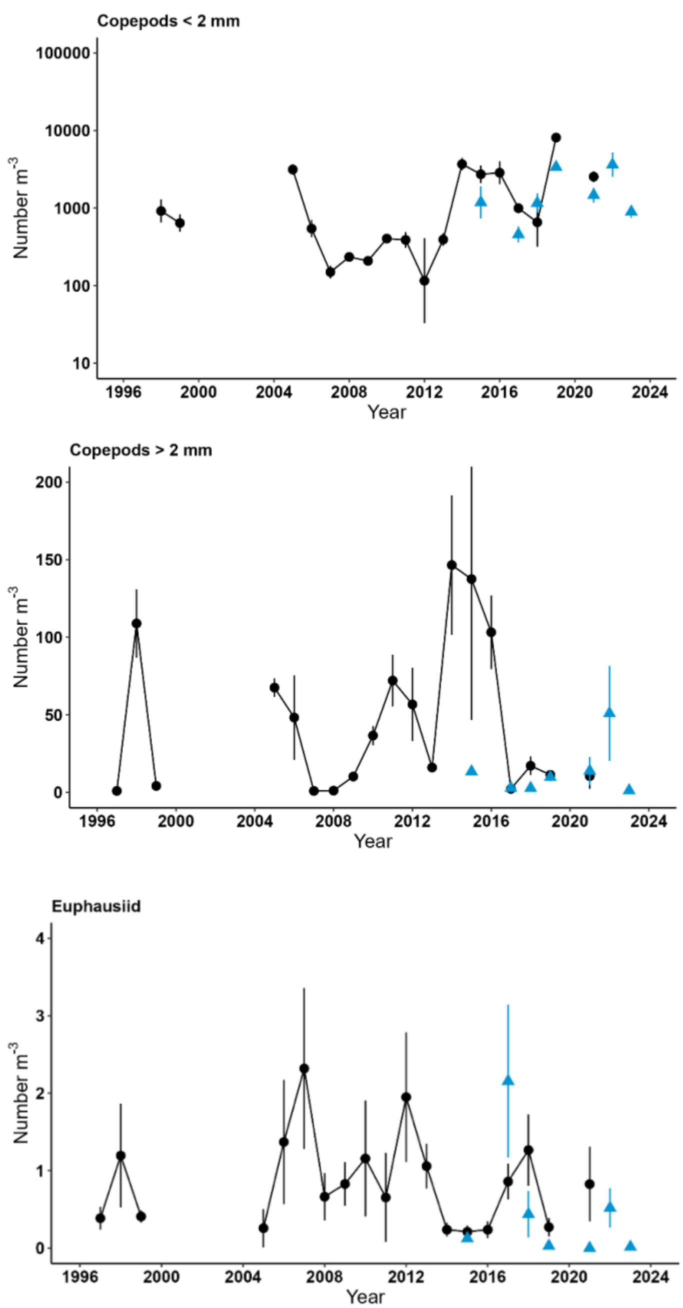

Figure 12. Mean abundances of small copepods (top), large copepods (middle) and euphausiids (bottom) collected with bongo nets towed obliquely over the water column at stations along the 70m isobath in late April-early May on the Spring Mooring survey. Black are samples counted at the Polish center and blue are rapid counts at sea (Rapid Zooplankton Assessment. Figure courtesy of Dave Kimmel (AFSC).

<u>Arctic Distributed Biological Observatory (DBO) and Ecosystems & Fisheries Oceanography Coordinated Investigations (EcoFOCI) Joint Cruise</u>, *R/V Sikuliauq*, 10 September – 04 October to conduct oceanographic and ecosystem research in the north Bering and Chukchi seas, including CTD and along track oceanographic data collection, sampling of plankton, benthic invertebrates and sediments, eDNA, harmful algae, net community production, monitoring of sea birds and marine mammals, mooring deployment and retrieval (Fig. 13). An imaging flow cytobot (IFCB) will be used for continuous monitoring of phytoplankton community composition and harmful Algal bloom (HAB) species, August – early October by Woods Hole Oceanographic Institution (WHOI) and NOAA AFSC scientists. Data will be used for a variety of projects, including informing local communities of HAB presence in near real time (Contact Evie Fachon, WHOI). Figure 14 shows an example of IFCB data from the Bering Sea in 2022 using the WHOI IFCB dashboard. A CPICs will also be deployed on the CTD to provide images of zooplankton and expand of temporal and spatial coverage of zooplankton population estimates (Fig. 15, Contact Dave Kimmel, AFSC). Survey Contacts: Phyllis Stabeno (NOAA PMEL) and Jackie Grebmeier (Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science).

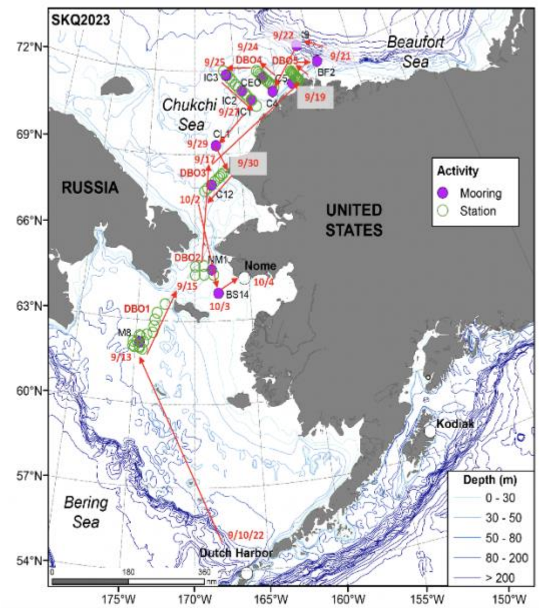

Figure 13. Planned station locations and track lines for the 2023 Arctic DBO survey.

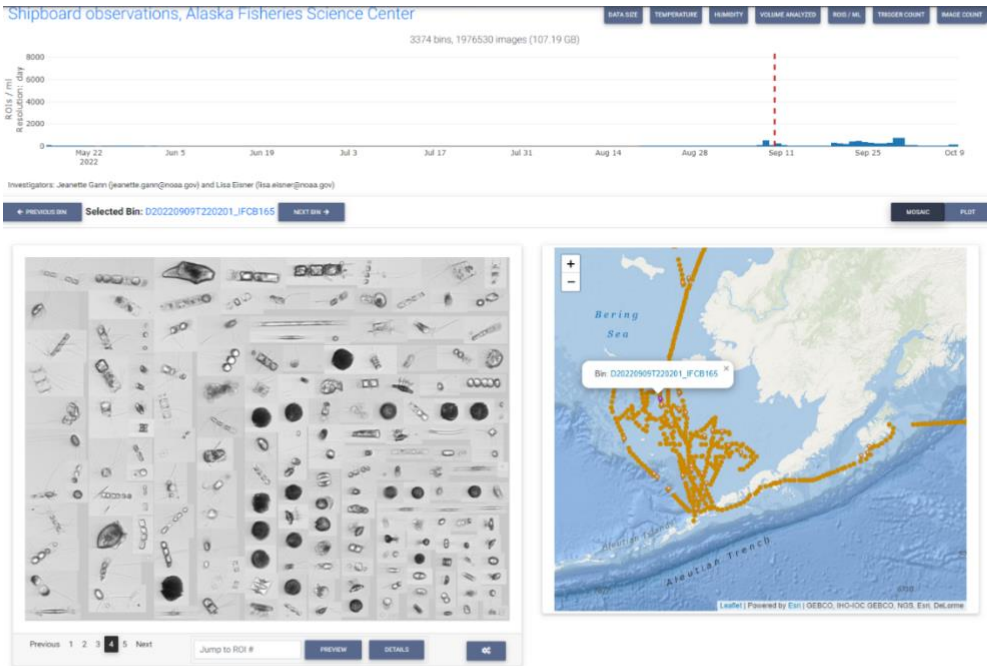

Figure 14. Image from IFCB (5 m depth), 9 Sept 2022. The dark roundish cells are *Alexandrium* spp.

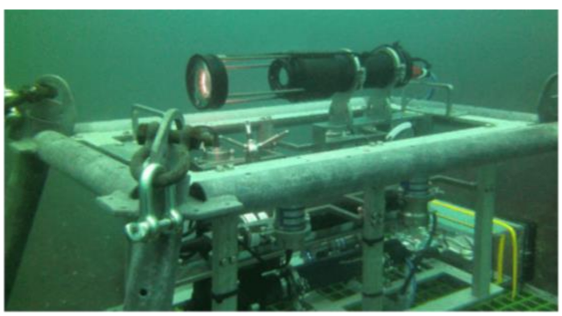

Figure 15. CPICs imaging system is the black horizontally mounted instrument above the mooring package.

NOAA AFSC Bottom Trawl surveys aboard the FV *Northwest Explorer* and the FV *Alaska Knight* (Fig. 16) include:

- Annual Bottom Trawl Survey of the Eastern Bering Sea, May 17th – July 30th 2023. The objectives of this survey are to monitor the marine ecosystem of the eastern Bering Sea, produce fishery independent biomass and abundance estimates for commercially important fish and crab species, and collect other biological and environmental data for use in ecosystem-based fishery management.
- Bottom Trawl Survey of the Northern Bering Sea, July 30th – August 24th 2023. The objectives of this survey are to understand and monitor the effects of climate change and diminishing sea ice cover on bottom-dwelling fishes, crabs, and other marine life along the northern Bering Sea shelf. The northern Bering Sea Shelf survey has only been surveyed in 2010, 2017, 2019, 2021, 2022, and 2023.

- Temperature sensors attached to the trawl net recorded bottom temperature throughout the Bering Sea (https://www.fisheries.noaa.gov/alaska/science-data/near-real-time-temperatures-bering-sea-bottom-trawl-survey-2023, Fig. 16, right). Survey Contact: Duane Stevenson (AFSC, Groundfish Assessment Program Survey team lead).

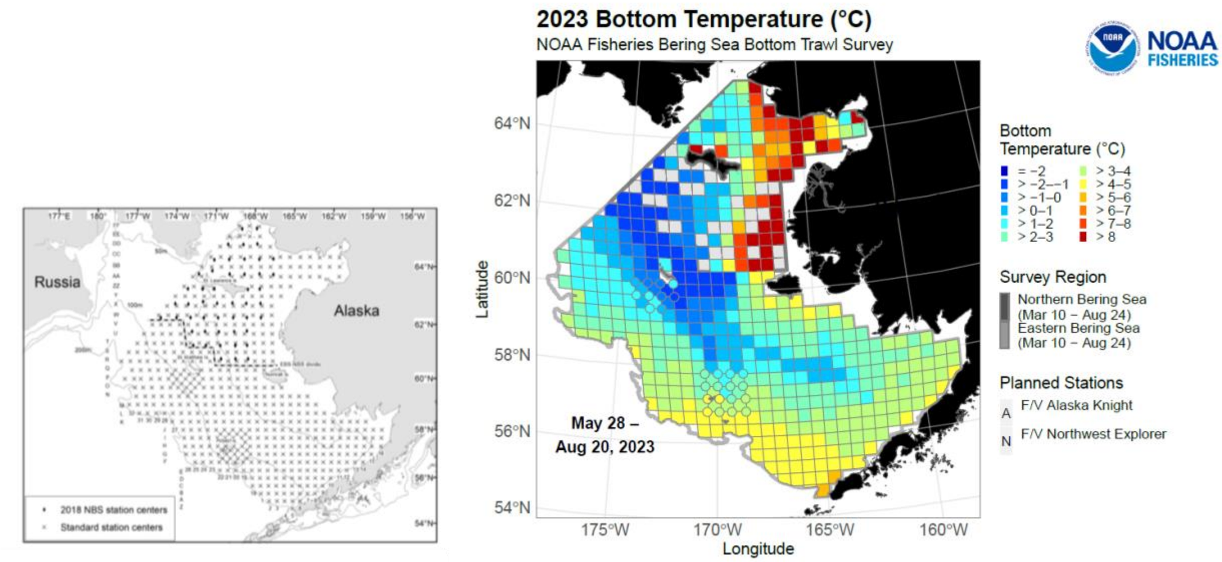

Figure 16. Bottom Trawl locations in the southeastern Bering Sea and northern Bering Sea (left) and bottom temperature collected May 28-August 20 (right).

Pacific cod tagging, baited cameras, longline cameras for bycatch, Nome/Savoonga, 21-30 August. Researchers form NOAA AFSC, Kingfisher Marine Research, and Freezer Longline Coalition will conduct a Pacific cod satellite tagging study and deploy baited cameras (pilot study) to estimate the presence of Age-0 Pacific cod. The also will test out a new bottom longline camera system, and talk with local fishermen about their fishery to gauge interest in innovations such as the use of lights to modify catch composition.

Surface trawl and ecosystem survey in the northern Bering Sea on the F/V Northwest Explorer, 27 August – 20 September (Fig.). The survey includes multiple sampling gear types, a CTD with rosette water sampler, bongo nets, surface trawl, small mesh beam trawl, and a Van Veen benthic grab. The survey will support a wide range of research activities, including stock-specific juvenile salmon abundance estimates, the pelagic food web, fish condition, oceanographic conditions, chlorophyll a biomass and size structure, zooplankton distribution and abundance, seabird densities, harmful algal bloom toxins, essential crab habitat, benthic invertebrate abundance, environmental DNA. Contacts (AFSC): Ed Farley, Jim Murphy.

Harbor Seal Aerial Surveys, Aleutian Islands (Dutch Harbor to Shemya Island), Bristol Bay and Lake Iliamna, 7/31-9/5. NOAA AFSC Marine Mammal Laboratory (MML) Polar Ecosystems Program conducted aerial surveys for abundance, trend and distribution of harbor seals along the coast and glacial fjords of Alaska. These surveys will provide info on the health of coastal regions, track ecosystem changes due to climate warming, and support conservation measures for this culturally and ecologically significant species.

Gulf of Alaska

Sea Surface Temperature (SST)

Satellite-derived estimates of SST for the GOA were compiled by Matthew Callahan (NOAA AFSC). The western GOA SST data indicate 2023 temperatures were generally near average (Fig. 17). The eastern GOA SSTs were also close to average (or slightly below) from December to late-July, with above average temperatures observed late July-August. A moderate marine heat wave was observed for a few days in August in the eastern GOA. Overall, SSTs were slightly cooler than 2022 during spring to mid-summer, with similar (WGOA) or higher temperatures (EGOA) in late summer. In contrast, the 2023 SSTs the Aleutian Islands were higher than average with moderate heat waves observed, particularly in the western and central regions in winter (December -January) and mid to late summer (mid July- mid September) (Fig. 18).

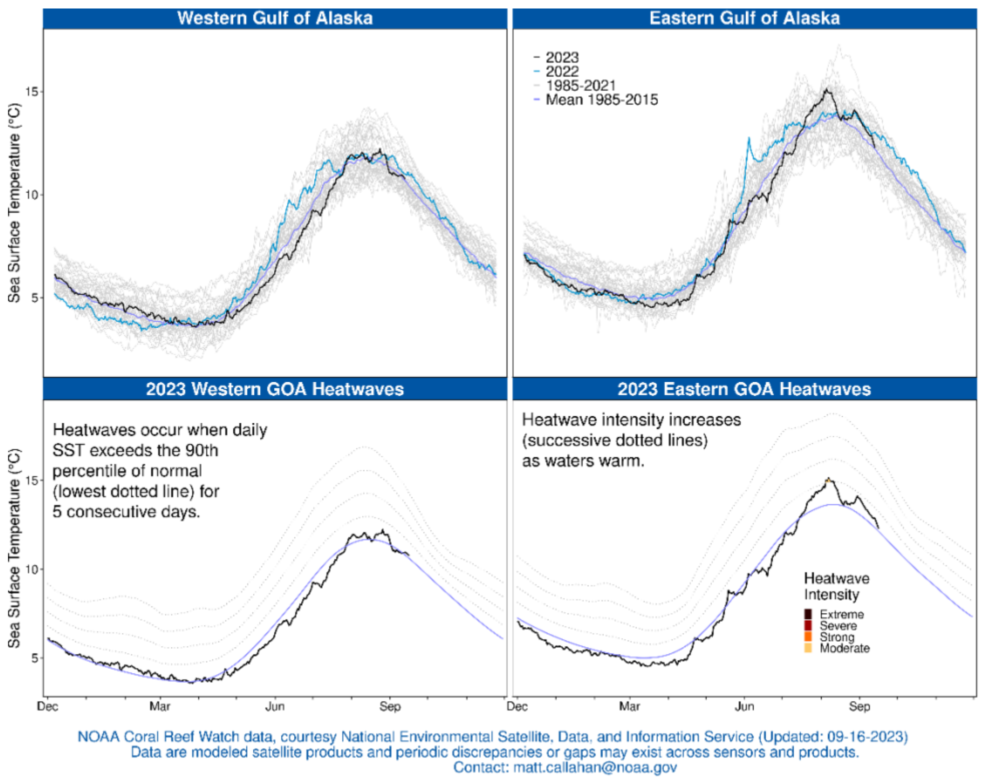

Figure 17. GOA SST for the western and eastern GOA for 2023 and 2022 compared to means for 1985-2015 from satellite analysis. Courtesy of Matthew Callahan.

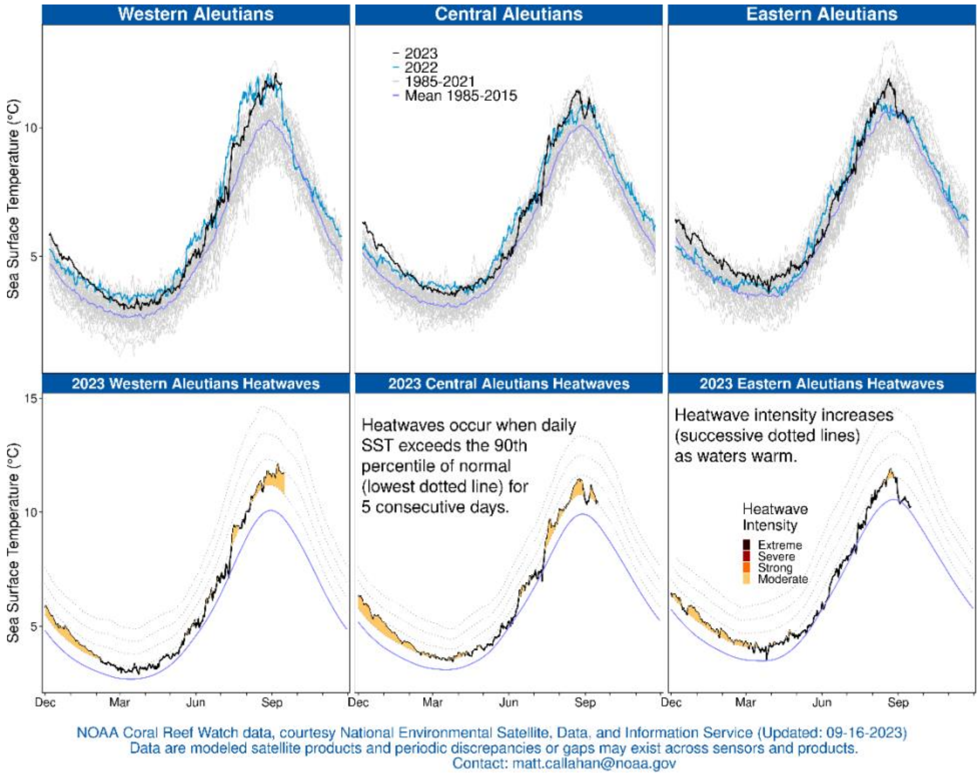

Figure 18. Aleuitan Islands (AI) SST for the western, central and eastern AI for 2023 and 2022 compared to means for 1985-2015 from satellite analysis. Courtesy of Matthew Callahan.

2023 survys in the Gulf of Alaska

As stated earlier, many of the Gulf of Alaska surveys are described in the link https://www.fisheries.noaa.gov/alaska/science-data/2023-alaska-fisheries-science-center-field-season. Information and excerpts from this site are also included in the list below. Credit: NOAA Fisheries.

Gulf Watch Alaska (Fig. 19) is the long-term ecosystem monitoring program of the Exxon Valdez Oil Spill Trustee Council for the marine ecosystem affected by the 1989 oil spill. Gulf Watch Alaska & Northern GOA Long Term Ecological Research (LTER) programs conduct surveys in the northern GOA (Fig.). Contact: Rob Suryan (AFSC), Seth Danielson (UAF), Russ Hopcroft (UAF).

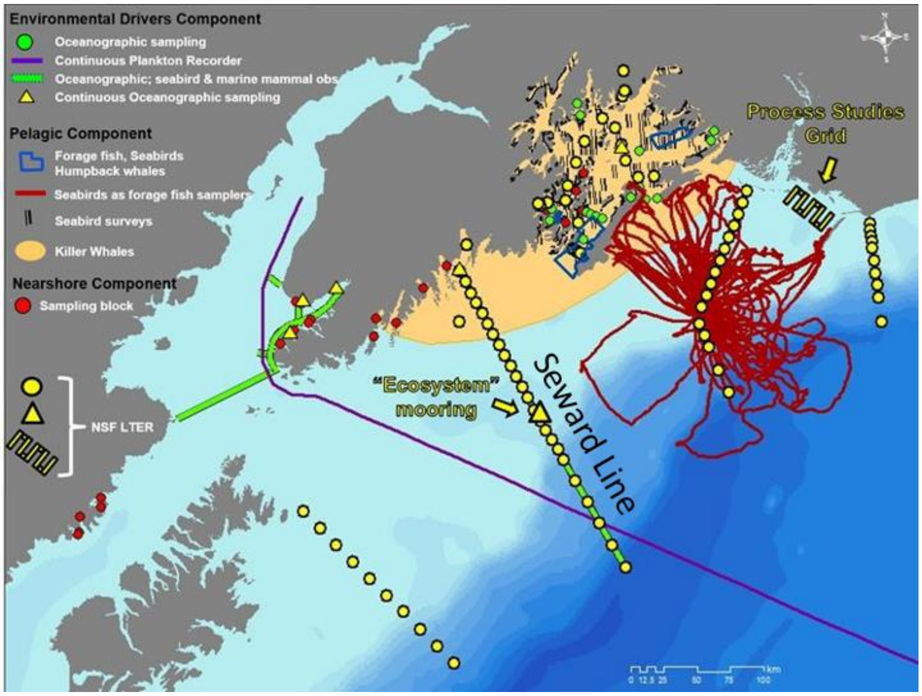

Figure 19. Gulf Watch Alaska and N. GOA Long Term Ecological Research (LTER) surveys.

Gulf of Alaska Biennial Bottom Trawl Survey, May 18 to August 6, 2023 on the FV *Alaska Provider* and RV *Ocean Explorer*. Our objective is to characterize the distribution and abundance of the ecologically and economically important species that live on or near the seafloor in Alaska. Our survey produces observations of species occurrence, species densities, and biological characteristics such as length, gender, age, and food habits. groundfish survey, temperature, groundfish food habits data. These data collected on our surveys are used to support annual stock assessments and ecological models. Contact: Ned Laman, Gulf-Aleutian Team Lead, ned.laman@NOAA.gov.

Winter and Summer Acoustic-Trawl Surveys in the Gulf of Alaska
The Midwater Assessment and Conservation Engineering (MACE) program of the Alaska Fisheries Science Center (AFSC) conducted acoustic-trawl surveys on the NOAA Ship Oscar Dyson in the Gulf of Alaska (GOA) during late winter and summer 2023 to estimate the abundance and distribution of walleye pollock (Gadus chalcogrammus) using acoustics and targeted trawling on acoustic backscatter, to inform fish stock assessment models and catch allocation.

Late winter surveys were conducted in the Shumagin Islands, Pavlof Bay, and Morzhovoi Bay (February 15 - 21) and Shelikof Strait, Chirikof Shelfbreak, and Marmot Bay (March 5 - 17). The summer survey (Fig. 20) was conducted over 3 legs across the GOA shelf from the Islands of Four Mountains to Yakutat Trough including in the Shumagin Islands, Shelikof Strait, Chiniak Trough, and Barnabas Trough regions (June 14 - August 17). During Leg 2 of the summer survey (June 28 - July 22) a DriX uncrewed surface vehicle (Fig. 21) was also tested as part of an OMAO-funded project. The 8 m motorized vehicle is equipped with EK80 echosounders similar to those used on the NOAA Ship Oscar Dyson. The DriX project goals were to test operation capabilities and evaluate its potential to make separate complementary observations during acoustic-trawl surveys. Contact Darin Jones (AFSC).

Figure 20. Acoustic transects for the 2023 summer MACE survey of the Gulf of Alaska shelf including the Shumagins Islands area, Shelikof Strait, and Barnabas and Chirikof Troughs.

Figure 21. DriX uncrewed surface vehicle underway during tests in Alaska (photo Alex De Robertis).

Alaska Fisheries Science Center Longline Survey, May 28 – August 28, 2023. The overall research objective is to conduct a fisheries-independent survey of groundfish resources throughout Alaskan waters. The AFSC Longline Survey is specifically designed to provide a relative population index for assessing sablefish, or black cod, but its data is also useful for several other groundfish species. Longline Survey in the Aleutian Islands and GOA on the F/V Alaskan Leader, 01 June – 28 August. The main objective of the survey is to collect relative abundance information for sablefish and other groundfish species, including GOA Pacific cod, shortspine thornyhead, rougheye/blackspotted rockfish, shortraker rockfish, spiny dogfish, and grenadiers. Scientists fish 8,100 hooks/day at depths from 150-1000 m. Contact: Pat.Malecha@noaa.gov (ABL, Survey Coordinator)

Spring Ichthyoplankton Survey, May 14 - 25th, 2023 on the NOAA Ship Oscar Dyson. The objectives of this project are to conduct zooplankton and ichthyoplankton surveys and process studies in the region between Unimak Pass and Shelikof Strait to estimate the abundance, transport, and other factors influencing the survival of young commercially-important fishes, including Walleye pollock.

Observations support research on recruitment processes and contribute to our understanding of how young fish and their prey respond to changes in climate. Contact: Jesse F Lamb (EcoFOCI, Chief Scientist).

Juvenile Groundfish and Forage Fish Survey, August 27 – September 12, 2023. NOAA Ship Oscar Dyson. The objectives of this project are:1), to conduct a survey to extend a time series of abundance of the juvenile stage of commercially important fish species, including walleye pollock, and other forage fish species in the western Gulf of Alaska, and 2), to collect zooplankton (prey of those fishes), and to measure other environmental variables that influence the survival of those fishes. Observations support research on recruitment processes and contribute to our understanding of how young fish and their prey respond to changes in climate. Contact: Steve Porter (EcoFOCI,Chief Scientist).

Southeast Coastal Monitoring (SECM) survey (27 year time series) in the eastern GOA inside waters during May, June, and late July/ early August (Fig.), exerpt Fergusen et. al. 2023 ESR. Surface trawl for juvenile salmon, age-0 gadids (Pacific cod, saffron cod, pollock), and sablefish and oceanographic sampling (CTD, zooplankton tows) to evaluate onshore-offshore gradient of juvenile gadid growth and energetics, feeding ecology of southern coastal age-0 groundfish, and HABs. Recent trends had shown increases in most zooplankton taxa since 2017 however, the 2023 total density showed a stark decrease to well below the long-term average (Fig. 22). During 2023, densities of large and small calanoid copepods, hyperiid amphipods, and gastropods all decreased from densities in 2022, and all were below the long-term average with the exception of large calanoid copepods. The decrease in densities to below average for most taxa indicates negative availability of selected prey utilized by larval and juvenile fish in Icy Strait. Contact: Wes Strasburger and Emily Fergussen (AFSC).

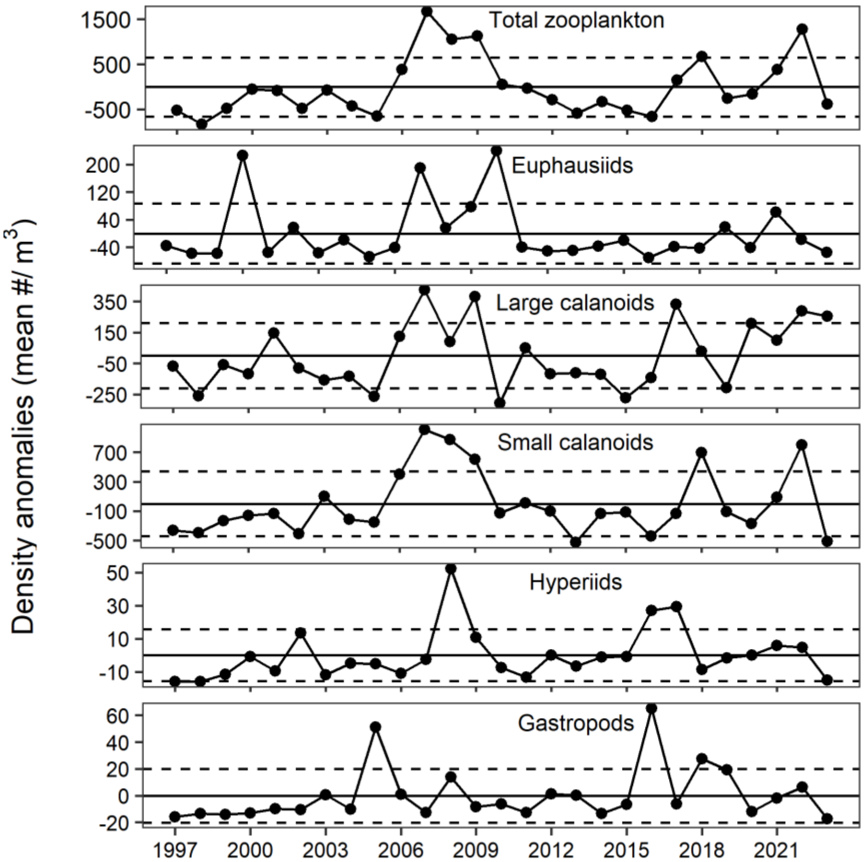

Figure 22. Average annual total zooplankton and taxa specific density anomalies for the northern region of SEAK (Icy Strait) from the Southeast Coastal Monitoring project time series, 1997-2023. Dashed lines denote ±1.0 SD from the long-term mean (solid line). Annual densities are the grand mean of the monthly means from May to July in Icy Strait. No samples available for May 2007. Courtesy of Emily Fergussen (AFSC).

Western GOA Summer Beach Seine in Kodiak: July/Aug. This survey provides the first indication of GOA Pacific cod recruitment by surveying the abundance of newly settled fish in coastal nurseries. There are two beach seine surveys, the 'Core' survey (2006 - present) and the 'Expanded' survey 2018-present. All sites are surveyed with identical gear at fixed site locations. The 'core' survey (led by Ben Laurel, NOAA) is conducted at two Kodiak Island bays (n=8 fixed stations/bay, 16 total stations) and the “expanded survey” (led by Alisa, Alaska Coastal Observations and Research with partial NOAA support) is conducted across 13 additional bays on Kodiak Island, the Alaska Peninsula, and the Shumagin Islands (n = 3–9 fixed stations per bay, 95 total stations). Sampling at sites for the core survey is conducted twice in July and again twice in August of each year. Sampling at sites in the expanded survey is done once per year across July and August. However, in 2018 sites on Kodiak Island and the Alaska Peninsula were sampled twice. Of note, unusually low salinities (compared to the prior 6 years) were observed at some locations during 3-7 July, possibly related to heavy late spring rainfall (May was wettest on record in Kodiak). Contact: Ben Laurel, Mike Litzow, Alisa Abookire (AFSC).

Acoustic and visual survey for cetaceans in Behm Canal and Southern Clarence Strait, Southeast Alaska, April 8-15, 2023. The overall research objectives are to conduct visual and acoustic surveys for marine mammals, primarily cetaceans, to estimate density and abundance in this area. Contact: AFSC Marine MammmalLab (MML) Program Leader: Robyn Angliss, Robyn.Angliss@noaa.gov.

Testing the effectiveness of pingers in deterring harbor porpoise in Southeast, Alaska, May 1 – August 31, 2023. The overall research objective is to test and compare the effectiveness of two commercially available pingers in deterring harbor porpoise. Contact: AFSC MML..

Steller sea lion population assessment aerial surveys, Eastern Aleutian Islands and Gulf of Alaska, June-July conducted aerial surveys to photograph sea lion rookeries. Contact: AFSC MML.

Ship-based Steller sea lion pup cruise, Attu to Ugamak Islands, June-July conducted a ship cruise on the RV Tiglax to the Western, Central and Eastern Aleutian Islands to access remote cameras, fly helicopters for abundance surveys, re-sight marked animals, and collect biological samples. Contact: AFSC MML.

International Whaling Commission POWER cruise, Southern Gulf of Alaska, 8/4-9/25 - visual and passive acoustic marine mammal observations. Contact: AFSC MML.

Cook Inlet beluga photo-identification and biopsy sampling, Cook Inlet, 8/25-9/6. Contact: AFSC MML.

3. China

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4. Republic of Korea

1. National Institute of Fisheries Science (NIFS)

Marine Heatwaves (MHWs) monitoring in the Korea Waters

In summer of 2023, the marine heatwaves were started from mid-July and were continued to mid-August because of maintaining for a long time of strong heatwaves around the Korea Peninsula. In this period, SSTA(Sea Surface Temperature Anomaly) around the Korea Peninsula was about 1~3℃. To serve real-time water temperature along the coast of Korea, NIFS operates 140 real-time water temperature monitoring system with 30-minute interval. 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.

Real-Time observation system using Ferry vessel

To study the physical oceanic condition of the surface layer around Korea Waters, real-time observation system using ferry vessel is operating. The main observation factor is water temperature and salinity, and total 2 vessel is in operation. Especially, the regular route of vessel around GangWon-Ulleung Island is useful to understand distribution and diffusion of low saline water around Korea waters.

2. Korea Meteorological Administration (KMA)

Ocean weather observation system around the Korea Peninsula

KMA operates 28 ocean data buoys to observe the wind, air pressure, humidity, water temperature, wave heights and wave direction in the Korea Waters. They will install large-scale marine data buoys in this year, consisting of one 10-meter buoy in the coastal area of the South Sea, one 3-meter buoy and one 6-meter buoy in the East Sea.

3. Korea Hydrographic and Oceanographic Agency (KHOA)

Real-time Korea Ocean Observing Network

KHOA operates the Korea Ocean Observing Network (KOON) which consist of tidal station, ocean station, ocean research station, ocean buoy, and surface current station. KOON, Composed of 139 stations, provides real-time ocean information with improved data quality for the needs of maritime policy, maritime industry, and public activities. KHOA currently operates 53 tidal stations, 3 ocean stations, 3 ocean research stations, 36 moored ocean buoys, and 44 HF radar stations.

5. Japan

National report from Hokkaido University, Japan (by Hiroto Abe at Faculty of Fisheries Sciences)

Hydrographic observations by training ships Oshoro-Maru and Ushio-Maru

Hokkaido university have two training ships, one is *Oshoro-Maru* and the other is *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 Hokkaido island, Japan.

Over the last one year, we had *Oshoro-Maru* cruise to the Bering-Chukchi continental shelves in summer of 2023, which is 5 years after the last cruise to the same shelves with some northward extension to reach southern boundary of sea ice area (Fig. 1). With the financial support from a national flagship project, ArCSII (Arctic Challenge for Sustainability II) sponsored by MEXT (Ministry of Education, Culture, Sports, Science and Technology) Japan, we conducted physical, chemical, biological observations to reveal current status of ocean environment and its influence on ecosystem under the progress of the global warming and sea ice loss in the Arctic Ocean. Observation items include CTD, sea ice sampling, microplastic sampling, water sampling for environmental DNA, virus, plankton, seabirds/marine mammal sighting surveys. Researchers and undergraduate/graduate students of our university, those in other domestic universities and University of Alaska Fairbanks joined this cruise. Especially in Leg 3, we invited undergraduate students in other domestic universities who aim to become researchers in the natural sciences and humanities of the Arctic region, wish to become actively involved in directly/indirectly contributing to solving various problems in the Arctic region and disseminating knowledge about the Arctic region through various social activities such as business, government, education, and NPOs. They not only conducted hydrographic survey as natural science but learned history and culture of Arctic Region.

Coastal monitoring in Tsugaru Strait, a strait between Hokkaido and main island of Japan, by training ship *Ushio-Maru* has been quarterly conducted with researchers from Mutsu Institute for Oceanography (MIO) JAMSTEC since 2009. Over the last one year, four times of observation at every season was planned (November 2022, February, May, September 2023), among which two times have been already done, one time canceled (Nov 2022) and the last one will be coming soon.

Sea surface temperature observations by satellites

Map of monthly-mean sea surface temperature (SST) is shown in Fig. 2, which was created using SST data measured by satellites (Aqua/AMSR-E and GCOM-W/AMSR2). This is SST anomaly with respect to monthly climatology during the period of 2002 to 2023. Over the last one year, most remarkable feature is positive SST anomalies (> 3℃) prevailing over Kuroshio Oyashio confluent region east off Japan. As mentioned in last year’s national report, this feature was found in 2021-2022, but the anomalies are enhanced in the following year. Time series of SST was created using the satellite data with focus on the region west and east of Hokkaido island (Fig. 3, see Fig. 2 for location of the box region). Remarkable positive SST anomalies reported in the last year’s national report still continue this year as well.

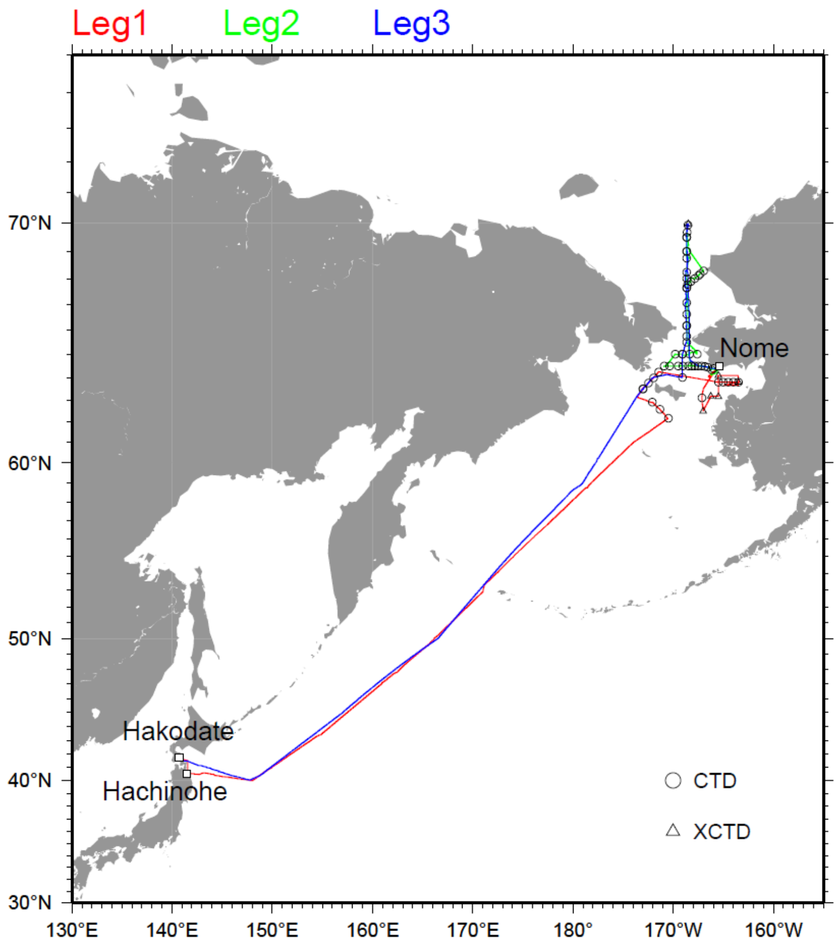


Fig. 1. Map of *Oshoro-Maru* cruise conducted during June 8th to August 1st, 2023. Red, green, blue lines indicate track of the ship in Leg1, Leg2, Leg3, respectively. Circle and triangle symbols denote location of CTD and XCTD.

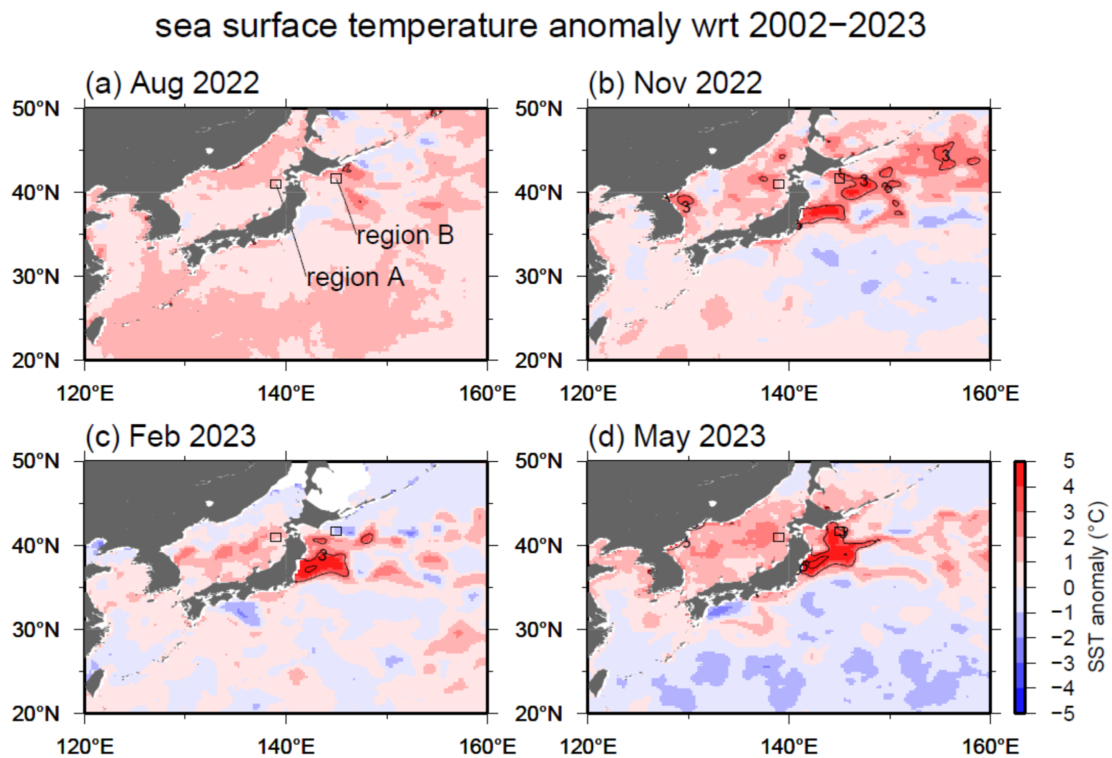


Fig. 2. Maps of monthly-mean SST anomaly in (a) August, (b) November, (c) February, (d) May of the last one year with respect to monthly climatological SST over 2002–2023. The contours denote SST anomalies at +3℃ and +6℃. SST data observed by satellites (Aqua/AMSR-E and GCOM-W/AMSR2), downloaded from G-Portal, data server of JAXA (Japan Aerospace Exploration Agency), have been used.

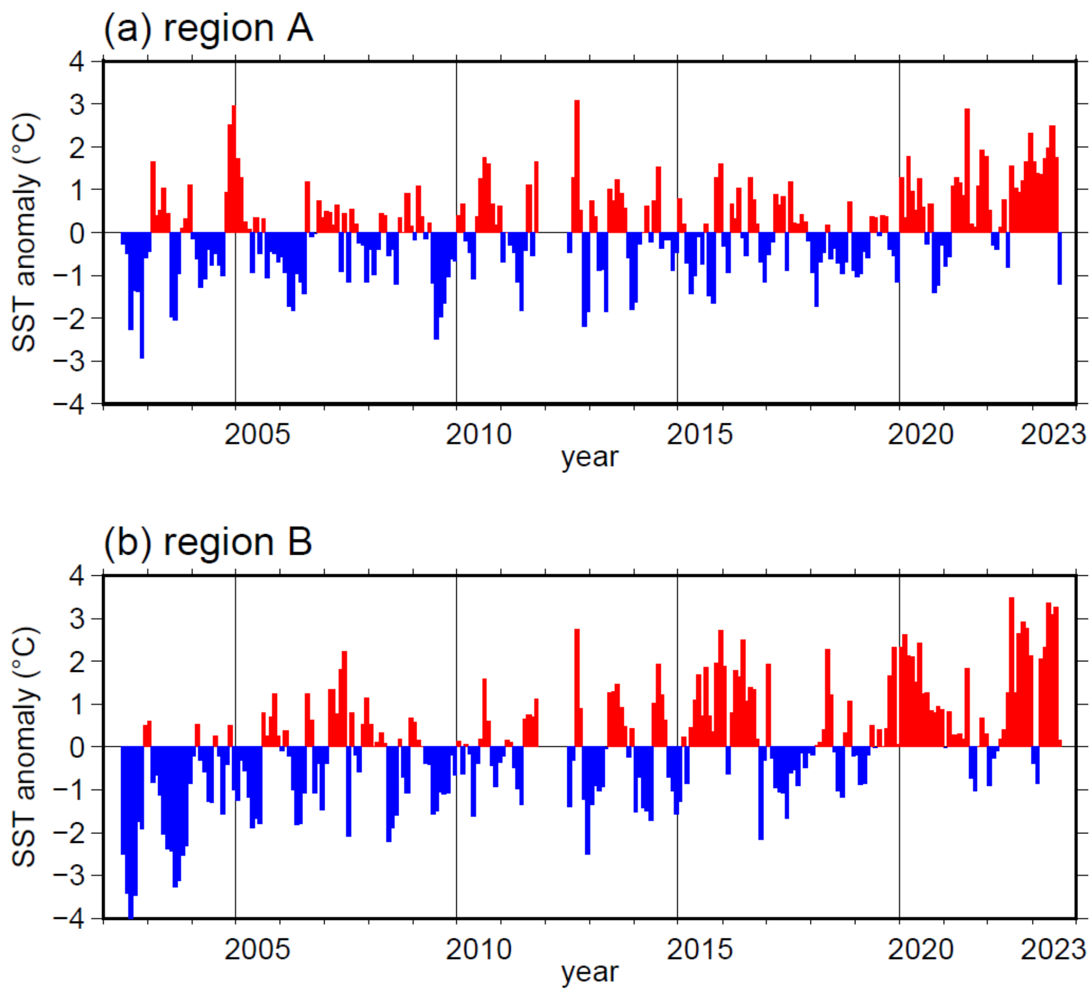


Fig. 3. Time series of monthly-mean SST anomaly with respect to monthly climatological SST over 2002 – 2023 averaged over the box regions shown in Fig. 2. SST data observed by satellites (Aqua/AMSR-E and GCOM-W/AMSR2), downloaded from G-Portal, data server of JAXA (Japan Aerospace Exploration Agency), have been used.

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

Minoru Kitamura, RIGC JAMSTEC

JAMSTEC is in charge of variety of ocean observation programs. These programs are under operation. Although there were some COVID19 patients onboard some research vessels, ships operation turned back to normal mode in JAMSTEC.

<u>1. Biogeochemical time-series at K2, the western subarctic Pacific</u>

The K2 (47°N, 160°E, 5200 m) is a time-series station to observe biogeochemical processes and long-term trend of ocean environment in the western subarctic gyre of the North Pacific. Observations and sample collections by using mooring systems, shipboard hydrographical observations, and satellite remote sensing are key components in the time-series study at K2. Since 2001, Sediment trap moorings have been deployed. Currently, many kinds of sensors/samplers such as CTDs, pH and DO sensors, water samplers, and an ADCP are also attached into the mooring system. Further hydrographic observations are made from shipboard during annual maintenance visits by a surface vessel. During the visits at K2, CTD casts up to 10-m above the sea floor, analysis of seawater (salinity, dissolved oxygen, phosphate, silicate, nitrate, nitrite, dissolved inorganic carbon, dissolved organic carbon, total alkalinity, and phytoplankton pigments), incubation experiments for primary productivity, and etc. are carried out. In 2023, recovery and redeployment of the mooring system and hydrographic observations were successfully conducted during the August cruise.

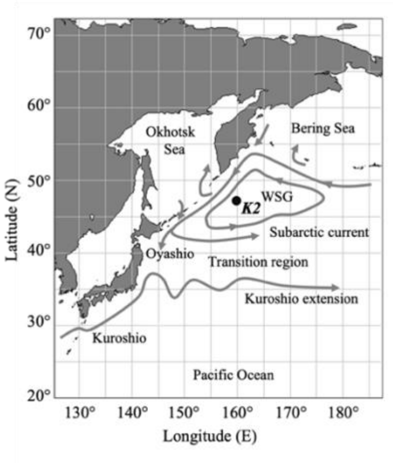


Fig. 1. Location of the time-series station K2 and the surface current systems (modified from Qiu, 2023). WSG means the Western Subarctic Gyre.

From the two decadal observations at K2, several environmental trends are distinguished.

(a) Warming of water temperature: there is a long-term trend towards rising SST at K2 (Fig. 2). By using the data set of annual mean SST, increasing rate of SST in this period was calculated as 2.5˚C/100years which was higher than that around Japan. The increase rates of SST varied seasonally; the highest value was shown in September while SSTs basically didn't change during March (Fig. 3).

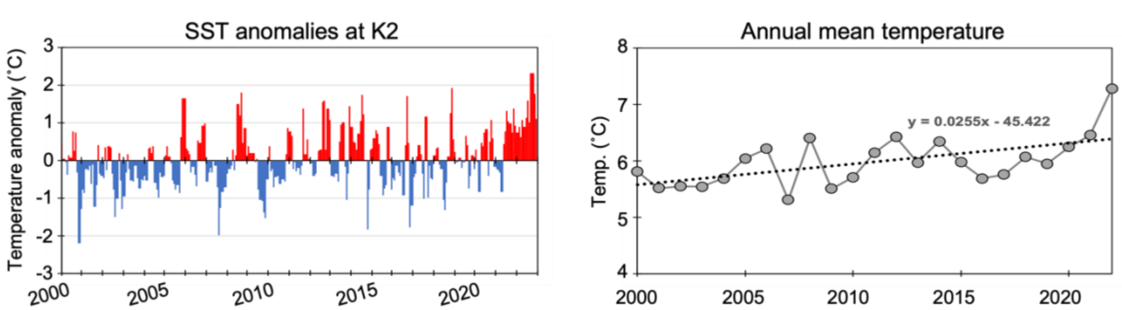


Fig. 2. Time-series of satellite derived monthly mean SST anomalies (left) and annual mean SST (right).

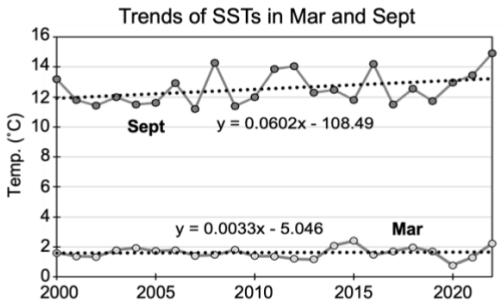


Fig. 3. Seasonal difference of decadal increase rates between March and September.

(b) Surface Chl.*a*: satellite derived surface Chl.*a* concentrations were also compiled to understand long-term trend of phytoplankton biomasses. Seasonal peak and minimum in Chl.*a* concentrations are observed in June and April, respectively (Fig. 4). As regards long-term change, both the increase and decrease trends are hardly detected from the two decadal time-series of Chl.*a* concentrations and Chl.*a* anomalies (Fig. 5). However, mean concentration of Chl.*a* during the warm season (from June to October) seems to be decreased in this research period if two data showing extremely high Chl.*a* concentrations (in 2020 and 2022) are omitted (Fig. 6). Maybe there is a decreasing trend in surface Chl.*a* concentration as the basic tendency at K2.

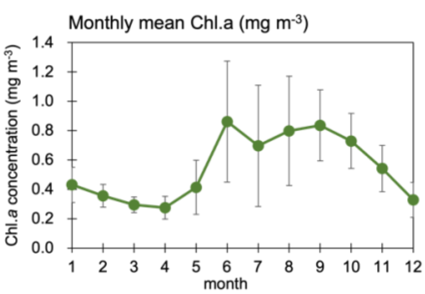


Fig. 4. Seasonal variability of monthly mean Chl.*a* concentrations (mg m^{-3}) around K2.

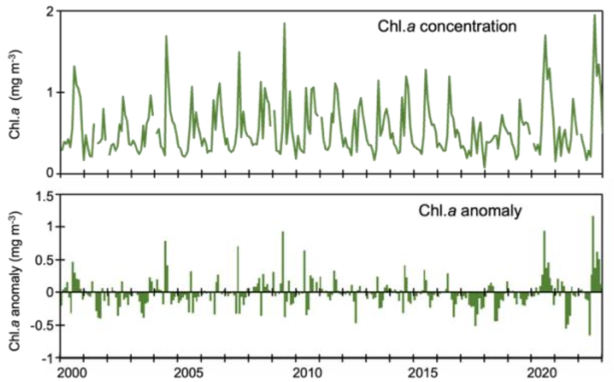


Fig.5. Two decadal variabilities of monthly mean Chl.*a* concentrations (top) and monthly mean Chl.*a* anomaly (bottom) around K2.

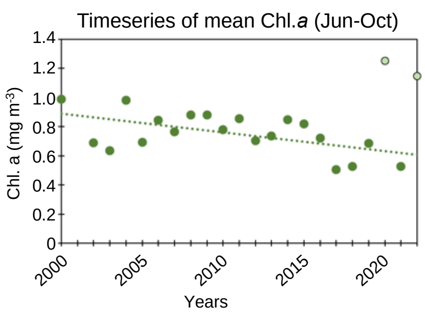


Fig. 6. Time-series of mean Chl.*a* concentration (mg m^{-3}) in the warm seasons (June-October). The dotted line is a regression line excluding two data of 2020 and 2022.

(c) Acidification: the rate of increase of oceanic pCO_2 at K2 was similar to that of atmospheric pCO_2. In the surface layer of the ocean, the annual mean pH significantly decreased at a rate of 0.002±0.0006 $year^{-1}$ mostly in response to oceanic uptake of anthropogenic CO_2. Annual mean $\Omega_{aragonite}$ at K2 also decreased significantly. Marine organisms, especially calcifying species, and ecosystem might be very susceptible to acidification in this region.

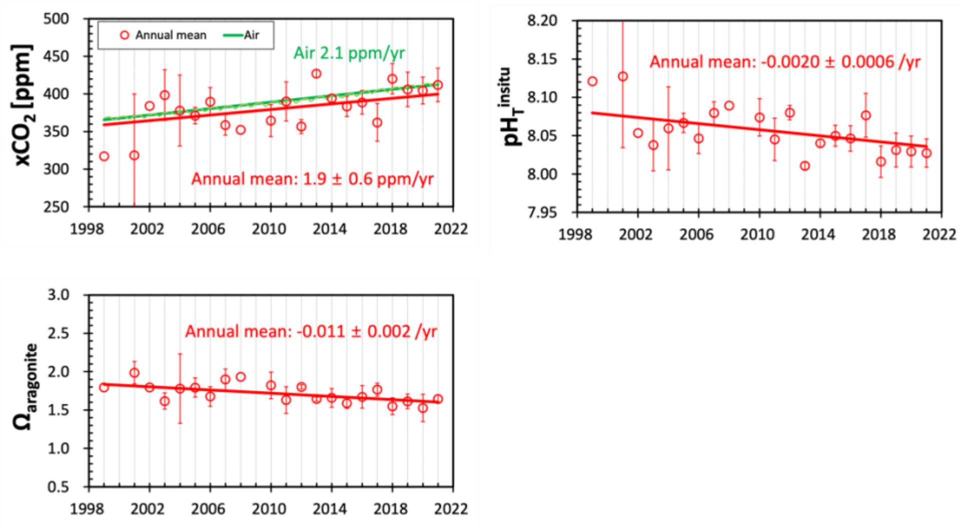


Fig. 7. Time-series of xCO_2, pH and $\Omega_{aragonite}$ in surface water at K2.

(d) Biological pump: from the sediment trap experiment at K2, several characteristics of the biological pump in this area are distinguished; (1) high rain ratio (the ratio of particulate organic carbon flux to inorganic carbon flux), (2) major component of the sinking particles is organic opal, (3) small vertical attenuation of POC, and (4) decadal decrease of $CaCO_3$.

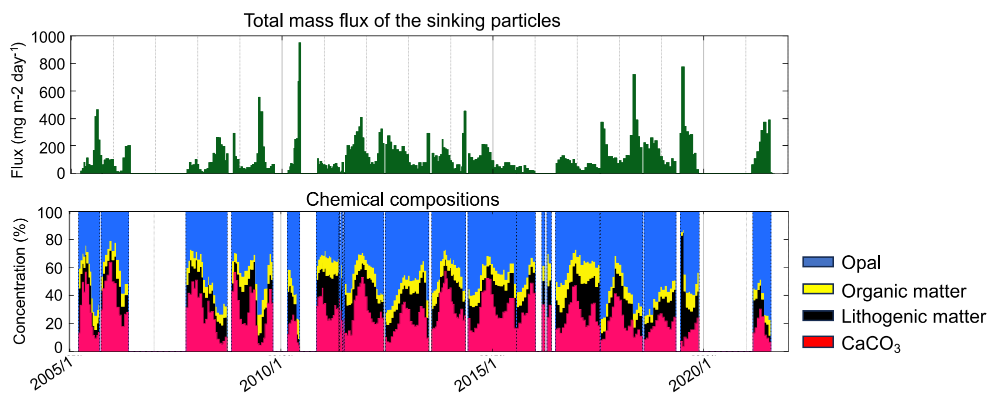


Fig. 8. Time-series of total mass flux of the sinking particles (top) and chemical composition (bottom) obtained by the sediment trap experiment at about 4800 m in K2.

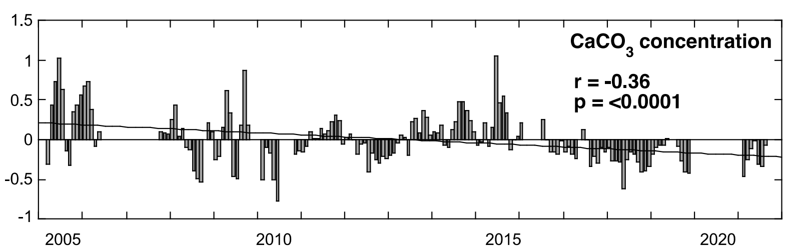


Fig. 9. Decreasing trend of $CaCO_3$ obtained by the sediment trap experiment at K2.

The ocean condition in 2022 can be characterized by comparison with data past 20 years. As regards SST, high water temperature was maintained through the year. Especially, a monthly mean SST in September (14.9˚C) was the highest record through the 20 years long observations. Surface Chl.*a*; from January to June of 2022, monthly means of Chl.*a* were maintained in the low concentration. After that, phytoplankton bloom occurred in the later timing compared with the past seasonality. The monthly mean Chl.*a* concentration in September 2022 was the highest through the study period from 2000 to 2022.

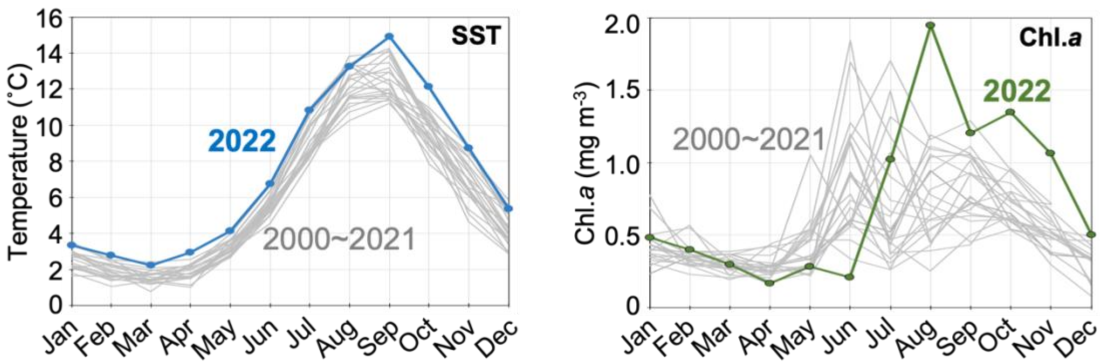


Fig. 10. Seasonal variabilities of monthly mean SSTs (left) and Chl.*a* (right) in 2022 compared with those from 2020 to 2021.

2. Sediment trap experiment at KEO, the western subtropical Pacific

The Kuroshio Extension Observatory (KEO; 32°18′N, 144°36′E) is a mooring station maintained under NOAA’s Ocean Climate Stations Project. The KEO mooring has meteorological instruments as well as sensors to measure upper ocean environments. JAMSTEC deployed other mooring system with sediment traps near the KEO since 2014. From 2014 to 2019, only a sediment trap was moored. After 2019, two sediment traps were installed at 1800 and 4900 m in depths in the mooring system. In June 2023, the mooring system was recovered, and time-series samples of the sinking particles were successfully collected from the two depths. After the sample recovery, the sediment trap mooring was redeployed in June 2023.

3. Ocean-atmosphere observations in the Philippine Sea by moored buoy

A time-series observation station was established at the Philippine Sea (13ºN, 137ºE) in 2016. To obtain real-time air-sea data, a surface buoy system (Ph buoy) has been deployed in the site. Payloads in this buoy for atmospheric observations are temperature, humidity, wind, atmospheric pressure, rainfall amount, long and short-wave radiations sensors. In addition, to collect environmental parameters in the surface ocean, water temperature, salinity, and dissolved oxygen sensors and an ADCP are installed to bottom of the buoy or the mooring wire rope above 300 m in depth. In 2023 summer, the buoy system was successfully recovered and redeployed.

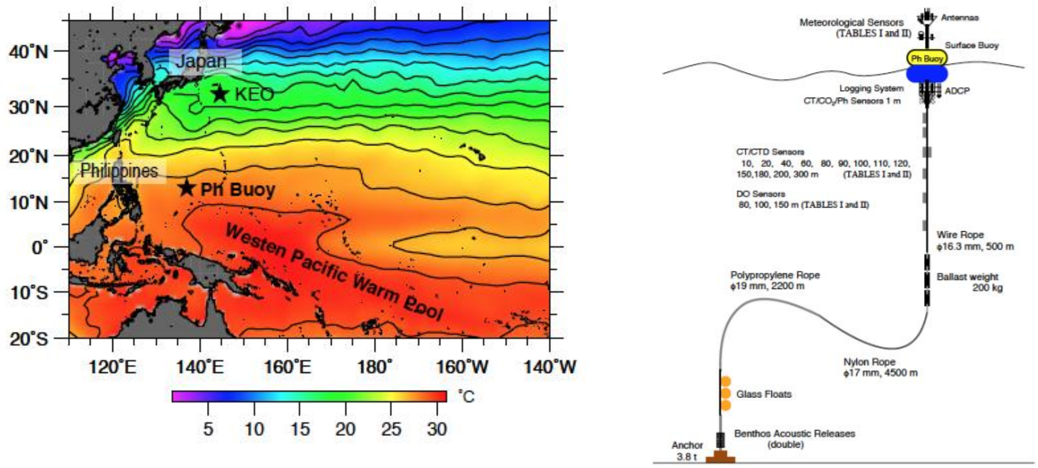


Fig. 11. Deployment site of the Ph buoy (left) and schematic diagram of the buoy (right).

National Report of Japan Fisheries Research and Education Agency (FRA) (by Kazuaki Tadokoro, Fisheries Resources Institute, Shiogama field station)

1. Zooplankton sample collection of Japan Fisheries Research and Education Agency

FRA has collected zooplankton samples from the 1950s to present. The sampling gears are NORPAC net, Bongo net, Larval net, Neuston net, MTD net, VMPS, IKMT, MOHT, etc. The total number of samples was 260226 on September 8, 2023. The samples are preserved by 5% buffered formaldehyde. The zooplankton samples are stocked in a dedicated storage building at the FRA Fishery Resources Institute of Shiogama field station (Fig. 1), 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 the university. The sample number of each decade is indicated in Figure 2. Although the sample number is 1981 in the 1950s, it increased decade by decade. The number reached 83192 in 2010s. A part of the sample was collected by Dr. Kazuko Odate and it is well known as Odate collection. Those samples were used for the study of the relationship between marine ecosystems and climate change and the biodiversity of marine ecosystems. Moreover, the samples collected by Neuston and Larval nets are used for the study of geographical and temporal variation of microplastics in the western North Pacific (e.g. Miyazono et al., 2021). Web site: https://ocean.fra.go.jp/plankton/hyohon_home.html (only Japanese)

(a) (b)

Fig. 1 Sample storage building at Shiogama field station of FRA Fishery Resources Institute. Exterior (a) and inside (b) of the Building.

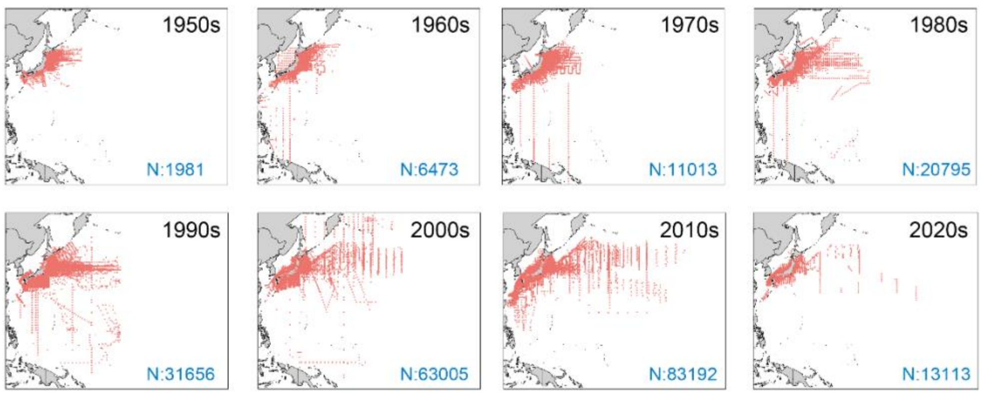


Fig. 2 Sampling location and number of zooplankton collection for the each decade

2. Observation of Monitoring lines

FRA have carried out oceanographic observation monitoring at 6 lines around Japan (Fig. 3). Detail of the observation is described as below.

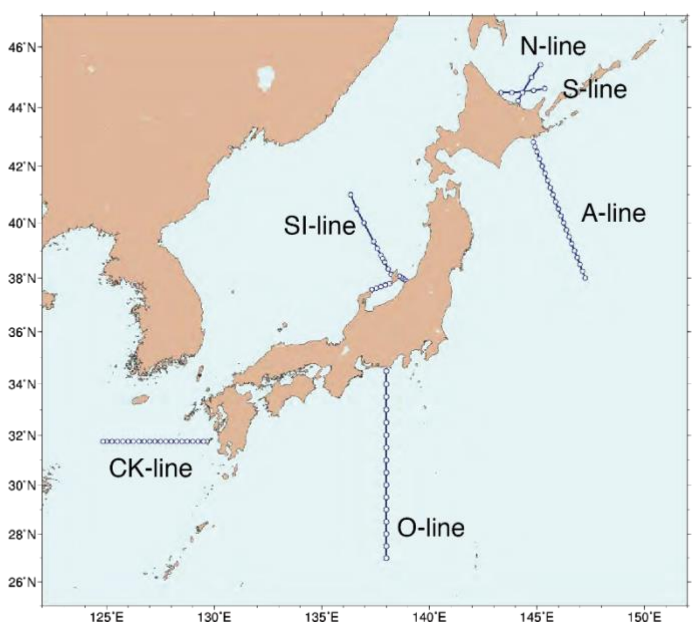


Fig. 3 6 monitoring lines around Japan has been conducted by Fisheries Resources Institute of FRA

<u>A-Line</u>

Shiogama and Kushiro field stations of Fisheries Resources Institute, FRA 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. The oceanographic data are opened and available from the website (Fig.4). Period of published data are from 1990 to 2020 for CTD and from 1990 to 2016 for others.

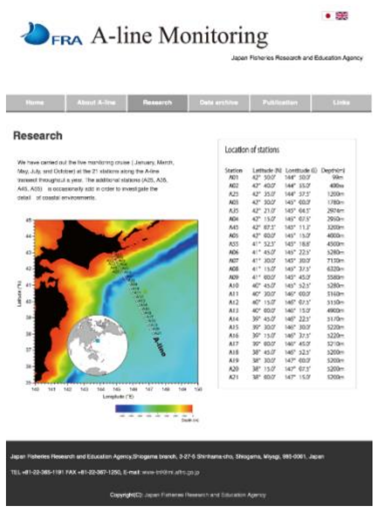


Fig. 4 Website of A-line monitoring (https://ocean.fra.go.jp/a-line/a-line_index2.html)

<u>O-line</u>

Yokohama head quarter of Fisheries Resources Institute, FRA 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.

<u>CK-line</u>

Nagasaki head quarter of Fisheries Technology Institute, FRA 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.

<u>SI-line</u>

Niigata field station of Fisheries Resources Institute, FRA 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.

N-line, S-line

Kushiro field station of Fisheries Resources Institute, FRA 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.

3. Monitoring of stock assessment project commissioned by FRA

The observations have been carried out at 760 stations (Fig. 5) 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).

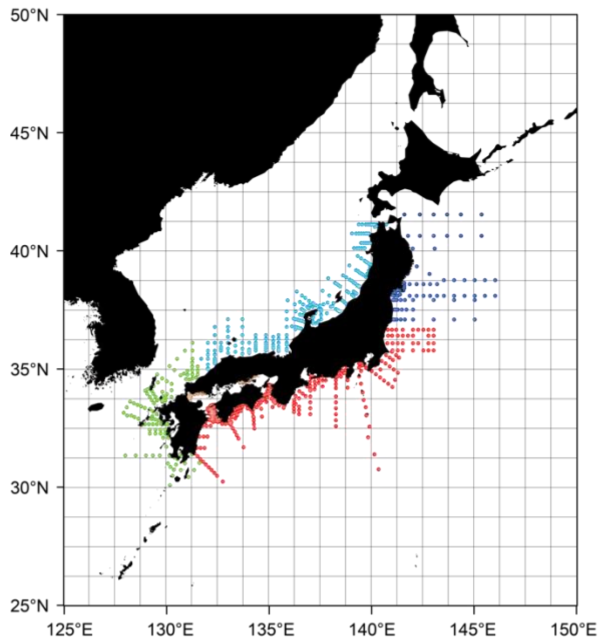


Fig. 5 Sampling location of the Monitoring of stock assessment project

4. <u>Fish eggs, larvae, juvenile sample collection</u>

Yokohama head quarter of Fisheries Resources Institute, FRA started to collect the samples (Fig. 6) 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.

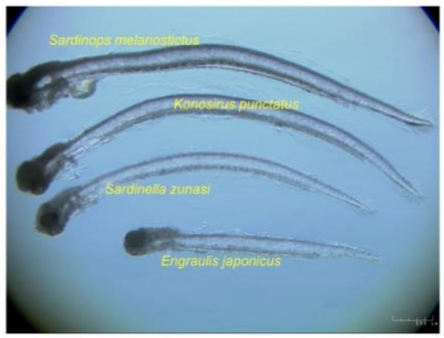


Fig. 6 Fish larvae specimen samples

5. <u>Fish specimen sample collection</u>

Nagasaki head quarter of Fisheries Technology Institute (Fig.7), FRA have collected fish specimen samples. The number of species 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.

Fig. 7 Sample storage building (above) for the fish specimen collection, and the specimens (below)

References

Miyazono K., R. Yamashita, H. Miyamoto, N. H. A. Ishak, K. Tadokoro, Y. Shimizu, and K. Takahashi (2021) Large-scale distribution and composition of floating plastic debris in the transition region of the North Pacific, Marine Pollution Bulletin, 10.1016/j.marpolbul.2021.112631

6. Russia

Conducted by the Pacific branch (TINRO) of the Federal State Budget Scientific Institution "Russian Federal Research Institute of Fisheries and Oceanography" (VNIRO)

Each midwater trawl station is accompanied by hydrological and hydrobiological stations just before or after the trawling.

TINRO's vessels conducted 738 midwater trawls during fishery-independent surveys in the Northern part of the Pacific Ocean in 2022 (Fig. 1). 116 of those trawls were conducted in the high seas (including 32 trawls in the North-Eastern Pacific under the International Year of the Salmon).

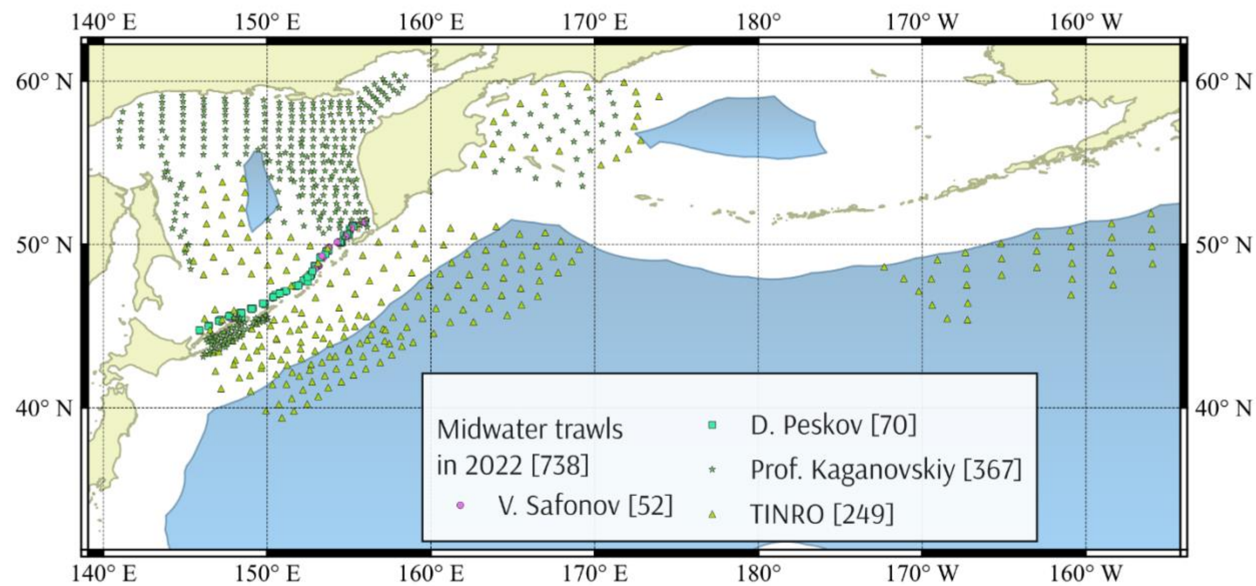


Fig. 1. Midwater trawls, conducted by TINRO's R/V in 2022

There were 378 midwater trawls conducted by R/V of TINRO in the Northwestern part of the Pacific Ocean in 2023, which have been processed already (Fig. 2). In the high seas there were 52 trawls.

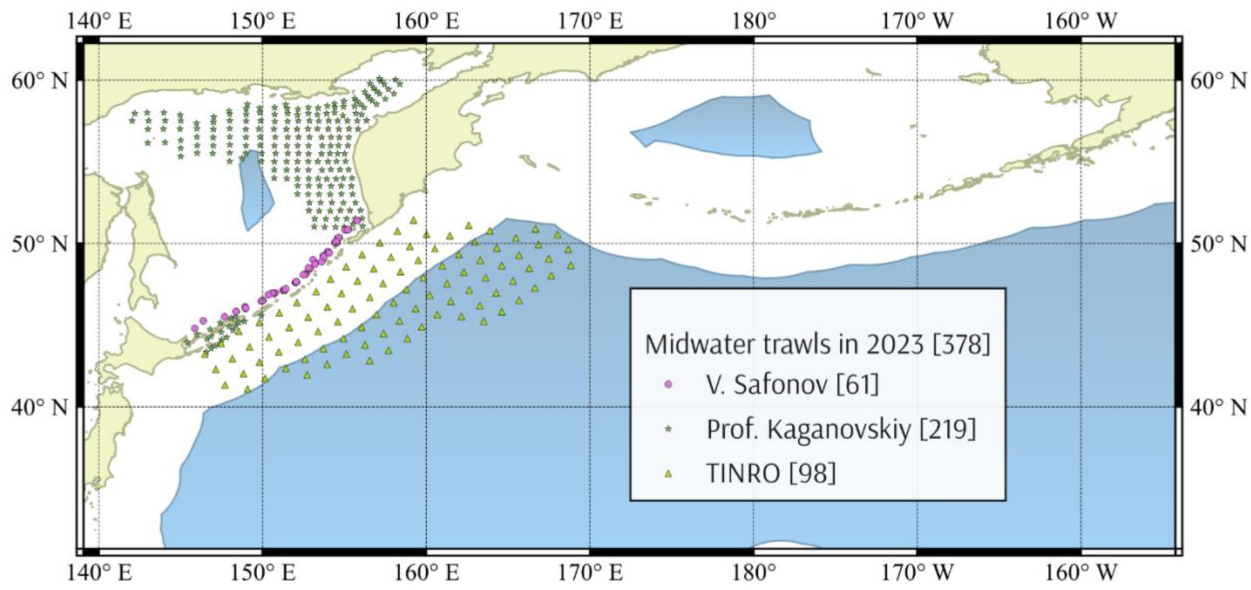


Fig. 2. Midwater trawls, conducted by TINRO's R/V in 2023 so far (the figure will be updated in 2024)

There were 560 bottom trawls conducted by R/V in 2022, which were imported into the database in TINRO (Fig. 3).

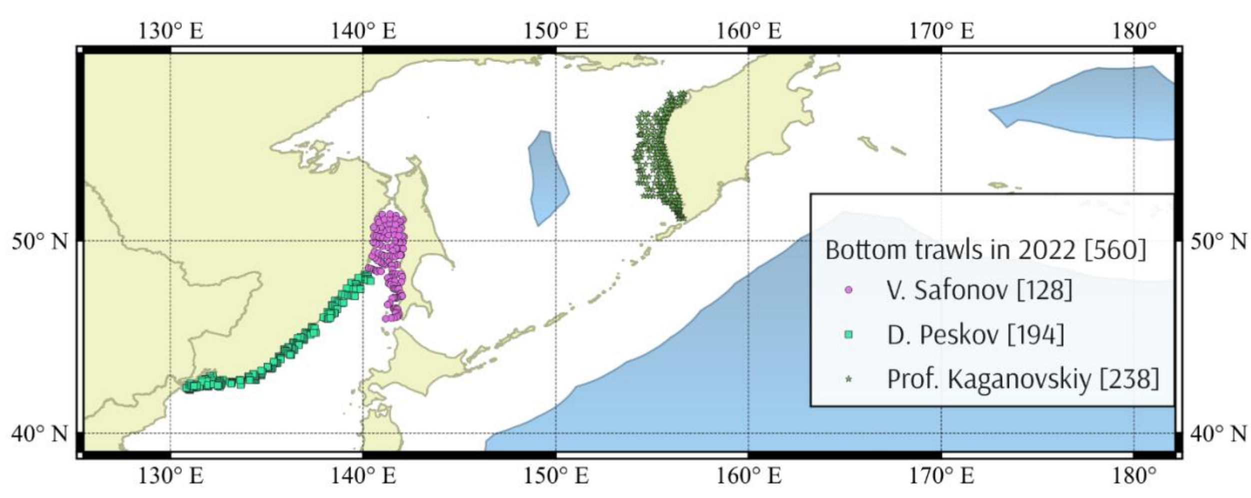


Fig. 3. Bottom trawls conducted by TINRO's R/V in 2022

In 2023 the Division for fishing statistics and databases has processed fully only 1 scientific survey with 132 bottom trawls (Fig. 4).

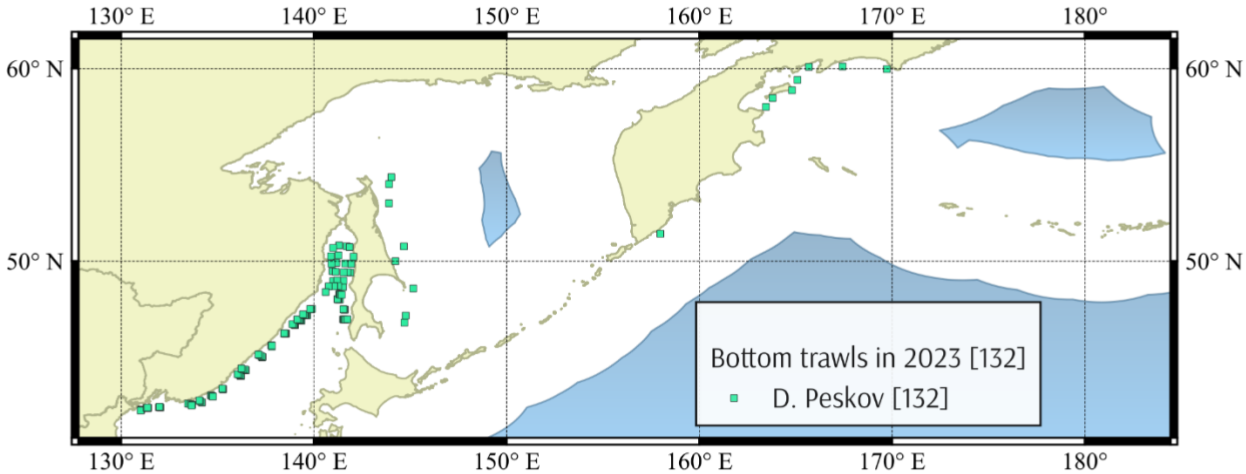


Fig. 4. Bottom trawls conducted by TINRO's R/V in 2023, which have been processed so far (the figure will be updated in 2024)

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

AGENDA ITEM 6: OTHER BUSINESS

1. Annual report and briefing book

MONITOR Annual Report has included the National Reports. However, it does not fit the recently revised annual report template, which requires a short description. Thus, the National Reports were dropped in the 2022 MONITOR National Report. Based on clarification from Sanae, we can include the National Reports in the MONITOR Annual Report. Note that the Annual Report posted on the Publication web page and the Report under the Annual Meetings and Products on the MONITOR web page are identical.

2. Note on ranking the PICES-2024 session/workshop proposals
    a. Session/Workshop deadline: September 22nd
    b. Proposal circulation/evaluation is expected from Oct. 2 to Oct. 7.

The DAY 1 meeting was adjourned.

DAY 2

AGENDA ITEM 7: WELCOME AND INTRODUCTION

MONITOR Chair Prof. Sung Yong Kim called the meeting to order, participants introduced themselves (name, affiliation, roles in PICES/MONITOR, and research area), and the agenda was reviewed and adopted.

Attendee of the 2nd day meeting: **[on-site members]** Sung Yong Kim (MONITOR Chair, Korea), Jennifer L. Boldt (Canada), Tjatiana Ross (Canada), Kazuaki Tadokoro (Japan), Jack Barth (USA), Kym Jacobson (MONITOR Vice-Chair, USA), Lisa Eisner (USA), **[on site observers]** Jae-Hak Lee (Korea), Sei-Ichi Saitoh (Japan), Robin Brown (Canada), Carol Janzen (USA), Maciej Telszewski (USA), Sonia Battten (PICES, CPR), David Checkley (USA), KW Jung (Korea) **[virtual members]** Vyacheslav B. Lobanov (Russia), Hiroto Abe (Japan) **[virtual observers]** Jan Newton (USA), Mariela Brooks (USA), Carol Janzen (USA)

AGENDA ITEM 8: UPDATES/RECAP FROM THE PREVIOUS MEETING

The Chair reviewed the previous meeting and reported supporting proposals based on votes that the committee members provided.

Supporting 2024 PICES Annual Meeting session and workshop titles:

- Sessions
  - Climate Extremes and Coastal Impacts in the Pacific
  - Observational frontier and new studies for understanding of ocean and ecosystem
  - Past, Present and Future of CREAMS program: 30 years of international research in North East Asian Marginal Seas
  - Advanced tools to monitor, observe, and assess small pelagic fish populations in support of ecosystem based fisheries management and maintaining ecosystem services
- Workshops
  - Applying social-ecological frameworks to explore actionable solutions for climate extreme events across the North Pacific
  - Integrating biological research, fisheries science and management of flatfish species in the North Pacific Ocean in the face of climate and environmental variability
  - Co-creating a shared framework for ocean data management: Finding common ground on terminology
  - North Pacific Plankton Time Series Data Analyses and Synthesis

AGENDA ITEM 9: UPDATES FROM EXPERTS GROUPS

1. Activities of FUTURE: Jennifer Boldt

The FUTURE Science Program Phase III priorities are:

1. Retain a Flagship Science Program to integrate PICES science,
2. Maintain the momentum of FUTURE and proceed with Phase III tasks,
3. Bring ECOPs, others into SSC membership for new ideas, enthusiasm,
4. Facilitate cross-pollination across FUTURE, AP-UNDOS, AP-ECOP, AP-SciComm [FUTURE recommendation: Joint AP meeting at Annual Meeting],
5. Renewed focus on science-based solutions & operational products,
6. Around 2025-2027, rethink a new Science Program for PICES, informed by emergent themes identified in UNDOS.

The FUTURE Science Program has an Early Career Ocean Professional SEES Award. The objective of this award is to encourage recognition and application of the SEES approach, and engage early career scientists in PICES activities. As part of this award, the FUTURE SSC will provide funds (~$3,000 CAD) to support the travel costs of early career scientist(s) to participate in the following PICES Annual Meeting. The early career scientist (or team of early career scientists) will be invited to present the work in the Science Board (or other plenary) Symposium to highlight the application of the SEES approach. This year's Early Career Ocean Professional SEES Award was awarded to Dr Vivitskaia J.D. Tulloch. Dr. Tulloch is presenting an invited talk in S1 (16678) titled "Application of a Social–Ecological–Environmental System Framework to address and manage future climate change impacts on threatened killer whales and their Pacific salmon prey".

The FUTURE SSC is drafting a review paper on Climate Variability and Ecosystem Resilience in the North Pacific: Lessons Learned from the PICES FUTURE Program. The objective of this paper is to evaluate the success of FUTURE in addressing PICES' Science Plan, identify gaps in scientific advancement, determine causes of gaps, and to provide lessons learned for large-scale science programs. The lead authors are Drs. Shion Takemura and Mitsutaku Makino and the target journal is Frontiers in Marine Science.

During the PICES 2024 annual science meeting, the FUTURE SSC is planning a one-day symposium titled "The FUTURE of PICES: Science for Sustainability in 2030". FUTURE has helped PICES develop a better understanding of the combined consequences of climate change and anthropogenic pressures on marine ecosystems, ecosystem services, and marine-dependent social systems. We now embark on the "FUTURE" of PICES that will lead to better observations, improved awareness of mechanisms of change, and ultimately science for sustainability by 2030.

2. Activities of AP-CREAMS: Jae-Hak Lee

In this presentation, we will report the status of AP-CREAMS activities in 2023 and explain the planned activities in

- The intersessional meeting was held twice on June 20-21 and September 20, 2023. In a situation where the impact of COVUD-19 has not yet been completely terminated, it was conducted in the form of a video conference.
- The annual business meeting was held in hybrid form in Seattle on October 22, 2023.
- The FUTURE/HD/POC topical workshop led by AP-CREAMS was held in Seattle on October 20, 2023. Originally, it was planned to be held all day, but there were unexpectedly many people who did not attend the meeting, so it was reduced to holding it in the morning. Workshop 4 Changing social-ecological-environmental system of the North East Asian Marginal Seas: New challenges for integrative marine science.
- The construction of the CREAMS web-site http://inno.hostwhale.co.kr and cruise database, which are being promoted as major activities of AP-CREAMS, is continuously being reported on progress and reviewed for problems at each meeting. Develop a format/template based on metadata table
- 2024 marks the 30th anniversary of the CREAMS program, and AP-CREAMS has proposed two events to celebrate it. One is the Scientific Session (1 day) at the 2024 PICES Annual Meeting. Past present and Future of CREAMS, 30th Anniversary of Creams"and the other is the Inter-sessional Workshop to be held inSeoul, Korea "International studies of NE Asian Marginal Seas: from circulation and biogeochemistry to socio-economic research.
- Dr. Lobanov won a distinguished award from Sea Star Award from the Governor of Primorye Region, Russia for the achievements in the research of seas around Primorye including development of international collaboration.
- Four new AP-CREAMS Members were announced; one from China, one from Japan, and two from Korea. These are nominated from the national delegates. All are requiested through indivual countries' GC members.

3. Activities of AP-NPCOOS: Sung Yong Kim (on behalf of AP-NPCOOS co-chairs)
   - As a part of communication with non-PICES audience, individual EGs prepare primary activities and roles (e.g., TORs, summer school, best practices, etc) developed as a fact sheet.
   - AP-NPCOOS summer school planned
     - Theme: Macro Coastal Oceanography including physics, biology, and bio-geochemistry
     - Venue: Kagoshima or Hakodate, Japan
     - Tentative season: 2025 Fall or 2026 Spring
     - Expected number of students: up to 20
     - Primary point of contact: Prof. Naoki Yoshie, Dr. Takahiro Tanaka
     - Need to prepare the proposal in 2024 Spring
     - From GC-2021 Appendix A 2021/S/17 (please see below), SB confirmed that PICES will contribute the CAD 15,000 that has been deferred from the 2020 Spring School, to partially support the salary of the Virtual Summer School Coordinator. GC approved.

- Dr. Kim Juniper stepped down from his co-chair role, and Dr. Jennifer Jackson was recommended to take the co-chair role. Requested to add Alex Harper (USA) starting from January 1st, 2024
- Jack Barth who attended the Fact Sheet workshop is drafting one for MONITOR Jack Barth will circulate a first draft for comment
  - o Nothing in the "North Pacific Ocean" makes sense except in the light of "monitoring ocean conditions"
  - o Unseen ocean changes still cause harm

AGENDA ITEM 10: UPDATES FROM INTERNATIONAL ORGANIZATIONS

1. Activities of the CPR: Sonia Batten (on behalf of Clare Ostle)

North Pacific CPR Survey:

This year marks the 24th consecutive year of data collection, the figure below (figure 1) shows the sample coverage:

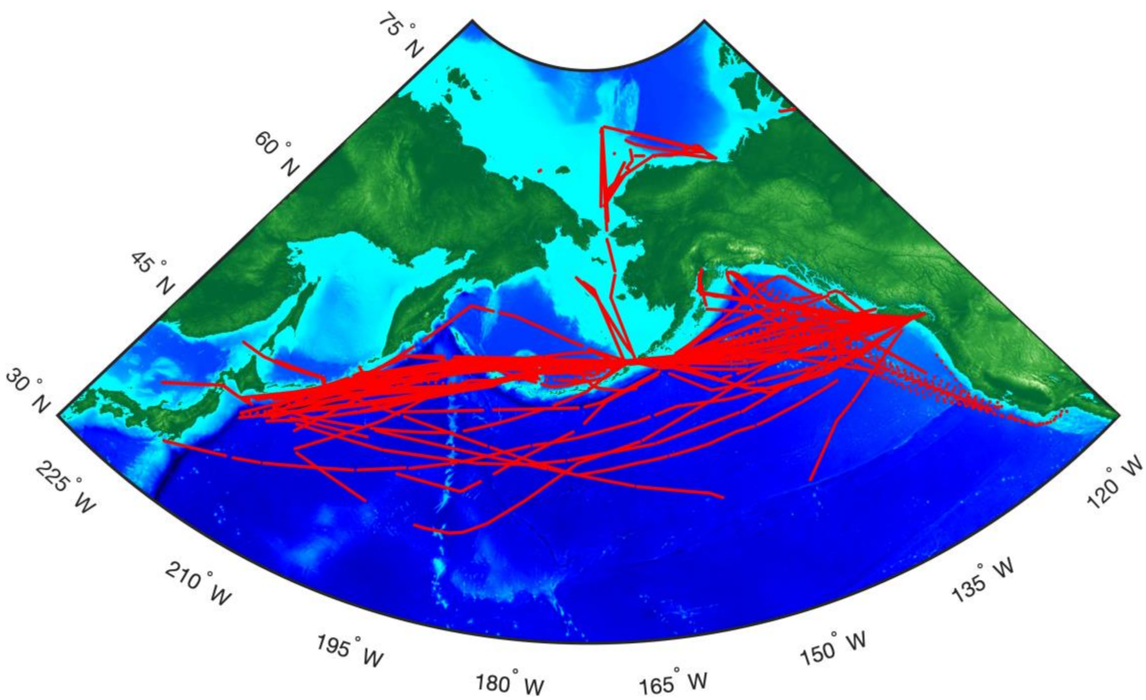


Figure 1. CPR sample locations in red (2000-2023). Please note samples often overlap, and there are additional transects to be added to the figure for 2023 once sample processing has been completed.

Funding remains consistent, and we have recently (Sept 2023) received news that we have been successful on two NPRB proposals which will start in 2024. One of these projects entitled "Extending the North Pacific Continuous Plankton Recorder survey into the Western Arctic Ocean, PI C. Ostle" will help to support the new route through the Bering Strait into the Arctic Ocean, alongside molecular investigations on CPR samples. The other successful proposal is entitled “Through the Looking Glass: Zooplankton and seabird community structure in a changing North Pacific, PI B. Hoover”, in which we will be collaborating with colleagues at the Farallon Institute (CA, USA) to investigate microplastics and seabirds in the Gulf of Alaska.

The CPR survey sampled the east-west transect in May to October, and the north-south transect from April to October in 2023. Identification and counting of plankton samples is ongoing at this time.

We also successfully deployed next generation PlankTag sensors that measure temperature, salinity, and fluorescence on the CPRs on both the east-west and north-south routes in 2023 and examples of the data collected are shown in figure 2.

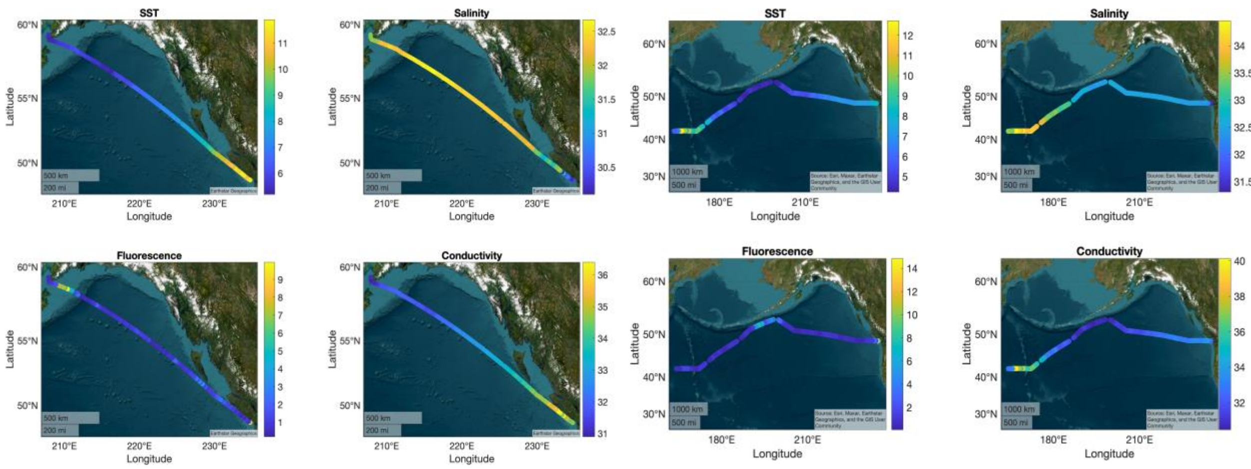


Figure 2. Measurements of temperature, salinity, fluorescence and conductivity collected using PlankTag sensors fitted to CPRs on the N-S route in May 2023 (left) and E-W route in April 2023 (right).

Recent publications, reports and articles:

Batten, S. D., C. Ostle, P. Hélaouët, and A. W. Walne. 2022. Responses of Gulf of Alaska plankton communities to a marine heat wave. Deep Sea Research Part II: Topical Studies in Oceanography 195:105002.

Li, K., J. C. Naviaux, S. S. Lingampelly, L. Wang, J. M. Monk, C. M. Taylor, C. Ostle, S. Batten, and R. K. Naviaux. 2023. Historical biomonitoring of pollution trends in the North Pacific using archived samples from the Continuous Plankton Recorder Survey. Science of the Total Environment 865:161222. Elsevier B.V. Pinchuk, A.I., Batten, S.D., and Strasburger, W.W. (2021). Doliolid (Tunicata, Thaliacea) blooms in the southeastern Gulf of Alaska as a result of the recent heat wave of 2014-2016. Frontiers in Marine Science – Marine Ecosystem Ecology.

Ostle, C., and Batten, S. (submitted.) NOAA Ecosystem Status Report 2023: Continuous Plankton Recorder Data from the Aleutian Islands and Southern Bering Sea: Lower Trophic Levels in 2022.

Ostle, C., and Batten, S. (submitted.) NOAA Highlight Report 2022: Continuous Plankton Recorder Data from the Eastern Bering Sea: Lower Trophic Levels in 2023.

Ostle, C., and Batten, S. (submitted.) NOAA Ecosystem Status Report 2023: Continuous Plankton Recorder Data from the Gulf of Alaska: Lower Trophic Levels in 2022.

Sydeman, W. J., S. Ann, M. García-Reyes, C. Kroeger, B. Hoover, S.D. Batten, and N. A. Rojek. 2023. Progress in Oceanography Effects of currents and temperature on ecosystem productivity in Unimak Pass, Alaska, a premier seabird and biodiversity hotspot. Progress in Oceanography

2. Activities of the WGICA: Sei-Ichi Saitoh

Working Group on Integrated Ecosystem Assesment of the Central Arctic Ocean (WGICA) aims to provide a holistic analysis of the present and future status of the Central Arctic Ocean (CAO) ecosystem and human activities therein. Representatives from PICES, ICES, and Protection of the Arctic Marine Ecosystem (PAME), and engaging scientists from 13 nations. Group active since 2016, meet yearly (this year in conjunction with this meeting). Climate change reduces sea ice, increases light penetration, causes regionally variable trends in stratification and mixing of the water column, increases inflow in both the Atlantic and Pacific sectors, and enlarges heating of waters at the surface and extending deeper. These changes in turn affect primary production and cascade through the foodweb to ice-associated fauna, zooplankton, fish, benthos, seabirds, and marine mammals. They may be exacerbated by increasing human activities in and around the CAO, including increasing pollution from ship traffic and from the transport of contaminants to the ecoregion by rivers and ocean currents. During this past year, WGICA has studied and described human activities in and around the CAO and resulting pressures. In the next three years, WGICA planned to identify ecological, economic, social, and institutional research questions, to enable further stakeholder involvement, and to identify integrated assessment methods that can help evaluate ecosystem conditions and changes. In this presentation we present the main results from the ongoing reporting of the main human activities (global sources, shipping, military and tourism), pressures (contaminants, garbage, noise, etc) and the work on describing the vulnerability of the ecosystem. Published report (through ICES) on ecosystem components. Working on (similar) human activity report, pressure and ecosystem vulnerabilities. Can watch a 5 min movie summarizing the report (i.e. the CA ecosystems)

3. Activities of the US IOOS/NANOOS: Jan Newton

NANOOS consist of 77 member organizations. Serving 1334 datastreams, 232 assests served on NVS and fund approximated 0% of these. A very diverse governing council. Leveraging and linking of observations and forecasts, data products, outreach etc. Collaborations with Columbia River Inter-Tribal Fish Commission (CRITFC), OSU and Quinalt Indian Nation. Replacing infrastructure. HABS is an important issue for the Washington Coast and razor clamming. An ESP measure domoic acid in real time. NSF award to deploy spotter buoys with tribal nations. Celebrating 20 years.

4. Activities of the OneArgo: Tjatiana Ross

Currently 3000 floats, 6000 research papers. Measures temp and salinity. In 2023, Argo is still in transition from the original highly-successful core Argo program to OneArgo (4700 floats), a new plan that combines core, Carbon, Biogeochemical and Deep floats and expands spatial coverage in key regions. However, this expansion is not without it's challenges. Funding is flat so adding more expensive floats has led to a slow net decline in the Argo array. Technically ready.

Jack Barth suggested writing a letter of support for OneArgo Main take-away messages:

- Argo and observations from space are a powerful observing system combination
- The OneArgo design targets gaps in the deep and polar oceans, and for biogeochemical sampling
- Currently Argo array is in decline
- Ongoing community support is needed to achieve full implementation of OneArgo
- A strong voice from the PICES community about the need for OneArgo is essential

5. Activities of the BECI: Robin Brown

PICES (along with partners) continues to develop the plans for BECI (Basin-Scale Events to Coastal Impacts). A UN Ocean Decade sponsored program As you may recall, BECI aims to create a North Pacific ocean intelligence system or situational awareness system. The components of BECI will be Modeling/Projections; Observations/Monitoring; Data Mobilization; Targeted At-Sea Research and Communications/Coordination. The primary beneficiaries are expected to be agencies and organizations (including RFMOs) that manage fisheries in an era where climate change is disrupting existing patterns and arrangements. While there are many fisheries and target species, there is a lot of overlap in the information required to manage these fisheries in a changing climate.

Major Components: Modeling, Data Mobilization, Observation and modeling,Targeted at-sea research (but not a fleet of ships), Outreach, Communication and Coordination

In the spring of 2023, a hybrid workshop was held to develop the BECI Science Plan, received funding to staff a science director and an additional position (beci.info/careers). Since that time, most of the effort has been dedicated to fundraising to allow PICES to have some dedicated staff and resources to develop the BECI Science and Implementation Plans. Funding coming.MONITOR can assist by providing oversight and advice on the Observations/Monitoring component as well as assisting with identification and coordination with existing monitoring initiatives in the North Pacific.

6. Activities of the AOOS: Carol Janzen

The Alaska Ocean Observing System (AOOS) is one of 11 Regional Associations that make up the U.S. Integrated Ocean Observing System (IOOS). AOOS has a stakeholder-driven mission aimed at coordinating and leveraging observing activities with regional partners. These efforts emphasize filling critical data gaps in ocean information and observations, increasing observing capacity for atmospheric and oceanic forecasting, providing public access to accurate and reliable coastal ocean data, and developing data tools and information products useful to those who need to make management decisions or just decide if they can safely go out on the water on a given day. To fulfill this mission, AOOS focuses observing efforts on improving safe maritime operations, increasing in situ observations and access to information related to coastal hazards, supporting projects that track ecosystem and climate trends, and monitoring water quality. AOOS also emphasizes making coastal ocean information publicly accessible by providing a statewide data portal that hosts the largest collection of coastal ocean data and data products for the Alaska region. In this presentation, we provide an update on the AOOS in situ observing portfolio with an emphasis on operational assets. Brief overviews of AOOS and regional partner activities related to wave buoys, high frequency radar arrays, weather and water level observing, and progress with the ecosystem moored observatory build-outs are presented. The recent expansion of autonomous glider missions that benefit the "Ecosystem Approach to Fisheries Management" (EAFM) are also introduced, along with examples of associated "ecometrics data dashboard" reporting tools that provide immediate oceanic condition information to fisheries managers as well as the general public. More information about AOOS and access to the AOOS Data Portal, data viewing tools and numerous project descriptions are available at the following AOOS Website link: www.aoos.org

Recent installations:

i. SOFAR Ocean Wave Buoys (Backyard Buoys project, as mentioned in NANOOS prezzie) also being deployed in Alaska (where there is traditionally very little sampling)
ii. Weather and AIS tracking stations
iii. Alternative water level stations (14; increasing water level observing by 50%)
iv. 4 ecosystem moored arrays
v. Ocean sound installations (OTN and PAM)
vi. Using loaded gliders: annual surveys in Gulf of Alaska and crab tracking in Bering; also added a real-time eco-metric dashboard (showed example from Seward Line)

Four Ecosystem Morred Observatories, support Ocean Telemetry Network acoustic arrays in GOA, Mapping ocean and ecosystem conditions ions gliders and ships. Gliders with full biogeochmeial sensors, acoustic transducers and PIT tag detectors. They also promote long-terms ocean acidification and local HABs monitoring: OA mapping from ferry service and stationary Burke-o-lators. Many projects are being driven by fishery stakeholders.

7. Activities of the IOCCP: Maciej Telszewski

International Ocean Carbon Coordination Project (IOCCP)

a. Focus on the need for observing the ocean carbon budget and variability – urgent need for monitoring capacity
b. Showed how pCO2 observations have been dropping since 2016
c. GGGW (global greenhouse gas watch), this will require a lot more investment in observing carbon in the ocean
d. PICES help in writing implementation plan?

Ocean uptake variability caused by many not well observed processes
Requirement to rapidly and operationally link ocean data through to policy makers and minimize mitigation/adaption costs

Measure, synthesize, fill models, provide to international assessments, but pCO2 surface observations are sparse. Since 2017 alarming decline in open ocean CO2 measurements. Need operational funding. World Meteorlogical Org. coordinated Global Greenhous Gas Monitoring Infrastructure.

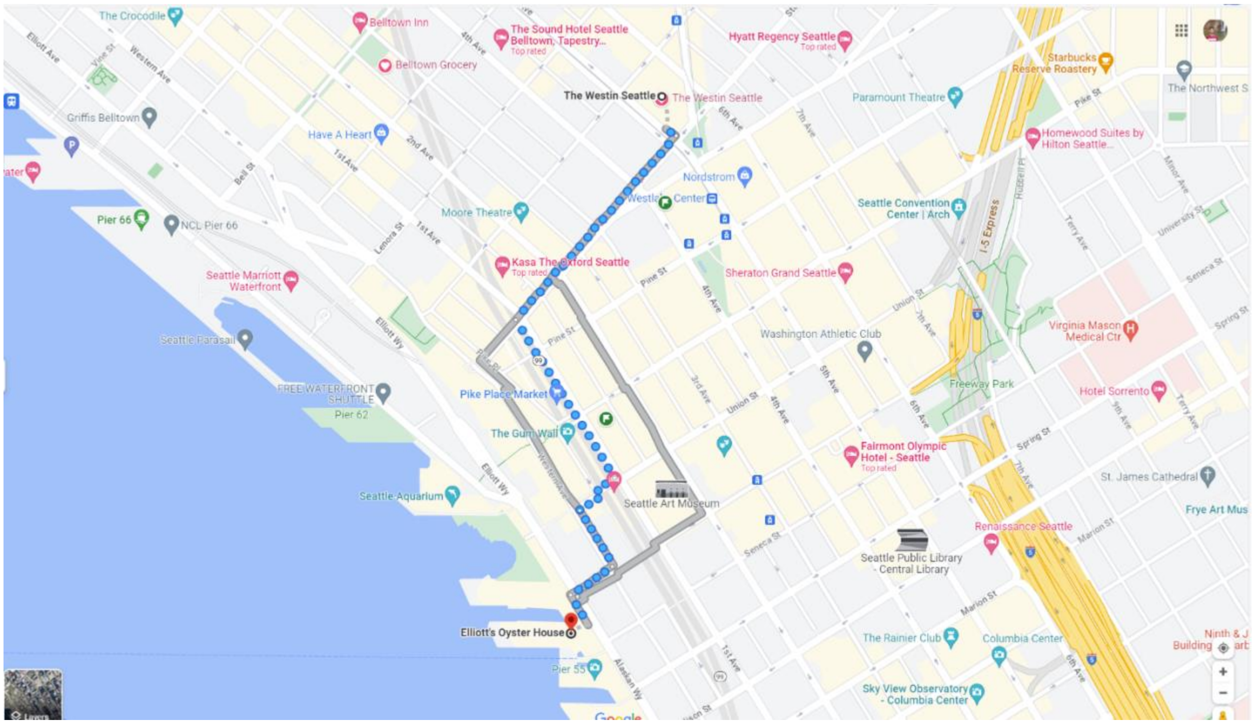
AGENDA ITEM 11: OTHER BUSINESS

1. Discussion

- POMA candiates
  - o OneArgo, Tide gauge stations/program including sea level
  - o Elligiblity - Global, regional observational programs, research vessel, and advancing technique (see more details in Appendix B)
  - o Comment – If ther is no appropriate candidate for POMA, we may not offer the POMA in that year. However, the given scoring system (1 for highly relevant to POMA, *N* for less likely for POMA amog *N* applications; A simple sum of members' evaluaiton will make the order of our committe. Then, SB members discuss ours and TCODE's results similarly evaluated determine the awardee) may not be applicable to the non-offering case. The MONITOR chair uaually asked members to provide whether this year POMA should be offerred and your evalaution using the scoring system. If a member wants to express not offering yearly POMA, it would be better to describe your intention intead of high number scoring as it can bias the scring system.
  - o We recommend to find appropriate candicates encourage them to apply
  - o Nominations Nov 1st through the end of March. Recommendation if none are worthy of award reviewer should state so.
  - o Scoring system - it would be good to doublc chck with the TCODE chair to see how they score POMA applications

- The Chair recapitulated the DAY2 discussion National reports; updates of EGs; review proposal based on votes. . Further discussion on timing of briefing book. Request to have it later.

AGENDA ITEM 12: DINNER



Venue: Elliott's Oyster House
Date: October 24th 2023, Tuesday 6 pm
https://www.elliottsoysterhouse.com/
1201 Alaskan Way, Pier 56, Seattle, WA 98101
206-623-4340

The DAY 2 meeting was adjourned


EXIT

APPENDIX

A. MONITOR ACTION PLAN (2020-2025)

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.

B. PICES Ocean Monitoring Service Award (POMA)

1. Background

Progress in many aspects of marine science is based on ocean observations, monitoring, and the management and dissemination of the data provided by these activities. Long-term monitoring observations are particularly critical to detecting and understanding ecosystem changes. In addition to long-term monitoring, there are new innovative observation methods that are being developed alongside technological advancements, such as autonomous vehicles, remote data collection, ocean observing systems, new sensors and techniques, and algorithms, which contribute to the implementation of sustainable observation. Monitoring activities are often taken for granted or even targeted for budget cuts when organizations experience financial constraints. With this in mind, it was proposed at the 2006 Annual Meeting in Yokohama, Japan, that a new PICES award be established to acknowledge monitoring and data management activities that contribute to the progress of marine science in the North Pacific. The principles of the award were approved at the 2007 inter-sessional Science Board/Governing Council meeting, also in Yokohama, and the name and description of the award were finalized at the 2007 Annual Meeting in Victoria, Canada. At PICES-2019, a review of the Award was conducted and a decision was reached to broaden the eligibility criteria to include "innovative advances in ocean monitoring and service".

2. Aims

The PICES Ocean Monitoring Service Award (POMA) aims to recognize organizations, groups, and outstanding individuals that have contributed significantly to the advancement of marine science in the North Pacific through long-term ocean monitoring, data management, and innovative advances in ocean monitoring. The award also strives to enlighten the public on the importance of those activities as fundamental to marine science. It draws attention to an important aspect of the PICES Convention that is not so much in the limelight: "to promote the collection and exchange of information and data related to marine scientific research in the area concerned."

3. Eligibility

The award is given for significant contributions to the progress of marine science in the North Pacific through long-term monitoring operations, management of data associated with ocean conditions and marine bio-resources in the region, and development of advanced and innovative technologies for ocean monitoring or all categories. Recipients may include, for example, research vessels, research or administrative institutes or portions thereof, or technical groups involved in monitoring, data management, and dissemination, or the development of tools or technologies that have been shown to enhance ocean monitoring or a combination of these activities. Outstanding individual efforts may also be recognized.

4. Nomination and Selection

Nominations from individuals or groups from PICES member countries should be sent with supporting documentation to the Executive Secretary (Sonia.Batten@pices.int) by the deadline specified in the Call for Nominations. The Technical Committee on Monitoring (MONITOR) and the Technical Committee on Data Exchange (TCODE) will evaluate independently the documents submitted with each nomination, and recommend some or all of the nominations for consideration by Science Board. Evaluations will include the relevance, duration and balance of activities (ocean observation, resource monitoring, data management, etc.). If more than one nomination is considered worthy of recognition by MONITOR or TCODE, rank preferences will be provided to Science Board by each Technical Committee. A maximum of one award will be given each year. To keep a large pool of potential candidates, Science Board will reserve any surplus of recommendations for review in two consecutive years and will be reactivated if nominator gives approval.

5. Award and Presentation

The award consists of a certificate signed by the PICES Chair and the PICES Science Board Chair, which will be presented to the recipients (or their representatives) at the Opening Session of the PICES Annual Meeting. No financial support from PICES will be provided to the recipient to attend the Annual Meeting where the award is given. Should any representative be unable to attend the Annual Meeting, a Delegate of the recipient's country will be asked to accept the award on behalf of the recipient.

6. Call for Nominations

The award consists of a certificate signed by the Nominations for the POMA Award are accepted annually **from NOVEMBER 1st** of the preceding year, **to MARCH 31st** of the award year. Nominations, along with supporting documentation, should be sent to the PICES Executive Secretary (Sonia.Batten@pices.int) by MARCH 31. Late nominations will not be accepted.

C. COMMITTEE/PROGRAM AWARDS

1. Best Presentation Awards

These awards are intended to enhance the visibility and recognition of early-career scientists at PICES Annual Meetings and to encourage the development of outstanding presentations.

A maximum of one Best Oral Presentation award may be given by each Committee, regardless of the number of Topic or Contributed Paper Sessions sponsored. Recipients for Best Oral Presentation must qualify as an early career scientist.

Judging Guidelines for Oral Presentations

a. Each Committee Chair **may** select one award recipient from among the early career scientists giving oral presentations at Topic Sessions sponsored by that Committee, regardless of the number of sessions sponsored. **If none of the presentations is of sufficient quality, it is not necessary to make an award.**
b. The award will be presented to the recipient by the Chair of the sponsoring Committee at the Closing Session.
c. When two or more Committees jointly-sponsor a Topic Session, the Science Board Chair will determine which Committee is responsible for evaluating presentations in these sessions;
d. Where a Committee has parallel sessions, the Committee Chair may ask a Convenor(s) or Committee Member(s) to judge the session(s) presentations. The Committee Chair will then consult with the designated judge before deciding on an award recipient.
e. Each Committee Chair/FUTURE Co-Chairs is responsible for determining how to select a speaker to receive the award;
f. Criteria for selecting candidates:
   i. **Presenter** must be an early career scientist and first author of presentation.2
   ii. Scientific content of the presentation
   iii. Clarity of presentation (speak to the audience not to the screen so that people can hear; present the subject so the audience can understand; present clear conclusions; leave sufficient time for questions).
   iv. Good quality illustrations that are simple and to the point.
   v. Abstract clearly summarizes the presentation.
   vi. Presenter responds clearly and thoughtfully to questions.
g. The names of all best presentation recipients must be provided to the Secretariat by the end of the last Topic Session in order to allow time for preparation of the certificates before the Closing Session.
h. Awards will consist of a certificate with the name of the recipient and title of presentation, and be signed by the Chair/Co-Chairs of the awarding Committee/FUTURE.

Eligibility

a. Applicants should not be more than 5 years beyond receipt of the PhD.
b. The Committee/FUTURE Co-Chairs will be provided a score sheet identifying the early-career scientists in their session(s).

2. Best Poster Awards

Only one Best Poster Presentation award may be given by each Committee, regardless of the number of Topic or Contributed Paper Sessions sponsored. Best Poster Presentation recipients are Early Career Scientists only (subject to the eligibility requirements below).

Judging Guidelines for Posters

a. Each Committee judge delegated by the Committee Chair will review posters from the Topic Sessions assigned to their Committee.
b. **In the event that there is only one poster in a session, the Committee Chair may make an award if all eligibility criteria have been met, and the poster is considered worthy. If none of the posters is of sufficient quality, it is not necessary to make an award.**
c. Each Committee Chair will provide his/her choice to the Secretariat by the end of the Poster Session
d. At the Closing Session, the award will be presented by the Chair/Co-Chairs of the Committee/FUTURE responsible for evaluating that Topic Session

Eligibility

a. Only ECS posters accepted by Convenors of Topic Sessions/workshops are eligible for the Best Poster Award.
b. The recipient of the award must be the **senior author** of the poster **AND be mostly responsible for its scientific content**.
c. The recipient must have attended the Annual Meeting, and been present at the poster to field questions during the scheduled poster session.

D. PICES DATA POLICY

2018/A/6: Data Management Policy (https://meetings.pices.int/about/PICES-Policy)

1. Principles and Definitions

As stated in Article III of the Convention for the North Pacific Marine Science Organization (PICES), the Organization is to promote the collection and exchange of information and data related to marine scientific research in the North Pacific Ocean and its adjacent seas.

The PICES strategy on capacity development identifies TCODE as the committee responsible for the development of communication networks for the exchange of data and information.

Data gathered as a result of PICES activities will be responsibly managed to guard against loss and to ensure continued accessibility. The management of data using external data management systems is preferred to using internal PICES resources.

For any data provided to PICES, PICES will respect the ownership rights and any restrictions placed on these data by the provider.

- Data include data products and model outputs related to PICES activities. Metadata are data about data.
- End-users include a person, organization, group (including PICES expert groups) using data.
- Data providers include a person, organization, group (including PICES expert groups) providing data.
- The data inventory refers to data for which PICES has the primary responsibility to manage.

2. Roles and Responsibilities

The Technical Committee on Data Exchange (TCODE) is responsible to:

- Manage the PICES data inventory.
- Assist Expert Groups to identify data that are to be included in the data inventory.
- Assist Expert Groups in the development of data management options and strategies.
- Make recommendations to the Science Board on PICES data management and priorities, with particular emphasis on correcting or mitigating any known or anticipated deficiencies.

The PICES Secretariat is responsible to:

- Support TCODE in the maintenance of the data inventory.
- Support TCODE to correct or mitigate any known or anticipated deficiencies.

Science Board is responsible to:

- Include data management requirements in the Terms of Reference of each PICES expert group.
- Review the recommendations proposed by TCODE and provide recommendations to the Governing Council as necessary.

Expert Groups are responsible to:

- Identify any data developed during the activities of the expert group and inform TCODE and PICES secretariat.
- Develop, with assistance from TCODE, strategies, or options for managing data used by the expert group.

3. Data Produced by PICES

All data produced by PICES are considered to be publicly available unless explicitly specified otherwise.

Results, conclusions, or recommendations derived from the data associated with PICES do not imply an endorsement from PICES.

Contributions of data from PICES expert groups will adhere to the expert groups' Terms of Reference and be submitted to TCODE for inventory while the group is active.

All data, including metadata, should be archived using standard codes, formats, and protocols.

4. Data Provided to PICES

The quality assurance of data is the responsibility of the data provider.

In the event that PICES becomes aware that there may be quality issues in the data, PICES will inform the data providers as soon as possible.

Data providers should inform the PICES secretariat of any policies that may place special conditions on their redistribution.

End users are responsible for the proper use of the data and metadata provided.

PICES may reformat data or metadata but will never change the data provider's original record.

Data must be acknowledged, preferably using a formal citation.

5. Citation

Data citations should facilitate giving scholarly credit and normative and legal attribution to all contributors to the data, recognizing that a single style or mechanism of attribution may not be applicable to all data.

Where DOIs exist (Digital Object Identifier), they should be included in the citation.

E. MONITOR COMMITTEE MEMBERS

(As of September 23, 2023)

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