2025 Report of MONITOR Committee

Virtual and Yokohama, Japan

October 20/21 and November 9, 2025

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MEETING INFORMATION

Business meetings for the MONITOR Technical Committee will be held for two days, both online and in a hybrid setting.

1st-day session October 20, 2025, Monday 1700-1830 (US/Canada PDT) and October 21, 2025, Tuesday 0800-0930 (Beijing, China), 0900-1030 (Korea/Japan), 1000-1130 (Vladivostok, Russia) Topic: 2025 PICES MONITOR Business Meeting (Day 1) Time: Oct 21, 2025 09:00 AM Seoul Join Zoom Meeting https://kaist.zoom.us/j/83028153475 Meeting ID: 830 2815 3475
2nd-day session November 9, 2025, Sunday 1800-2000 at Yokohama, Japan (TBD) and November 9, 2025, Sunday 0200-0400 (USA/Canada PST) 1700-1900 (Beijing, China), 1800-2000 (Korea/Japan), 1900-2100 (Vladivostok, Russia) Topic: 2025 PICES MONITOR Business Meeting (Day 2) Time: Nov 9, 2025 06:00 PM Yokohama Join Zoom Meeting https://kaist.zoom.us/j/87221323120 Meeting ID: 872 2132 3120

AGENDA

Day 1: October 20, 2025, 0900-1030 (KST; *Note: times may shift*)

1. 09:00-09:10 Welcome, Introductions, and Sign-in [10 mins]
2. 09:10-09:25 Updates and discussion topics [15 mins]
    a. Updates from ISB: Kim
    b. ECOP Presentation Award Judge volunteer
3. 09:25-09:30 Break [5 mins]
4. 09:30-10:30 National reports – Written and Oral [60 mins]
   Written: Please provide national reports before the PICES meeting. Include relevant monitoring activities for the relevant years. Written reports will be posted to the PICES web page.
   Oral: Please include highlights and updates in the national reports of relevant monitoring and 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, Jung, H You
    - Russia Kulik, Lobanov
    - United States Barth, Jacobson, Brooks
    - China Zhao, Zhang, Cui, Zhou
5. 10:30-10:35 Other business [5 mins]

Day 2: November 9, 2025, 1800-2000 (JST; *Note: times may shift*)

6. 18:00-18:10 Welcome, Introductions, and Sign-in [10 mins]
7. 18:10-18:20 Updates/Recap from the previous meeting [10 mins]
8. 18:20-19:00 Updates from PICES Groups [40 mins]
    a. 18:20-18:30 Activities of CPR: Ostle [10 mins]
    b. 18:20-18:30 Activities of FUTURE: TBD [10 mins]
    c. 18:30-18:40 Activities of AP-CREAMS: TBD [10 mins]
    d. 18:40-18:50 Activities of AP-NPCOOS: TBD [10 mins]

   19:00-19:10 Break [10 mins]
9. 19:10-19:40 Relations with international organizations [30 mins]
    a. 19:10-19:20 Activities of the US IOOS/NANOOS/CeNCOOS/SCCOOS: Barth [10 mins]
    b. 19:20-19:30 Activities of the AOOS: TBD [10 mins]
    c. 19:20-19:40 Activities of the NEARGOOS: H You [10 mins]
10. 19:40-20:00 Other business: New MONITOR Chair election [10 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

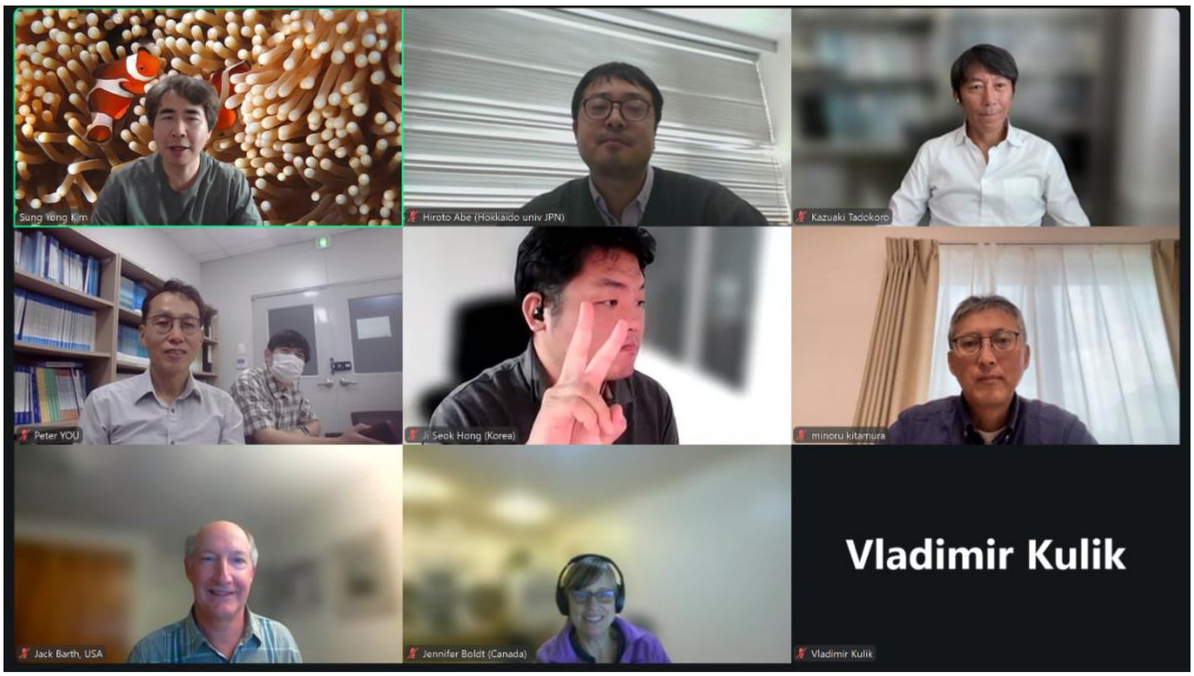
DAY 1

AGENDA ITEM 1: WELCOME AND INTRODUCTION

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

Attendees:

At the beginning of the 1st-day meeting**: [members]** Sung Yong Kim (MONITOR Chair, Korea), Hak Ryul You (Korea), Ji-Seok Hong (Korea), Hiroto Abe (Japan), Kazuaki Tadokoro (Japan), Minoru Kitamura (Japan), Jack Barth (USA), Mariela Brooks (USA), Kym Jacobson (MONITOR Vice-Chair, USA), Jennifer Boldt (Canada), and Vladimir Kulik (Russia)



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

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

1. Updates from ISB
    a. New member(s): Dr. Ji-Seok Hong (Korea)
    b. POMA/Zhu-Peterson Awards decision
    c. PICES Annual Meeting 2025 @ Yokohama, Japan (Nov. 10-Nov. 14)
        i. MONITOR business in-person meeting @ 301, 1800-2000 on Nov. 9
        ii. MONITOR dinner (TUE or WED; TBD)
    d. PICES Annual Meeting 2026 @ Nanaimo, BC, Canada (Oct. 26-Nov. 1)
    e. AP-NPCOOS summer school proposal
        i. Tentative schedule: 5 days in September 2026 at Hokkaido Univ. Fisheries Sciences at Hakodate, Japan
        ii. Topic: Ocean biologging
    f. MONITOR judges will evaluate ECOPs' talks/posters in S02, S05, S07, and W02

2. ECOP Presentation Award Judge volunteers
    a. S02: Changing Ecosystem Structure Under Global Climate Change: Monitoring, Detecting, Modeling, and Socio-Ecological Impacts [TUE and WED 30(O) 15(P)]
    b. S05: Climate Extremes and Coastal Impacts in the Pacific [WED 7(O) 4(P)]
    c. S07: The Impact of Oceanographic Processes on Ecosystems Supporting Fisheries Production in Boundary Current Regions [TUE 8(O) WED 11(P)]
    d. W02: Intercomparison of North Pacific Zooplankton Time Series [SAT 0(O) WED 1(P)]
    e. Each Committee will select ONE oral and ONE poster award from all the sessions/workshops they judge. If you see that no presentations are qualified, you don't need to select an awardee.

AGENDA ITEM 4: NATIONAL REPORTS

1. Canada

Overview and Summary of 2024

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 advanced identification of important changes that may potentially impact human uses, activities, and benefits from the ocean. The annual reviews consist of a 2-day meeting and a State of the Pacific Ocean report (Boldt et al. 2025).

DFO's Fieldnotes provides an overview of science field research and monitoring to be conducted each year by DFO and collaborators in the Northeast Pacific and Arctic oceans, and in the coastal and interior waters of

British Columbia and Yukon. An interactive map on the Fieldnotes website shows the locations and provides information about these field research and monitoring programs.

We thank the Indigenous communities whose territories we visit during our work. Their continued commitment, and their values, knowledge, insights and wisdom are invaluable to our collective efforts to build healthy oceans and aquatic ecosystems, sustainable fisheries and safe navigation. Mussi, huy ch q'u, quanaqutit, hu sukiłq̓ukni, g̱ilakas'la, sechanalyagh, haawa, t'ooyak̲siy̓ n̓iin, thank you!

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. (2025).

Below is the overview and summary from DFO's recent State of the Pacific Ocean report, with the same Figure and Section numbers as in the report (Boldt et al. 2025):

"2024 STATE OF PHYSICAL ECOSYSTEMS

Basin-scale and outer coast

Globally, 2024 was the hottest year on record (Ross and Robert, Section 7). Annual air temperatures were the 2nd warmest on record in B.C.; the annual mean temperature in B.C. is increasing and can be distinguished from natural variability during 1940-2024 (Curry et al., Section 5). B.C.'s snowpack was well below-normal or below-normal throughout the year (Curry et al., Section 5). Compared to 2023, drought conditions were less severe overall; however, catchment basins in Northeast B.C. continued to experience extreme drought (Curry et al., Section 5).

Despite warmer air temperatures, overall 2024 sea surface temperatures (SSTs) were near average. The Pacific Decadal Oscillation (PDO) was strongly negative but did not result in a cool year for the Northeast Pacific because it occurred on a background of steadily rising temperatures due to climate change (Figure 3-1). El Niño conditions ended in May and weak La Niña conditions emerged in December (Ross and Robert, Section 7). Climate forcing affects ocean temperatures, currents, upwelling, stratification, sea level, and other physical and biological variables (Hourston and Thomson, Section 10; Han and Chen, Section 14; Ferriss, Section 37; Suchy and Allen, Section 42; Riedel and Ballantyne, Section 52; Jones and Hannah, Section 54; Klymak et al., Section 70). SSTs varied over the year and spatially. In the open Northeast Pacific, SSTs were near average (vessel sampled data; Ross and Roberts, Section 7); however, within B.C.'s Exclusive Economic Zone, there were warm anomalies for much of 2024, including surface marine heatwaves (satellite data; Hilborn et al., Section 16; model simulations; Han and Chen, Section 14). Bottom temperatures were below normal over the slope, but were above normal for much of 2024 over the shelf (model simulations; Han and Chen, Section 14). Nearshore coastal water SSTs were generally above the 1991-2020 average (shore-station data; Jackson, Section 8); however, there were strong cool anomalies present in June, July and October in coastal Vancouver Island (VI) waters (satellite data; Hilborn et al., Section 16). Overlying multi-year oscillations in the annual SST, there is a long-term trend with ocean temperatures rising at a rate of 0.9 ºC per 100 years (Figure 3-1; Jackson, Section 8). Surface waters in the Northeast Pacific continued to be anomalously fresh in 2024 except in coastal waters where river discharge was low; this continues a freshening trend observed for the last eight years (Ross and Robert, Section 7). Winter mixing was weaker in 2024 relative to 2023, similar to marine heatwave years (2014-15, 2019). Thus, the mixing of nutrients to the surface was likely weaker.

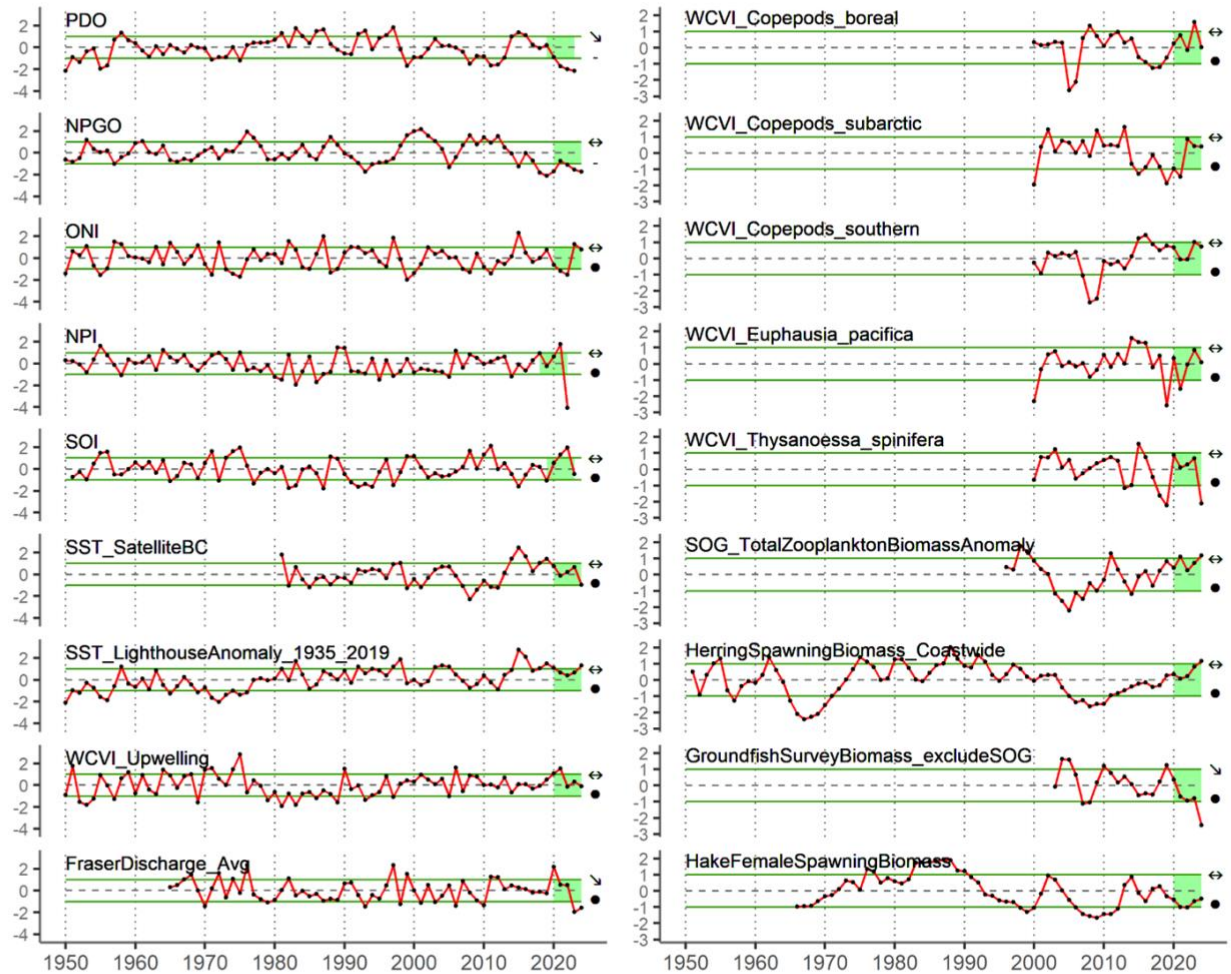


Figure 3-1. Selected indicators of the physical environment (left column), lower and upper biological trophic levels (right column) of B.C.'s marine ecosystems (1950-2024). Time series (red line and black dots) have been standardized (over the length of each time series, except as noted for SST lighthouse temperature anomalies normalized for 1935-2019) to have a mean of 0 (dashed horizontal line) and a standard deviation of 1 (horizontal green lines). The last five years of the time series are highlighted in green. The symbols to the top-right of each graph indicate the trend in the last five years of the time series (values in the last five years show no (□), increasing (□), or decreasing (□) linear trend). The symbols to the bottom-right of each graph indicate the status (mean value in the last five years is within (•), above (+), or below (-) one standard deviation. Broad-scale indicators include PDO, NPGO, ONI, NPI, SOI (Ross and Robert, Section 7); SST_SatelliteBC is satellite SST for all of B.C.; SST_LighthouseAnomaly (Jackson, Section 8); FraserDischarge (Giesbrecht and Moore, Section 6); copepods and euphausiids (Sastri and Galbraith, Section 20); SOG_TotalZooplanktonBiomass (Young et al., Section 45); HerringSpawningBiomass (Cleary et al., Section 27); GroundfishSurveyBiomass (summed survey biomass of all groundfish except those in the SOG; Dunic et al., Section 30); HakeFemaleSpawningBiomass (Gauthier and Stanley, Section 31).

Hypoxia, or low oxygen levels, received special attention at this year's meeting. Subsurface oxygen concentrations are declining in B.C. waters at most locations where there are data (Hannah, Section 12; Bluteau et al., Section 11; Holdsworth and Christian, Section 13; Lee et al., Section 15; Stevens et al., Section 71). There were sustained hypoxia events in the deep waters of southern Queen Charlotte Sound in the summers of 2022, 2023, and 2024; this is a new feature on the open continental shelf. In general, subsurface oxygen concentrations are declining across the Subarctic Pacific Ocean. The area of the Northwest Pacific that is being ventilated every winter has been declining since at least the early 1980s with strong bi-decadal (20 year) variability (Mecking and Drushka 2024; Hannah, Section 12). One potential cause of the decline is freshening of the subarctic Pacific due to input from melting Alaska glaciers (Zemp et al. 2019; Hannah, Section 12).

The timing and magnitude of upwelling of deep, nutrient-rich water off the west coast of VI (WCVI) is an indicator of marine coastal productivity across trophic levels, from plankton to fish to sea 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 2024 transition timing of spring upwelling was average relative to the 1991-2020 mean, and the magnitude of upwelling-favourable winds was below the mean, resulting in an expectation of average to below-average upwelling-based coastal productivity (Figure 3-1; Hourston and Thomson, Section 9; Wang et al., Section 61). With the exception of the Strait of Georgia (Evans, Section 18), the winter of 2024-2025 (as of January 2025) was characterized by above-average downwelling-favourable winds, indicating that winter storm activity was above normal (Hourston and Thomson, Section 9). Persistent upwelling, particularly along the southern VI (SVI) continental slope, brings 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 toward the coast. In winter, spring, and summer 2024 along Line P, nitrate and chlorophyll concentrations in surface waters were within the range of values from previous years (Peña, Section 17). There were negative anomalies of other nutrients along Line P, but not as anomalous as during the Marine Heat Waves (MHWs) of 2014-2015 and 2019-2020, which restricted winter nutrient renewal, via vertical transport, due to increased stratification (Peña, Section 17).

Salish Sea

In spring 2024, the Salish Sea was generally warmer than the 1999-2024 average. In summer, conditions were warmer than normal in the Strait of Georgia but cooler than normal in the Juan de Fuca Strait, and the whole region was saltier than normal. In fall, conditions were warmer than normal, saltier than normal and had lower than normal dissolved oxygen concentrations (Jackson, Section 40; Esenkulova et al., Section 43; Taves et al., Section 58). The annual Fraser River discharge was at or near the minimum observed during 1995-2024 (Figure 3-1; Giesbrecht and Moore, Section 6). Increasing CO_2 in the atmosphere has increased the acidification of the ocean. A reduction in the storm season intensity in the northern Salish Sea resulted in an increase in the extent of the water column exhibiting corrosive conditions for Ωcal (Evans, Section 18).

2024 STATE OF BIOLOGICAL ECOSYSTEMS

Lower trophic levels and forage base

Outer, central, and north coast phytoplankton and zooplankton

In 2024, satellite chlorophyll-a showed early phytoplankton blooms in numerous (but not all) areas of B.C. coastal and shelf waters (Hilborn et al., Section 16). Phytoplankton species composition in 2024 was similar to that of previous years along Line P, except for a decrease in the abundance of diatoms (Peña, Section 17). Along the Continuous Plankton Recorder transect (shelf and offshore) the phyto- and zooplankton communities returned to average values following the marine heatwaves of 2014-2016; the numbers of copepods typically associated with warm waters were low, and the mean copepod length increased in 2024 compared to 2023 (Ostle and Batten, Section 21). In 2023 and 2024, there were positive biomass anomalies of sub-arctic and boreal copepods (favourable for fish growth) for both north VI (NVI) and SVI, associated with a strong El Niño event; this was also reported for the Gulf of Alaska (Ferriss, Section 37). There had been a steady decline in abundance of southern copepods (less favourable for fish growth) in all areas since 2015, but that pattern reversed in 2023 and 2024, with large positive biomass anomalies for both NVI and SVI (Figure 3-1; Sastri and Galbraith, Section 20). Euphausiid biomass varies by area and season (e.g., Young et al., Section 59). Euphausiid biomass anomalies on the NVI Shelf were above average; whereas, on the SVI shelf, they were average (*Euphausia pacifica*) or significantly reduced (*Thysanoessa spinifera*; Figure 3-1; Sastri and Galbraith, Section 20).

Salish Sea phytoplankton and zooplankton

Annual variation in spring bloom timing and community composition may affect the food web through a temporal match or mismatch between prey and predators. In 2024, the SOG spring bloom timing was typical compared to the long-term average (Allen and Latornell, Section 41; Kafrissen et al., Section 51; Del Bel Belluz, Section 19). In-situ chlorophyll fluorescence observations indicated that there was a relatively weak “double” spring bloom in March and May (Esenkulova et al., Section 43). In 2024, the SOG total zooplankton biomass (averaged over the year) increased from 2023 and was higher than the time series average since 1996 (Figure 3-1; Young et al., Section 45). Medium and large-sized copepods, euphausiids, and amphipods (important juvenile salmon prey) dominated the biomass (Young et al., Section 45).

Invertebrates

Extreme heat events, such as the atmospheric heat dome of 2021, may have a long-term negative effects on invertebrates in the intertidal zone, such as Olympia Oyster; however, no evidence of decrease in Olympia Oyster density was observed at index sites in 2024 (Herder and Bureau, Section 23). The Tsawout First Nation has established an adult Dungeness Crab (*Metacarcinus magister*; Á,ĆEX) Monitoring Program the QEN,T Indigenous Protected and Conserved Area; this program will be used to construct a temporally comprehensive time series (Chaves et al., Section 24).

Forage Fish

Forage fish form a critical link in marine ecosystems, transferring energy from lower (phytoplankton and zooplankton) to upper trophic levels, such as groundfish, seabirds, and marine mammals. Forage fish species include Pacific Herring, Eulachon, and Northern Anchovy among others. Coastwide Pacific Herring spawning biomass increased during 2010-2024, dominated by the SOG stock and with increases in the WCVI stock since 2020; however, in some assessed areas, such as Haida Gwaii, there have been prolonged periods of low biomass (Figure 3-1; Cleary et al., Section 27). In summer 2024, adult Pacific Herring biomass in continental shelf waters off the WCVI (mixed stocks) was the 2nd highest in the 2006-2024 time series, with scientific survey catch per unit effort values (CPUEs) particularly high off the SVI (Boldt et al., Section 28). In the SOG in 2024, the relative biomass of age-0 Pacific Herring was near the time series mean (Boldt et al., Section 46). Age-0 herring were smaller than average, but their condition was above average.

In 2024, the index of Fraser River Eulachon spawning stock biomass was estimated to be amongst the lowest in the time series, 1995-2024 (~15 tonnes; Flostrand et al., Section 47) at a level comparable to 2022 and 2023. However, the mean Eulachon CPUE from a WCVI multispecies bottom trawl survey was at moderate levels, with a slight increase in average catch weight from 2023 and a slight decrease in the total number of eulachon caught (Flostrand et al., Section 47).

In 2024, Northern Anchovy were present in 70% of the SOG age-0 Pacific Herring survey sets; the highest proportion in the time series (Boldt et al., Section 46). Other indicators of Northern Anchovy (and other forage fish) distribution and availability include species found in the diets of Chinook Salmon (Tabert et al., Section 68). Interestingly, some forage fish species, such as Northern Anchovy, can contain thiaminase, an enzyme that degrades thiamine, which can lead to deficiency (McLaskey et al., Section 62) and impact fry survival (Lerner et al., Section 64) of Pacific salmon.

Upper trophic levels

Groundfish

Changes to the physical environment and forage communities can impact higher trophic levels, such as groundfish, salmon, seabirds, and marine mammals. There was a continued increase in the biomass of shelf rockfish, several slope rockfish, and many flatfish species in the most recent 5-10 years (Dunic et al., Section 30). In contrast, Arrowtooth Flounder and Pacific Spiny Dogfish biomass declined in recent years (Figure 3-1). Dogfish stocks experienced the steepest declines with a particularly precipitous decrease in outside VI waters (Dunic et al., Section 30). The 2024 inside Pacific Hake population (Strait of Georgia) continued to increase, since 2010 (Gauthier and Stanley, Section 31). For the migrating Pacific Hake stock off the west coasts of Canada and the U.S., the Canadian commercial fishery had its lowest landings in history, with less than 4,000 tons caught and a mere 2.7% quota attainment for 2024.

Pacific Salmon

On the continental shelf of the northern and western coast of VI, juvenile Pacific salmon abundance was average in summer and fall, except Chinook Salmon and Chum Salmon abundances in fall were below average (King et al., Section 29). Juvenile Sockeye Salmon relative abundance in summer and fall was average. Juvenile Pacific salmon condition in summer and fall was also average, again with two exceptions: Chinook Salmon in fall and Coho Salmon in summer had above average condition (King et al., Section 29). Lengths of both 2-ocean and 3-ocean ages of returning Fraser Sockeye Salmon ranked 7th smallest among 31 even-numbered years since 1964. This was a considerable improvement over 2022 and especially 2020 (Latham et al., Section 60). In 2024, returns were early for most Fraser River Sockeye Salmon Management Units, with record early arrival for the Early Summer Management Unit (Wong et al., Section 48).

Seabirds

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, Section 32). For just the third time in the 1996-2024 time series, diets fed to nestling Cassin's Auklets on Triangle Island in the second half of June were without the copepods, their most important prey (Hipfner, Section 32). The fish-based diets fed to nestling Rhinoceros Auklets are also affected by prey availability, with nestling auklets growing more quickly in years in which their diets include more Pacific Sand Lance. Diets fed to nestling Rhinoceros Auklets on Pine Island in southern Queen Charlotte Sound and on Lucy Island in Chatham Sound included normal amounts of Pacific Sand Lance and Pacific Herring in 2024 (Hipfner, Section 32). In the Salish Sea, mean annual densities of Rhinoceros Auklet in 2022-2024 were half the peak observed in 2019; conversely, in 2023-2024, mean annual densities of Ancient Murrelet were the 2nd highest in the 2015-2024 time series (Bertram et al., Section 33).

Marine Mammals

In 2021, the mean abundance of Steller Sea Lions was 44,235 (95% CI: 35,855-54,574); this represented no change in abundance from 2017 (Tucker et al., Section 34). The number of rookeries and year-round haulout sites continues to increase in B.C. waters with the establishment of two new rookeries in 2021 and 4 new year-round haul out sites (Tucker et al., Section 34). In the Northeast Pacific, offshore Killer Whales exhibit seasonal shifts in latitudinal distribution likely mirroring their preferred prey – sharks and rays (90% of the diet; Wright et al., Section 35). In 2024, the number of Grey Whale strandings in B.C. decreased from the peak in 2019 (11 animals; Cottrell et al., Section 36). During 2019-2024, there were 753 Grey Whale mortalities in their range from Mexico to Alaska; mortalities were attributed to environmental drivers leading to malnutrition, human interactions, and Killer Whale predation (Cottrell et al., Section 36).

Habitat

Offshore seamount surveys have shown rapid degradation in cold-water corals and sponges on multiple sites in 3 to 6 years, linked to ocean deoxygenation and acidification (Du Preez et al., Section 26). In 2024, the Tuzo Wilson Seamount Complex was confirmed to be a pair of hydrothermal recharge-discharge seamounts (the 4th of its kind globally) and an estimated 2.1 million skate eggs were observed, making this a globally unique geothermally heated nursery area. In 2024, the second Joint Canada-USA International Seamount Survey was conducted on the Cobb and Brown Bear seamounts using underwater stereo video cameras (Rooper et al., Section 55). Reef-forming scleractinians were observed at 6% of transects; the corals and sponges are large and mature (Rooper et al., Section 55). In 2021, DFO established a survey in Barkley Sound to assess annual changes in kelp ecosystems and associated species assemblages of fish and invertebrates. Between 2022 and 2024, at nearly all depths the mean percent cover of algae declined, as did species richness for algae and invertebrates; however, the diversity of fish did not appear to change in this time period (Hankewich and Lessard, Section 22). DFO also established an eDNA Biomonitoring Program (Phase I, 2022-2025) to conduct a rapid biodiversity assessment in existing and proposed Oceans Act Marine Protected Areas (MPAs) and evaluate eDNA metabarcoding as a tool to detect the species level conservation priorities (Westfall and Rubidge, Section 25).

Pressures

Climate change continues to be a dominant pressure acting on Northeast Pacific marine ecosystems with a multitude of physical oceanographic impacts ranging from warming, to stratification and upwelling, to hypoxia just to name a few. These changes are having profound biological impacts on species distribution, reproduction, condition and survival. Moreover, increasing CO_2 in the atmosphere has increased the acidification of the ocean leading to a cascade of negative impacts on marine organisms, which will continue to intensify with the rise of anthropogenic carbon levels in the atmosphere (Evans, Section 18; Mason et al., Section 67).

Harmful algal blooms produce toxins, such as domoic acid, that can cause finfish, shellfish, and marine mammal mortalities, as well as impacts to human health, and economic losses. In the SOG in 2024, dense but localized blooms of *Noctiluca scintillans* were observed in April-June and *Pseudo-nitzschia* was abundant in May (Esenkulova et al., Section 43). *Pseudo-nitzschia* can produce domoic acid that is responsible for amnesic shellfish poisoning (Ross and Mueller 2024). In 2024, domoic acid and saxitoxins were at higher than average concentrations with saxitoxins peaking earlier than normal in Clayoquot and Barkley Sounds and domoic acid peaking later than normal in Malaspina Strait and Clayoquot Sound (Ross et al., Section 39)..

Marine Aquatic Invasive Species (AIS) are increasing in both range and abundance in B.C. European Green Crab continue to spread in B.C. (Dyke et al., Section 72). This high-impact invader negatively affects eelgrass, an important fish habitat, and was detected for the first time on Haida Gwaii in July 2020 (Dyke et al., Section 72). Bay barnacle (*Amphibalanus improvisus*) was detected for the first time on B.C.'s North Coast in 2024 (Dyke et al., Section 72). 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 pressures include oil spills, vessel traffic, and underwater noise. For example, increases in sound frequencies representative of commercial vessel emissions were observed in 2024, thought to be related to increased vessel transits resulting from the Transmountain Expansion starting in May (Burnham et al., Section 44). These additions were most apparent in the lower frequencies at Haro Strait, which also showed elevated peaks in noise from additions in the lowest frequencies (< 100 Hz) during April through to October (Burnham et al., Section 44). Independent observers provide real-time detection and communication to enhance marine mammal protection during Canadian Armed Forces ordnance destruction, demolitions training and sonar performance trials (Hall and Ogilvie, Section 56).

Monitoring

Advanced technologies and new monitoring programs can improve our ability to detect changes in B.C.'s marine ecosystems and guide MPA selection. Recent, new, and proposed monitoring programs (not already mentioned in the above summary) include: 1) an echosounder and remote operated vehicle survey in Mowachaht/Muchalaht territory (Nootka Sound, B.C., Canada) in August 2023 to detect benthic rockfish hotspots in low and moderate slope habitat (Lancaster et al., Section 57); 2) the application of machine learning to predict the formation of phytoplankton blooms (Bougoudis et al., Section 66); 3) a proposed west coast B.C. distributed biological observatory, from Victoria through the inside passage to Prince Rupert, providing a tool to observe land-ocean systems and identify and interpret Earth system change at multiple scales (Bauer and Carmack, Section 38); 4) a proposed Pacific Rim Institute for Sustainable Marine Systems (PRISMS) marine research center in western Canada, to drive ocean innovation, discovery and knowledge mobilization (Tortell et al., Section 69); and 5) annual monitoring at the Pacific Biological Station and the Institute of Ocean Sciences (Nelson et al., Section 73)."

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2. United States of America

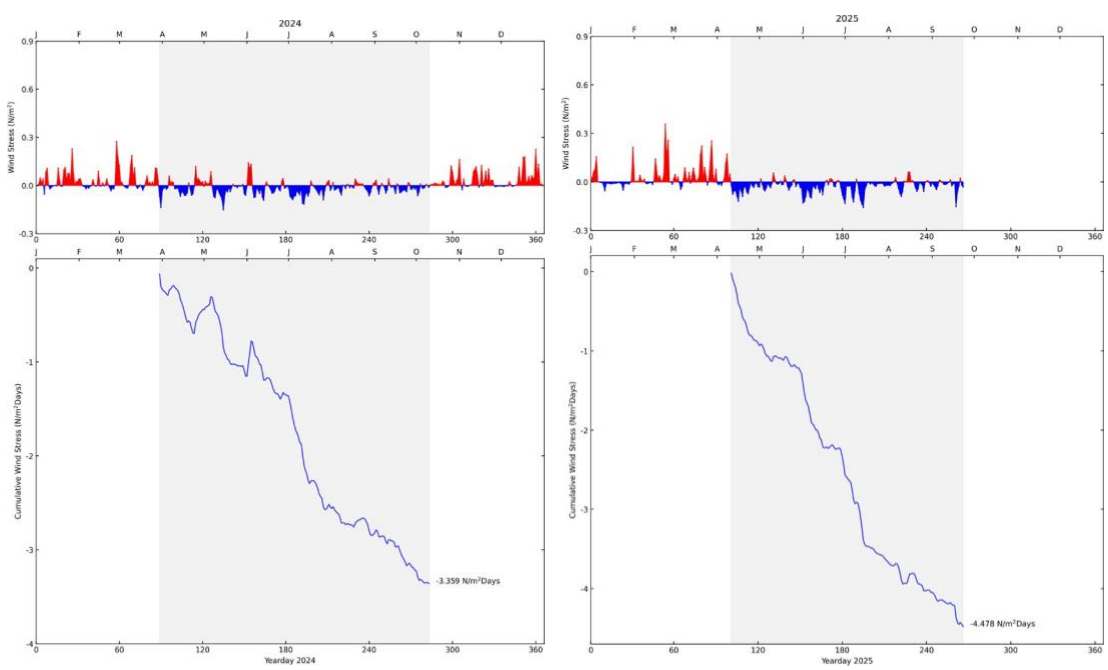
USA National Report to MONITOR, 2024-2025

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

This report includes highlights during 2024-2025 for select monitoring efforts off the US west coast. The report is in three sections:, each of which has its own figure numbering and references: 1) A summary of Environmental Conditions in the California Current during 2024-2025 and US NOAA-funded Integrated Ocean Observing Systems (IOOS) and NSF-funded Ocean Observatories Initiative (OOI) efforts by J. Barth; 2) A summary of ecosystem and fisheries survey monitoring efforts on the US west coast by K. Jacobson; and 3) A summary of North Pacific climate and Alaska fisheries oceanography surveys and observations by M. Brooks.

Environmental Conditions in the California Current during 2024-2025

During 2025, the summer upwelling season in the northern California current started about on average in early April and lasted through late September (Figure 1, right). The 2025 cumulative



upwelling was the second largest since 1985, indicating a strong year for coastal upwelling (Figure 1, right).

Sea surface temperature (SST) was above normal offshore in the California Current during late summer 2025, with the normal cool water near the coast due to wind-driven upwelling (Figure 2, right). These warm waters have been designated as Marine Heat Waves and the one in 2025 is similar, but not identical to "the blob" Marine Heat Wave of 2014 (Figure 2, left).

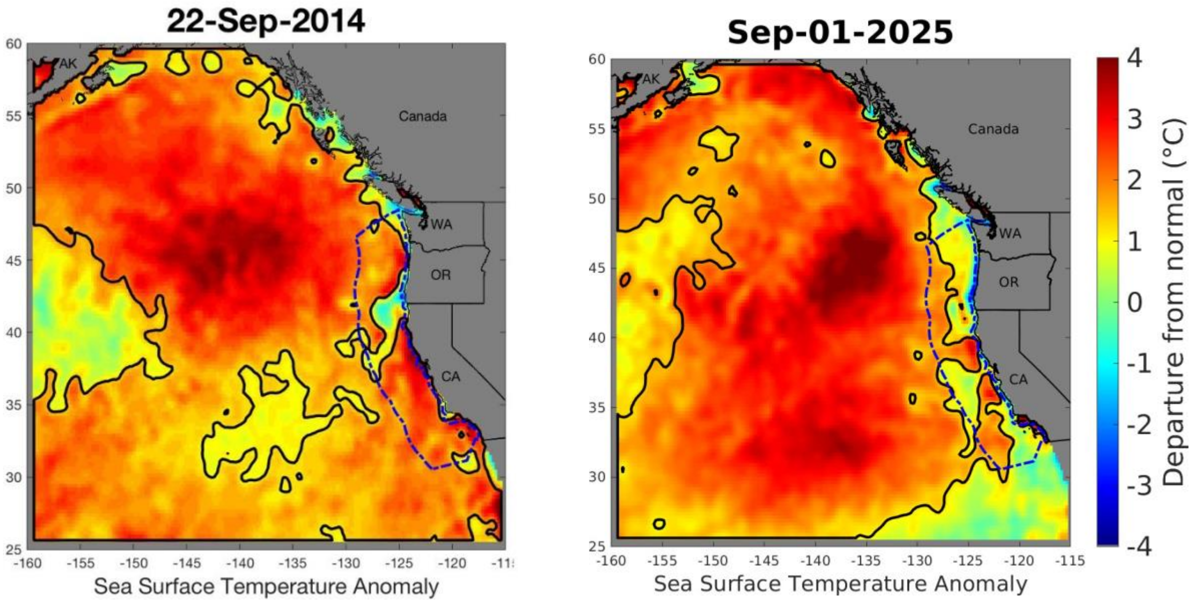


Figure 2: (left): The Marine Heat Wave (MHW) known as "the blob" at its near maximum areal extent in September 2014; (right) The 2025 MHW on September 1, 2025. Dark outline shows the current extent of Marine Heat Wave conditions, as delineated by values of the normalized SST + 1.29 SD from normal. Blue dashed line represents the US West Coast EEZ. Data from NOAA's Optimum interpolation Sea Surface Temperature analysis (OISST), with the SST anomaly calculated using climatology from NOAA's AVHRR-only OISST dataset. From https://www.integratedecosystemassessment.noaa.gov/regions/california-current/california-current-marine-heatwave-tracker-blobtracker .

NOAA continues to monitor marine heat waves off the US west coast, documenting the increase in occurrence and size of the marine heat waves over the last four decades (Figure 3) (https://www.integratedecosystemassessment.noaa.gov/regions/california-current/california-current-marine-heatwave-tracker-blobtracker).

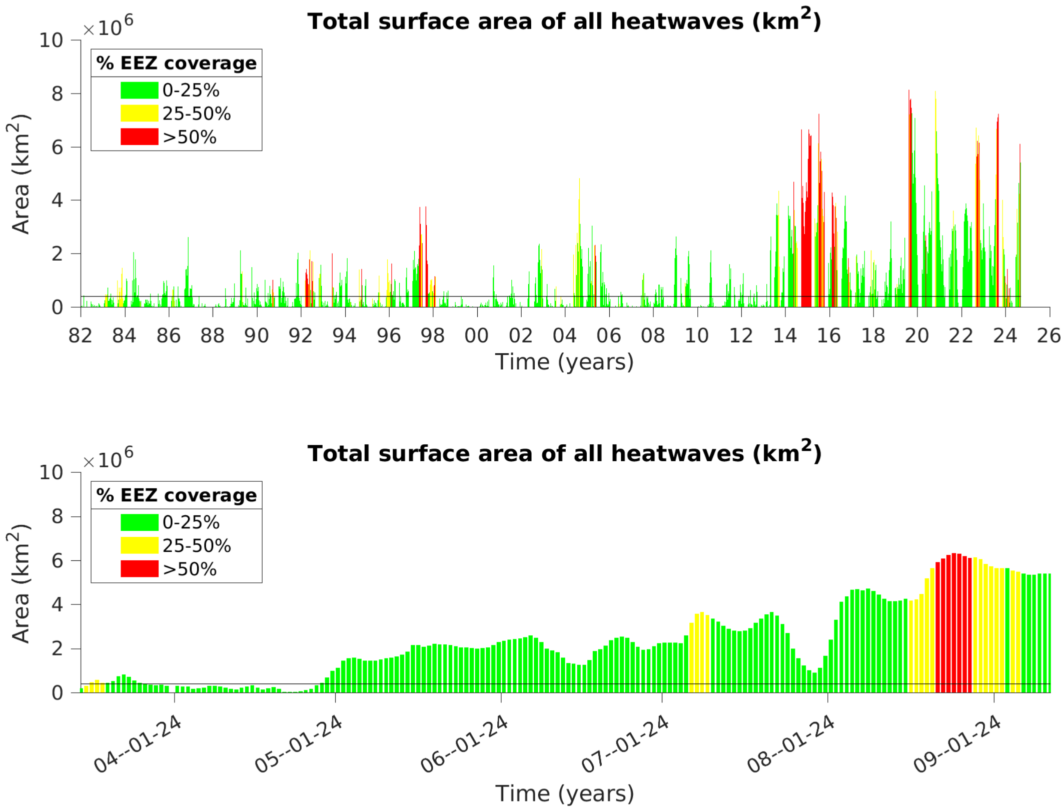


Figure 3: (top) Retrospective analysis of sea surface temperature anomalies in the California Current region, 1982-present. Figure shows daily total surface area from the entire study region (Figure 2) in heatwave status over time. Thin horizontal line indicates the area threshold cutoff (approx. 400,000 km2) used for tracking and analysis of Marine Heat Waves. Color indicates the % of the US west coast EEZ (area within blue dashed line, Figure 2) in heatwave status; (bottom) Daily estimated area of SST anomalies in the California Current region over the previous 12 months, color coded by relative EEZ coverage. From https://www.integratedecosystemassessment.noaa.gov/regions/california-current/california-current-marine-heatwave-tracker-blobtracker.

U.S. Integrated Ocean Observing System, IOOS (NOAA), 2024-2025

The west-coast regional associations of the U.S. Integrated Ocean Observing System (IOOS) funded by the U.S. National Oceanic and Atmospheric Administration continue to operate year-round during 2024-2025. From north-to-south, this includes the Alaska Ocean Observing System (AOOS, https://aoos.org), the Northwest Association of Networked Ocean Observing Systems that includes the states of Oregon and Washington (NANOOS, https://www.nanoos.org), then Central and Northern California Ocean Observing System (CeNCOOS, http://www.cencoos.org), and the Southern California Coastal Ocean Observing System (SCCOOS, https://sccoos.org)

NOAA Bjorkstedt et al.

(Figure 4). Another new activity in recent years is that CeNCOOS and SCCOOS have combined their data delivery on the California Ocean Observing Systems Data Portal (https://data.caloos.org/).

Figure 4: Overview of the U.S. Integrated Ocean Observing System (IOOS) funded by the National Oceanic and Atmospheric Administration.

The Pacific IOOS regional associations maintain a robust underwater glider monitoring program; more details and data can be found at https://gliders.ioos.us/map/# (Figure 5).

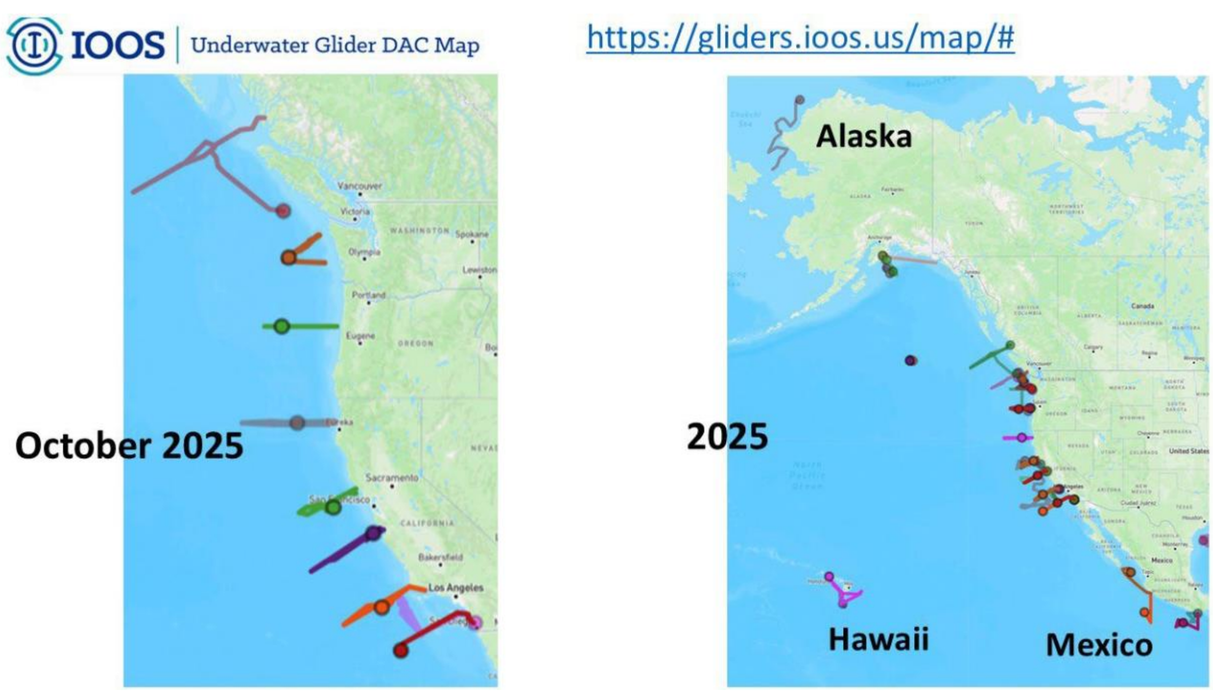


Figure 5. Maps of underwater glider tracks during 2025 as maintained by the IOOS regional associations in the Pacific.

During the last few years, these regional IOOS associations have made substantial investments in infrastructure through the U.S. Bipartisan Infrastructure Law and in new observational capabilities through the U.S. Inflation Reduction Act (IRA, aka climate change bill). Each of the west coast regional associations has invested in underwater gliders, buoys/moorings and high-frequency radar. Additional examples of infrastructure investment include three Imaging FlowCytoBots (IFCB) for NANOOS (southern Oregon, La Push, and Puget Sound moorings) to extend the twelve-sensor California IFCB network (https://sccoos.org/ifcb/) to the north. AOOS is also investing and installing IFCBs. SCCOOS in investing in shore-stations and additional CDIP (Coastal Data Information Program) wave buoys, lidar and cameras to expand their Coastal Flood Monitoring Network.

With IRA funds, the west coast IOOS regional associations are making investments in expanded biogeochemical observations using pH and nitrate sensors on gliders. There is also a coordinated effort in expanding the use of passive acoustic monitoring and listening for coded acoustic tags from moorings and gliders. IRA funds will also support data system expansion, model improvements for U.S. west coast ROMS and WCOFS (NOAA's West Coast Operational Forecast System, https://tidesandcurrents.noaa.gov/ofs/dev/wcofs/wcofs.html) applications, and operational wave forecasts for the Columbia River mouth and plume area.

During 2024-2025, the Backyard Buoys project (https://backyardbuoys.org/) continues to expand to enable Indigenous and coastal communities to gather and use wave data, enhancing their blue economy and hazard protection (Figure 6). By leveraging low-cost and scalable marine technology, Backyard Buoys offers a system for community-managed ocean buoys and web apps that simplify data access to complement Indigenous Knowledge. This is a partnership of AOOS, NANOOS and the Pacific Islands Ocean Observing System (http://www.pacioos.hawaii.edu/).

There have been 56 Backyard Buoys (BYB) and 12 “Friends of BYB” deployments in Alaska water since 2023.

NANOOS continues to improve and add features to its data visualization and data products web page, the NANOOS Visualization System (https://www.nvs.nanoos.org). Both observational data, from buoys, gliders, land stations, high-frequency radars, and satellites, and output from circulation, wave, weather, and biogeochemical numerical models are hosted on NVS. The "Real-Time HABs" website (https://www.nanoos.org/products/habs/real-time/home.php) incorporates HAB data (Figure 7). New this year is the ability to collect water samples for HAB analysis and for eDNA using an ASV Lightfish (Figure 7).

While the US west coast IOOS regional associations are funded through June 2026, funding for beyond that is uncertain. There is strong support for IOOS and there is hope for the associations to be able to compete for 5 additional years of funding.

NANOOS (with AOOS & PacIOOS) Innovations:

- **Backyard Buoys:** Two PNW tribes have deployed buoys via NSF-funded work; NANOOS will sustain and expand this capacity for community stewarded wave buoys.

BACKYARD BUOYS

Quinault Indian Nation wave buoy deployment

Figure 6. (left) Deployment of inexpensive wave buoys off the Washington coast by Quinault Indian Nation members; (right) Map showing growing network of Backyard Buoys.

NANOOS innovations:

- **HAB Obs:** NANOOS now using an ASV Lightfish and Cooperative Fisheries Research to expand the ability to sample HABs offshore via autonomous water sampling and fishing fleet ships of opportunity, respectively.

Data from this ASV will support this forecast of HAB risk

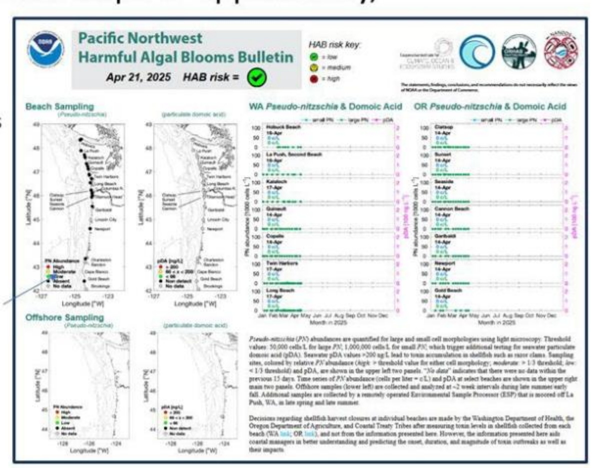


Figure 7. NANOOS Harmful Algal Bloom monitoring efforts including new ability to collect water samples offshore using an autonomous surface vehicle, the ASV Lightfish and fishing vessels via a Cooperative Fisheries Research network.

U. S. National Science Foundation's Ocean Observatories Initiative

The Ocean Observatories Initiative (OOI) is a science-driven ocean observing network that delivers real-time data from more than 800 instruments to address critical science questions regarding the world's ocean. OOI data are freely available online to anyone with an Internet connection (https://oceanobservatories.org). Data can be explored and downloaded from: https://dataexplorer.oceanobservatories.org/. There are five arrays of platforms collecting continuous data including three in the Northeast Pacific: Coastal Endurance Array off the coasts of Oregon and Washington; Regional Cabled Array including Axial Seamount and Hydrate Ridge; and Ocean Station Papa. The OOI celebrated 10 years of data collection in spring 2025.

There are 900 instruments deployed, 45 different types measuring more than 200 parameters (Figure 8). The instruments are deployed on 80+ platforms consisting of cabled and uncabled moorings, cabled instruments, and autonomous vehicles. As of late 2023, there were 987 million requests for data and 135 billion rows of data stored. The Ocean Observatories Initiative (OOI) is designated as a United Nations (UN) Endorsed Action as part of the UN Decade of Ocean Science for Sustainable Development 2021-2030.

Figure 8. The NSF-funded Ocean Observatories Initiative "by the numbers."

While much of the seafloor-focused Regional Cabled Array continues to operate, much its water-column monitoring and the majority of the Coastal Endurance Array have been "paused" as of September 2025 pending budgetary decisions. The Coastal Endurance Array continues to have a mid-shelf (~80 m of water) mooring off Oregon and a continuous glider line off Newport, Oregon (Figure 9). The Oregon shelf mooring has been sampling since 1997 (Risien et al., 2024) and the Oregon glider line has been sampling since 2006 (Adams et al., 2016).

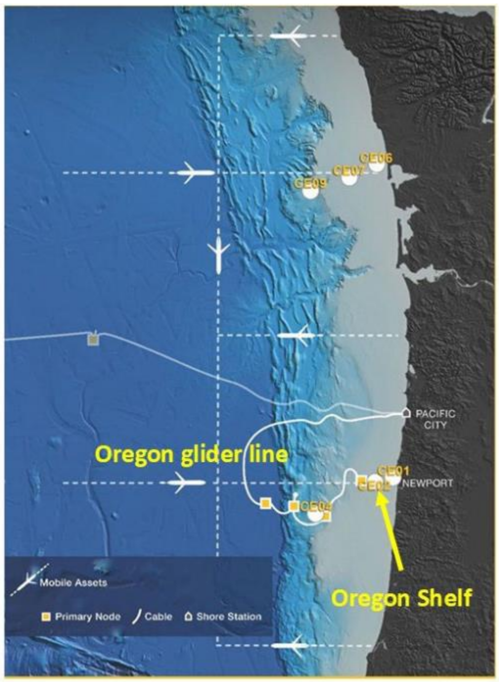


Figure 9. The Ocean Observatories Initiative Coastal Endurance Array with elements continuing past September 2025 indicated in yellow.

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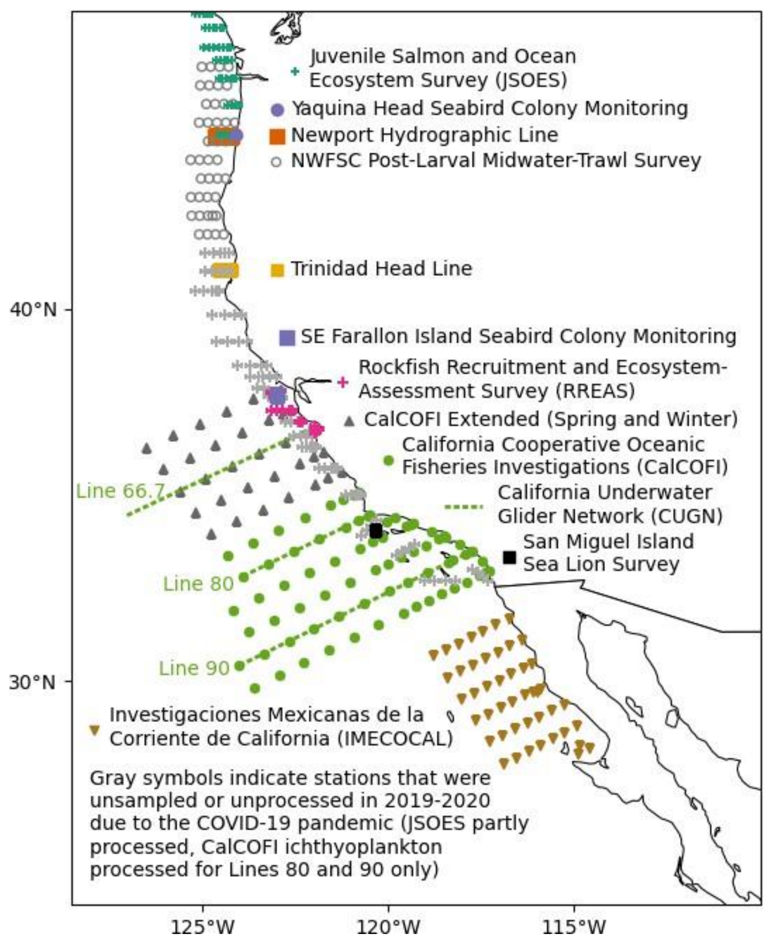
Ecosystem and Fisheries Survey Monitoring Efforts on the US West Coast, 2024-2025

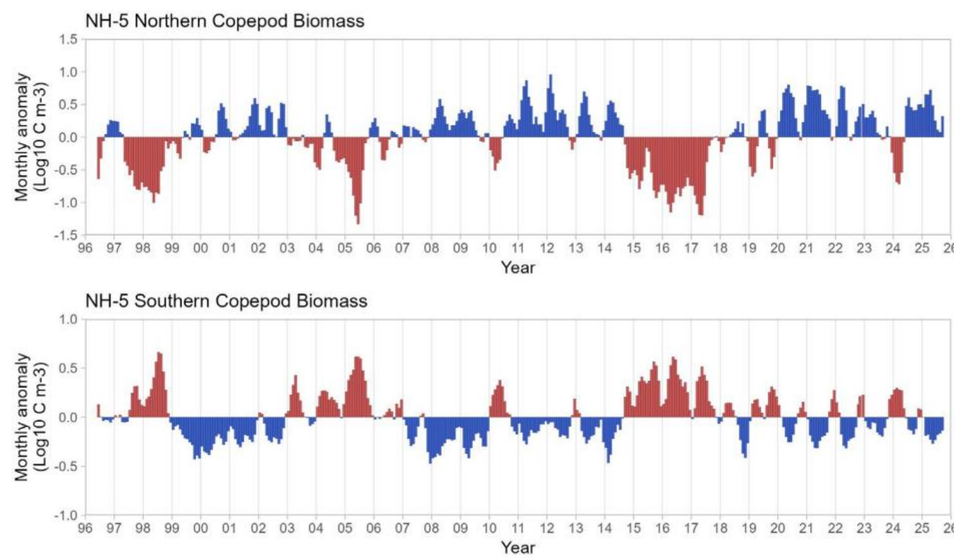
Summarized by Kym Jacobson, NWFSC, NOAA, Newport, Oregon, USA

Annual results of most of these monitoring efforts are summarized in the California Current Integrated Ecosystem Assessment Report to the Pacific Fisheries Management Council (PFMC) each March: https://www.pcouncil.org/documents/2025/02/f-1-a-cciea-report-1-2024-2025-california-current-ecosystem-status-report.pdf/



There are three NOAA surveys that collect physical data through lower trophics seasonally to bi-weekly (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. The location of these efforts and the seabird colonies and stationary sea lion monitoring site at San Miguel Island, California are shown in Figure 1.

- The Newport Hydrographic Line is sampled bi-weekly to monthly, year round (since 1996). Sampling occurs at 7 stations evenly spaced from 1-25 nm from shore. At each station, water column properties are measured (T, S, Oxy, aragonite); surface water is collected for nutrients, chlorophyll, and phytoplankton; and plankton nets collect zooplankton, fish and invertebrate larvae. provides the index of northern and southern copepod biomass. The copepod communities in 2024 were typical of El Niño conditions, but the biomass of northern copepods was high again through the upwelling season of 2025 (Figure 2).



Associated with the NH Line are the Northern California Current broadscale ecosystem surveys. Twice to three times annually, biophysical sampling is expanded to the edge of the EEZ along the NH Line and transects from the CA/OR border to northern WA. These surveys, conducted for 20+ years, provide the spatial data needed to evaluate lower trophic level responses to environmental variability throughout the NCC; a key step for building species distribution models. To take the next step toward EBFM, future spring surveys now incorporate sampling of larval and juvenile fishes. Together, with the SWFSC RREAS sampling off CA, fish recruitment can be examined throughout the CC. These NCC surveys also provide a unique platform for collaboration; addressing questions that include unmanned systems, machine learning and Omics. Examples include sampling phyto- and ichthyoplankton with high resolution cameras (IFCB and ISIIS), data processed with machine learning; eDNA of phyto-, zoo- and ichthyoplankton; development of predator/prey distribution models to reduce whale entanglements.

This year brought the most negative PDO values for 45°N on record, alongside weak La Niña conditions, suggesting a "cool phase" should be in effect. Despite that, during both broadscale NCC surveys, scientists observed a confusing mix of ocean conditions. During the May survey, this mix included classic "cool" signals like the welcome return of krill in moderate numbers and a widespread presence of young-of-the-year sardines. However, these were found alongside "warm" signals, as plankton nets were "quite gelatinous" with doliolids and jellies. Spatially, the patterns were also unusual, appearing opposite from the typical "green, phyto-goop" in the north and "pink, crustacean-rich" in the south. In September, conditions were also mixed but were overwhelmingly dominated by warm-water indicators. While krill remained abundant (a "cool" sign), the survey encountered very warm offshore surface waters (17-18°C) and hypoxic (low oxygen) water on the shelf. "Jellies were the theme" of the plankton tows, and scientists noted an unusual, widespread abundance of larval Galatheidae decapods, or squat lobsters. These dominant features strongly indicate that warm ocean conditions were persisting, defying the "cool phase" climate signals. Contact J. Fisher (NOAA, NWFSC)

- The Trinidad Head Line also samples for lower trophics and hydrography and provides an index of Euphausia pacifica, a key krill species within the CCE, which is sampled year-round along the Trinidad Head Line off northern California. There is no report from this effort for 2025. The lead of this monitoring effort retired from NOAA in the spring of 2024 with plans to resume sampling through the California State Polytechnical University, Humboldt.
- Data from CalCOFI cruises were not available at the time of the submission of this report.

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 Integrated acoustic trawl (IAT) surveys on a biennial basis to assess the abundance, distribution, and biology of Pacific hake (Merluccius productus; hereafter, “hake”) along the west coast of the U.S. and Canada. Age- and sex-specific estimates of total population abundance derived from IAT surveys are a key fishery-independent data source for the joint U.S.–Canada Pacific hake stock assessment. A time series of survey estimates of hake abundance and age composition is used in an age-structured assessment model, which ultimately acts as a foundation for advice on U.S., tribal, and international harvest levels. The surveys also collect key environmental data (temperature, salinity, dissolved oxygen) as well as samples for environmental DNA (eDNA) and RNA (eRNA) and the presence, distribution, and identification of harmful algal bloom (HAB) species and the toxins they produce. In 2025 this survey was combined with the Coastal Pelagics Survey to form the combined Integrated Survey and spanned from the US – Mexico border to the Canadian border. Data from the 2025 survey were not available at the time of report submission. Contact: Julia Clemons (NOAA, NWFSC)

Groundfish surveys have also been conducted over the entire US westcoast shelf and slope (55 – 1280 m) annually by the NWFSC since 2003 (except in 2020) from the border with Mexico to Canada. The survey collects data on the majority of the 91 groundfish included in the West Coast Groundfish Fishery Management Plan. The survey also collects key environmental data (temperature, depth, dissolved oxygen, turbidity, in vivo fluorescence, irradiance, wind speed, location) in association with each tow for use in ecosystem based fisheries management (EBFM).

Data from the 2025 survey were not available for inclusion by this year's report deadline. Contact: Aimee Keller (NOAA, NWFSC)

The Juvenile Salmon Ocean Ecosystem 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).
Results from Catch-per-unit effort of yearling Chinook salmon during the June 2025 survey was not available for inclusion by this year's report deadline. Contact:Brian Burke (NOAA, NWFSC)

Rockfish Recruitment and Ecosystem Assessment Survey (RREAS): Catches of young of the year 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. Data from 2025 were not available at the time of submission of this report. Contact:John Field (NOAA, SWFSC)

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North Pacific climate and Alaska fisheries oceanography surveys and observations for 2023-2024

Compiled by Mariela Brooks, NOAA Alaska Fisheries Science Center (AFSC), USA

Acknowledgements: Matthew Callahan, Lia Domke,, Bridgette Ferris, Jeanette Gann, Emily Lemagie, Jens Nielsen, Lauren Rogers, Elizabeth Siddon, Rob Suryan, Rick Thoman, Dongxiao Zhang

Excerpts from the 2025 ecosystem status reports (ESR) are included as indicated. Time series of fisheries and oceanographic data and ecosystem evaluations from ESR can be found at: https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands.

North Pacific Climate (Excerpt, Lemagie 2025 ESR)

Sea surface temperatures (SST) and sea ice data from the NOAA High-resolution Blended Analysis of Daily SST and Ice (OI SST V2), along with 10-m wind data from the NCEP/NCAR Reanalysis II[1] from September 2024 – August 2025 are described across eight regions of the North Pacific Ocean and U.S. Arctic (Figure 1).

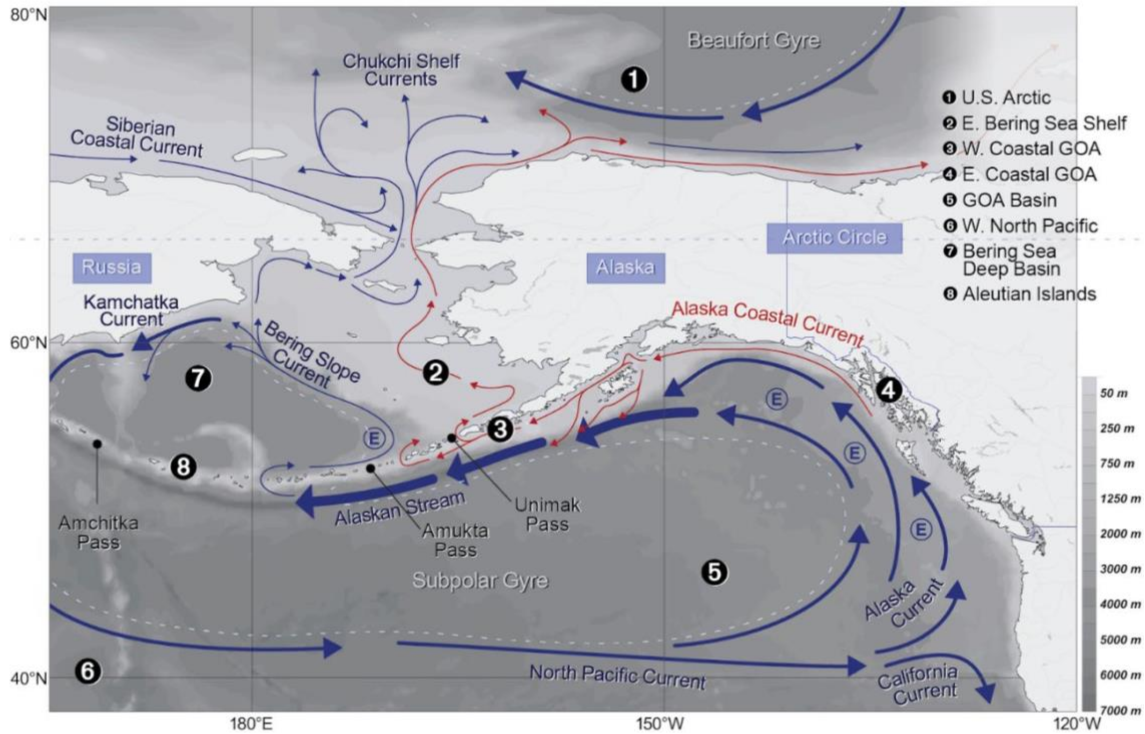


Figure 1. Geographic regions of interest, ocean bathymetry, and mean currents across the North Pacific and U.S. Arctic. ***Figure courtesy of Emily Lemagie (NOAA AFSC).***

Ocean surface temperatures were cooler than average in autumn 2024 (Figure 2). For example, over the Bering Sea shelf, this is attributed to a deep mixed layer and near-to-above mean heat content when integrated over the water column. The onset of seasonal winds saw a transition back to warm SST temperature anomalies over most of the North Pacific region as the water column heat was mixed back into the surface layer. Sea ice and SST conditions in winter and spring may be characterized as a competition between cooling influences of strong winds that acted to advance sea ice southward and also to mix and entrain often cooler waters from depth in the surface ocean layer and the warming influences from positive air and subsurface temperature anomalies and enhanced transport of warmer waters from the southern parts of the region.

Although the specific mechanisms in this balance varied by region, the processes that retained near-surface ocean heat prevailed and warm temperature anomalies generally persisted over much of the region through the spring, with warmth observed in the SST and in the subsurface ocean.

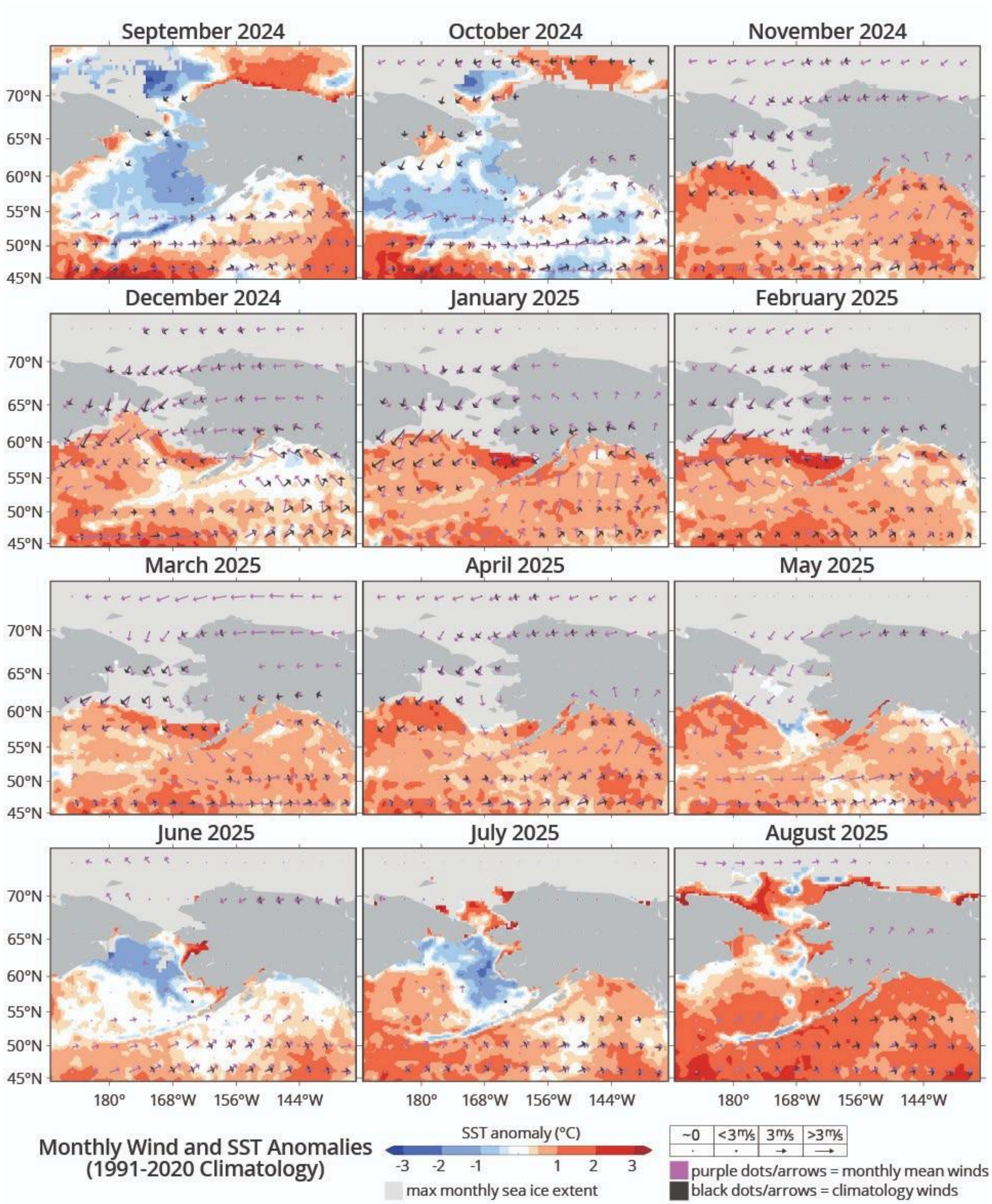


Figure 2. Monthly mean maps of sea surface temperature (SST) anomalies and surface winds. Monthly climatological winds (black) are compared to monthly mean winds (red). The climatological period is from 1991–2020. SST data are from the NOAA High-resolution Blended
Analysis of Daily SST and Ice (OISST), and 10-m wind data are from the NCEP/NCAR Reanalysis II;

both are available from NOAA's Physical Sciences Laboratory. *Figure courtesy of Emily Lemagie (NOAA AFSC).*

U.S. Arctic

As in 2023, sea surface temperatures began anomalously warm in autumn 2024 along the northern coast of Alaska, but southward and strong winds over the Chukchi sea in October and November coincided with near historical mean timing of sea-ice arrival (Figure 2). Winter air temperatures were anomalously warm over the Alaska and the northern coastal seas, as were surface ocean temperatures over the Bering sea. Despite the warm conditions, strong winds from the north through Bering Strait and over the northern Bering sea persisted through May and helped maintain the sea-ice front around 60°N even as a large polynya opened around Saint Lawrence Island (Figure 2). Following sea ice retreat, warm surface temperatures surrounded much of the U.S. Arctic coast.

Bering Sea Deep Basin

Winter wind anomalies from the north and the east associated with the strong mean Aleutian low pressure system, especially in December and February, likely advected warmer continental air and warmer waters from the south across the Bering sea basin. As across the greater region, warm SST anomalies persisted in the Bering sea deep basin through the spring (Figure 2). Late spring winds delivered cooler Arctic air masses over the Bering sea, and mixed the surface waters, contributing to cool and near-mean SST observed going into summer, similar to 2024 (Figure 2). Mean winds over the basin in July and August were towards the north, and warm anomalies strengthened from June through August, reaching 1-2°C above the historical mean over much of the region.

Eastern Bering Sea Shelf

Strong summer winds in 2024 had maintained a deep mixed layer, and correspondingly, cooler than average surface temperatures over the Bering sea shelf which lasted through October 2024 (Figure 2). The onset of seasonal winds mixed the heat content that was retained in the water column. Seasonal sea ice advance was a competition between the acceleration driven by winds from the north and melting over the anomalously warm waters. There were also reversals due to strong winds from the south and east, notably in mid-December and mid-February. South and east wind anomalies over the shelf can both drive the sea ice directly, and enhance northward oceanic heat advection onto the shelf via Ekman transport. This balance between ocean and atmospheric forces also characterized the spring over the eastern Bering sea shelf, as the warm SST anomalies persisted south of the ice edge and winds from the north maintained the ice extent at around 60ºN. The seasonal ice retreat and wind anomalies from the west along the Aleutian Islands in May and June helped contribute to a return to cool or near-normal SST over the shelf going into the summer.

Aleutian Islands

In autumn 2024, warm SST anomalies >3°C dominated the western north Pacific south of the Aleutian Islands, centered around 40-45°N. Strong subsurface warming has persisted over the central North Pacific Ocean since 2020, captured by ocean indices such as the Pacific Decadal Oscillation (PDO; https://psl.noaa.gov/data/climateindices/list/). While the greatest magnitude anomalies remained south of the Aleutian Islands, warm SST anomalies of up to 1°C persisted over the region into the summer. This heat persisted despite strong winds, which can deepen the mixed layer and entrain cooler waters towards the surface, which could be contributed by ocean-atmosphere heat fluxes, cumulative storage of heat at depth, and anomalous ocean currents.

Western Coastal Gulf of Alaska

Following the autumn of 2024 where SST was near the historical mean, ocean temperatures along the western coastal Gulf of Alaska were anomalously warm in the winter through spring throughout the surface layer of the water column (Figure 2). The mean wind conditions were favorable for downwelling of warm surface waters in the coastal region and local air temperatures were elevated above the historical mean through May. In June and July strong winds and cooler than average local air temperatures may have contributed to dampening the SST anomalies over the western coastal Gulf of Alaska in early summer, but by August SST was
>1°C above the historical mean over most of the coastal Gulf of Alaska. Eastern

Coastal Gulf of Alaska

Warm conditions along the eastern coastal Gulf of Alaska were similar to those along the western coastal region early in 2025 (Figure 2). The mean wind conditions were favorable for downwelling of warm surface waters in the coastal region and local air temperatures were elevated above the historical mean through April. Strong winds and cool air temperatures may have contributed to alleviating the warm SST anomalies in May and June, but by July and August the warm SST developed over the North Pacific and the eastern coastal Gulf of Alaska was no exception.

Gulf of Alaska Basin

The surface temperature anomalies were dynamic over the Gulf of Alaska basin from autumn into the winter of 2024–2025 (Fig. ABC1). Seasonal winds were stronger than historical averages, and varied in direction, which can increase the transfer heat between the atmosphere and the ocean–and below the relatively thin surface mixed layer where the ocean mass can store heat at inter-seasonal and inter-annual timescales. A strong Aleutian low mean pressure system was established in winter likely associated with advection of warmer air over the Gulf of Alaska from the south, and warm ocean currents from the western North Pacific. In spring, strong eastward and northward wind anomalies persisted, often associated with upwelling in the basin. Over this period, warm temperature anomalies from 100–200 m depth at Ocean Station Papa decreased in magnitude, but not enough to erode the warm anomalies at depth that had persisted since the previous summer (e.g. Figure 3). SST remained near or above historical averages through the summer, reaching up to 2°C above average in August as the winds slackened and seasonal stratification established itself.

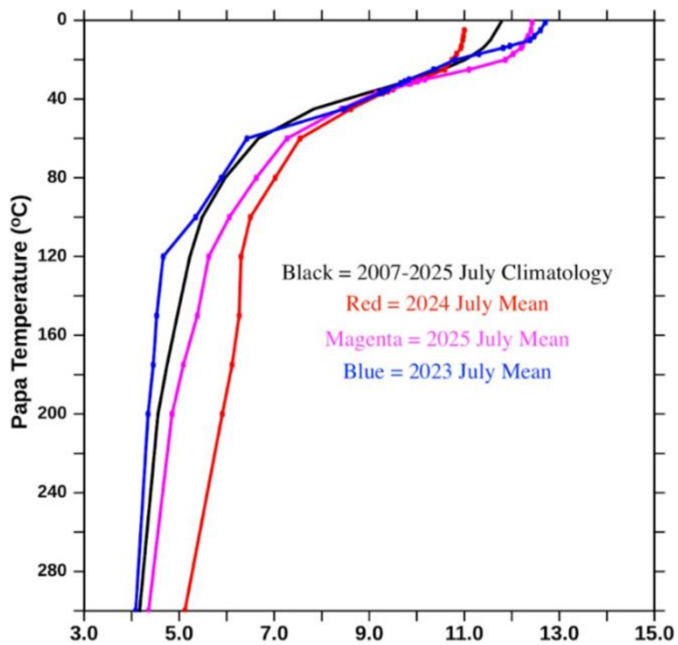


Figure 3. Subsurface temperatures in the North Pacific from the long time series measurements of ocean climate station Papa (50.1°N, 144.9°W). The July monthly climatology is shown in black, compared to July mean temperatures from 2023 (blue), 2024 (red), and 2025 (magenta). Figure courtesy of Dongxiao Zhang, UW/PMEL.

Bering Sea

Sea Surface Temperature (SST)

Satellite derived estimates of SST for the Bering Sea were compiled by Matthew Callahan (NOAA AFSC). In winter and spring (December 2024 – June 2025), northern Bering Sea SSTs were similar to the long-term mean (1985-2014, Figure 4). The northern Bering Sea experienced above average (warmer) SST values in late summer and early fall (August – September 2025), with brief and infrequent moderate marine heatwave conditions. The southeastern Bering Sea SST values were briefly close to average in late spring, and otherwise were above average and warmer than 2024. Moderate marine heatwave conditions were observed in winter-spring months in the southeastern Bering Sea. Time series SST data and plot are updated daily and available at https://connect.fisheries.noaa.gov/ak-sst-mhw/.

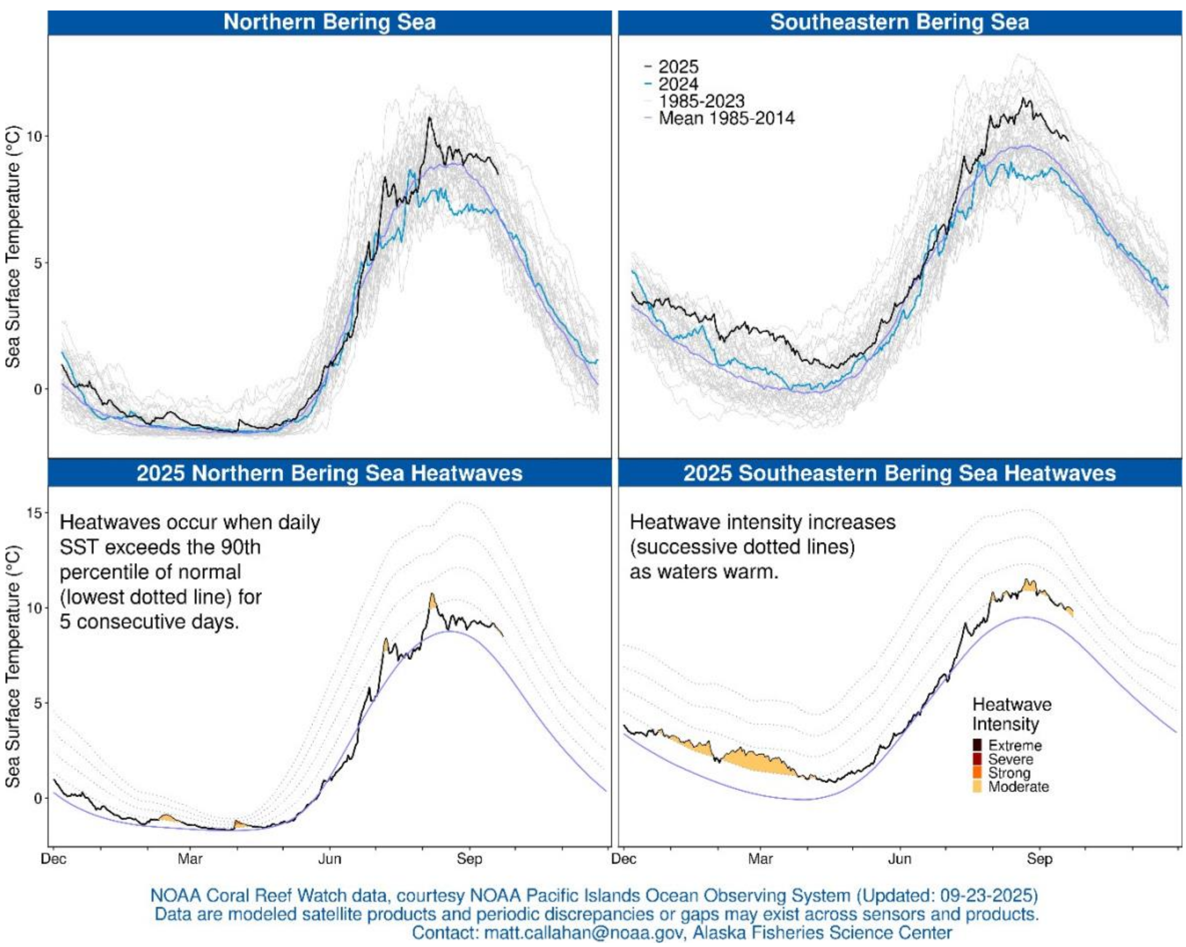


Figure 4. Daily mean SST for 2024 and 2025 compared to long-term mean (1985-2014) for the northern Bering Sea (north of 60°N) and southeastern Bering Sea (south of 60ºN) from satellite derived SST estimates. Figure courtesy of Matt Callahan (NOAA AFSC).

Sea Ice Extent

Bering Sea ice extent in 2024-2025. Contact: Rick Thoman (ACCAP, UAF)

Early Season Ice

Sea ice arrived later than the long-term average in fall of 2024. Early season (October 15 to December 15, 2024) ice extent was similar to most years since 2013 except for 2022's very high values and lower than any year prior to 2000..

Seasonal Sea Ice Extent

Maximum sea ice extent occurred in late-March (Figure 5). The 2024-25 average ice extent was predominantly lower than 2023-24 with the brief exceptions of early December, late January, and late April. While higher than the extreme 2017-18 and 2018-19 seasons, the 12-month average extent was similar to what were considered "low stanza" years prior to 2010. Winter storms in December and February led to sea ice retreat. Note: the current season is based on preliminary data and slight changes usually occur in extent values after final processing.

Sea Ice Thickness

For the week of March 15-21, sea ice thickness in most regions was roughly the same as the same week in 2024

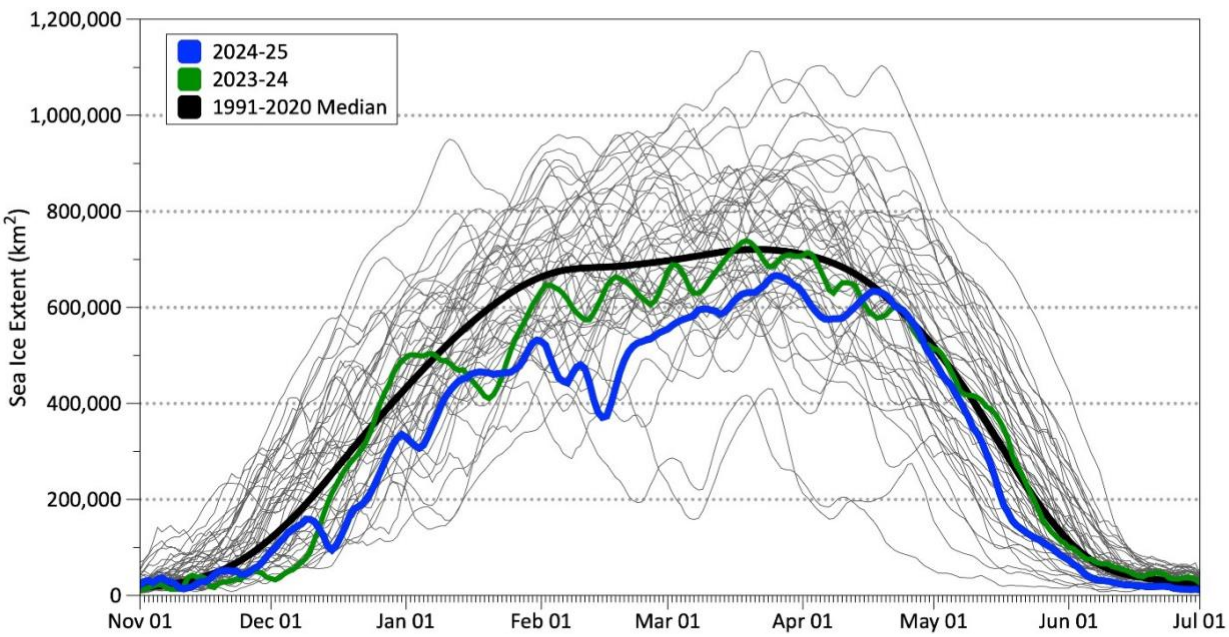


Figure 5. Bering Sea seasonal sea ice extent for 2024-25 (blue) and 2023-2024 (green) plotted against the 1991-2020 median (black). Maximum ice extent occurred in late March 2025. Figure courtesy of Thoman, ACCAP (UAF).

Spring phytoplankton blooms

In subarctic systems, such as the eastern Bering Sea, the timing and magnitude of the spring bloom 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 its timing, also impact benthic feeders in the Bering Sea.
Recent climatic changes in the Bering Sea have caused 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.

Satellite chlorophyll-a (chl-a) data, a proxy for phytoplankton biomass, allows analysis of large spatial scale patterns in phytoplankton dynamics. Weekly averaged satellite ice data and chl-a estimates from ocean color data from the European Space agency Climate Change Initiative Ocean Colour Product (OC-CCI) show small ice edge associated blooms in late March and early April 2025, with open water blooms in the Eastern Bering Sea shelf in May 2025 (Figure 6). Preliminary data from Imaging Flow Cytobot (IFCB) showed open water blooms in May to be dominated by Chaetoceros and other diatoms near M2 mooring in the eastern Bering Sea.
Satellite chl-a data obtained from https://climate.esa.int/en/projects/ocean-colour/ and sea ice fraction data obtained from https://coastwatch.pfeg.noaa.gov/erddap/.

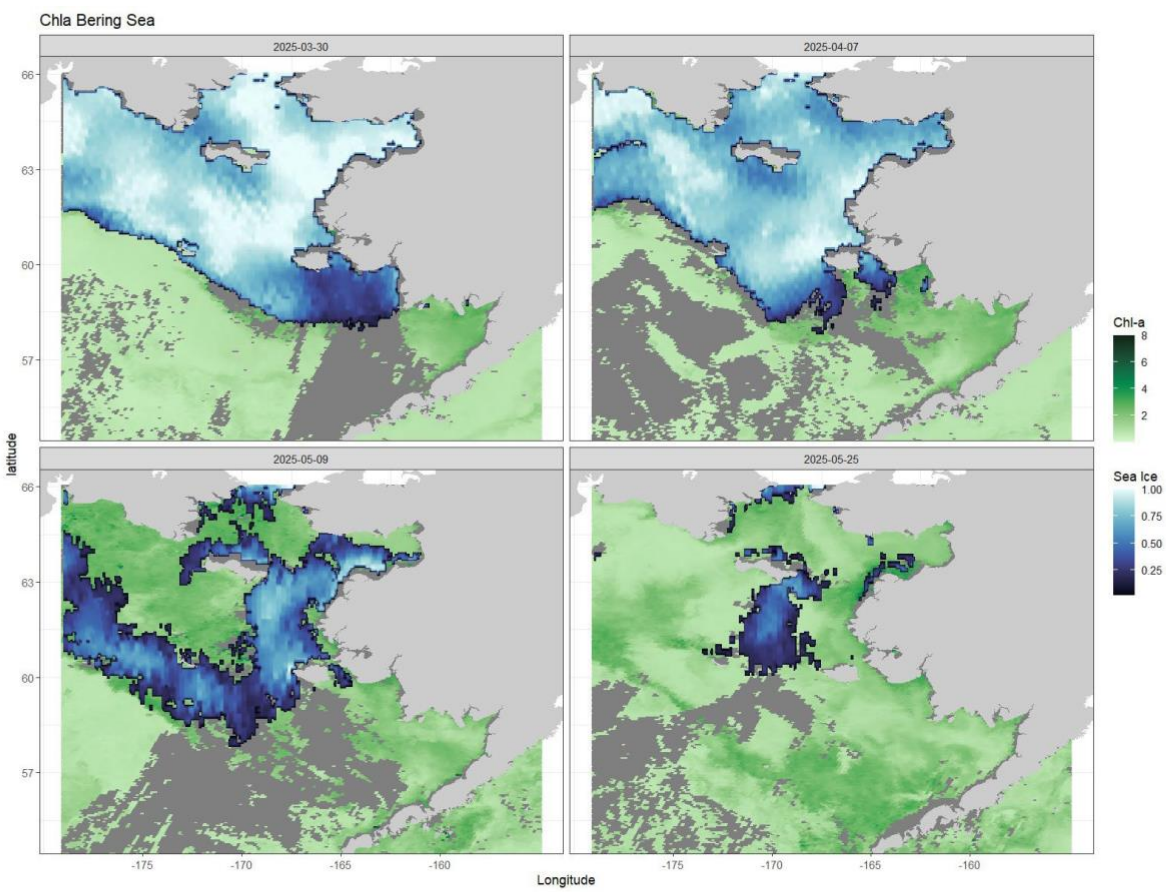


Figure 6: Weekly averaged satellite Chl-a estimates (greens) from the Bering Sea using OC-CCI

ocean color data. Bering Sea sea ice fraction is also shown (blues). Figure courtesy of Jens Nielsen and Matt Callahan (NOAA AFSC).

2025 Highlighted Surveys in the Bering Sea

Many of the 2025 AFSC and Pacific Marine Environmental Lab (PMEL) surveys in the Bering Sea are described in the link: https://www.fisheries.noaa.gov/alaska/science-data/2025-alaska-fisheries-science-center-field-season-and-program-updates. Select excerpts are included below. Credit: NOAA Fisheries.

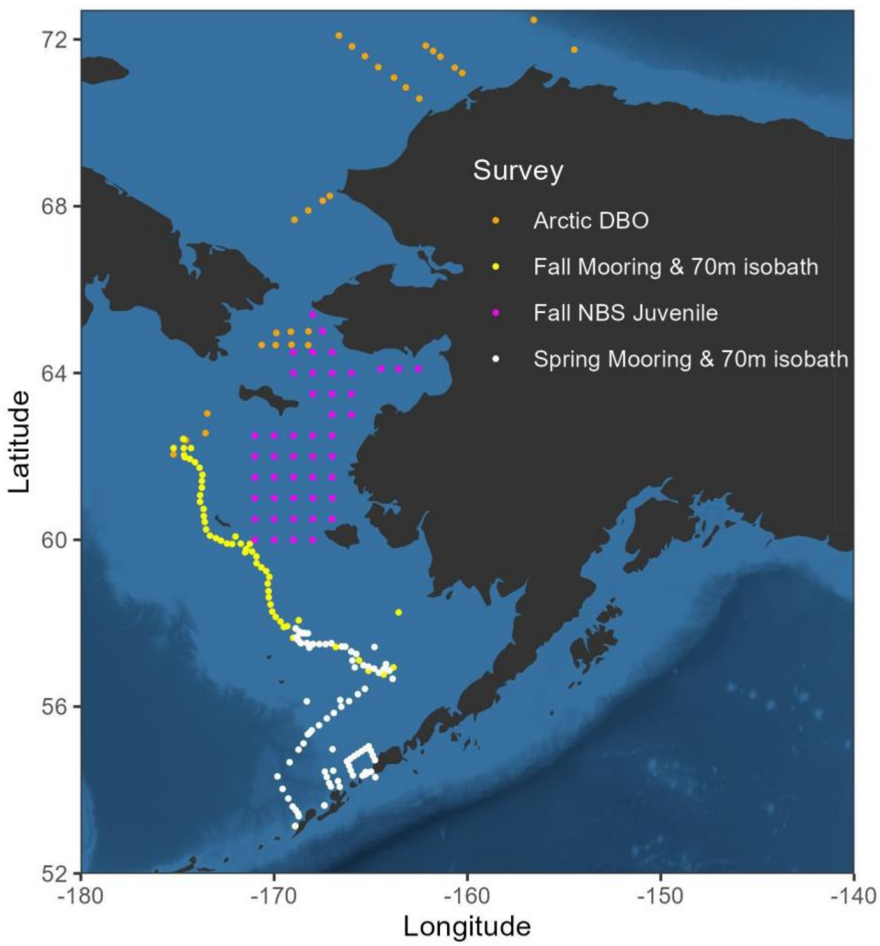


Figure 7. Surveys include physical oceanography (all stations), lower trophic level and juvenile fish sampling. Oceanographic, lower tropic level, and mooring survey stations in spring (white) and fall (yellow), Northern Bering Sea juvenile fish survey stations in fall (pink), and Arctic DBO survey (orange). Figure courtesy of the Recruitment Processes Alliance (RPA, NOAA AFSC).

Spring and Fall Mooring Cruise

This annual survey in the Bering Sea (Figure 7) provides baseline fisheries and oceanographic data to support sustainable management of living resources in the Bering Sea and the rapidly changing US Arctic ecosystem. The goals of the survey include the recovery and deployment of NOAA biophysical and passive acoustic moorings located in the Bering Sea, perform CTD measurements, as well as Bongo and net tow surveys for zooplankton and fish larvae at long-term sampling sites.

Survey contact: Heather Tabisola (NOAA AFSC)

EcoFOCI Spring Icthyoplankton Survey

The primary objective of the EcoFOCI Spring Ichthyoplankton Survey is to assess eggs and larvae of commercially-important fishes, including walleye pollock and Pacific cod, over the eastern Bering Sea shelf. Observations support research on fisheries recruitment processes and contribute to our understanding of how young fish and their zooplankton prey respond to changes in climate.

Survey contact: Kelia (Keely) Axler (NOAA AFSC)

Annual Bottom Trawl Survey of the Eastern Bering Sea

The 2025 Eastern Bering Sea Bottom Trawl Survey was led by scientists from the Alaska Fisheries Science Center with participation from the Alaska Department of Fish & Game (ADF&G), International Pacific Halibut Commission (IPHC), and regional universities. 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.

Survey contact: Duane Stevenson (NOAA AFSC)

Northern Bering Sea Bottom Trawl Survey

The 2025 Northern Bering Sea Bottom Trawl Survey was led by the Alaska Fisheries Science Center (AFSC), and also included participation by the International Pacific Halibut Commission (IPHC) and regional universities. The objectives of this survey are to understand and monictor the effects of changing sea ice cover and water temperature on bottom-dwelling fishes, crabs, and other marine life along the northern Bering Sea shelf.

Survey contact: Duane Stevenson (NOAA AFSC)

Gulf of Alaska

Sea Surface Temperature (SST)

Satellite derived estimates of SST for the western and eastern Gulf of Alaska were compiled by Matthew Callahan (NOAA AFSC). The western Gulf of Alaska SSTs in 2025 were mostly higher (warmer) than the long-term mean (1985-2014) with near average values in the early summer months and moderate marine heatwave conditions in spring and late summer/early fall (Figure 7). The eastern Gulf of Alaska experienced above average (warmer) SST values inwith moderate marine heatwave conditions in spring and late summer/early fall. Time series SST data and plot are updated daily and available at https://connect.fisheries.noaa.gov/ak-sst-mhw/

Spring phytoplankton blooms

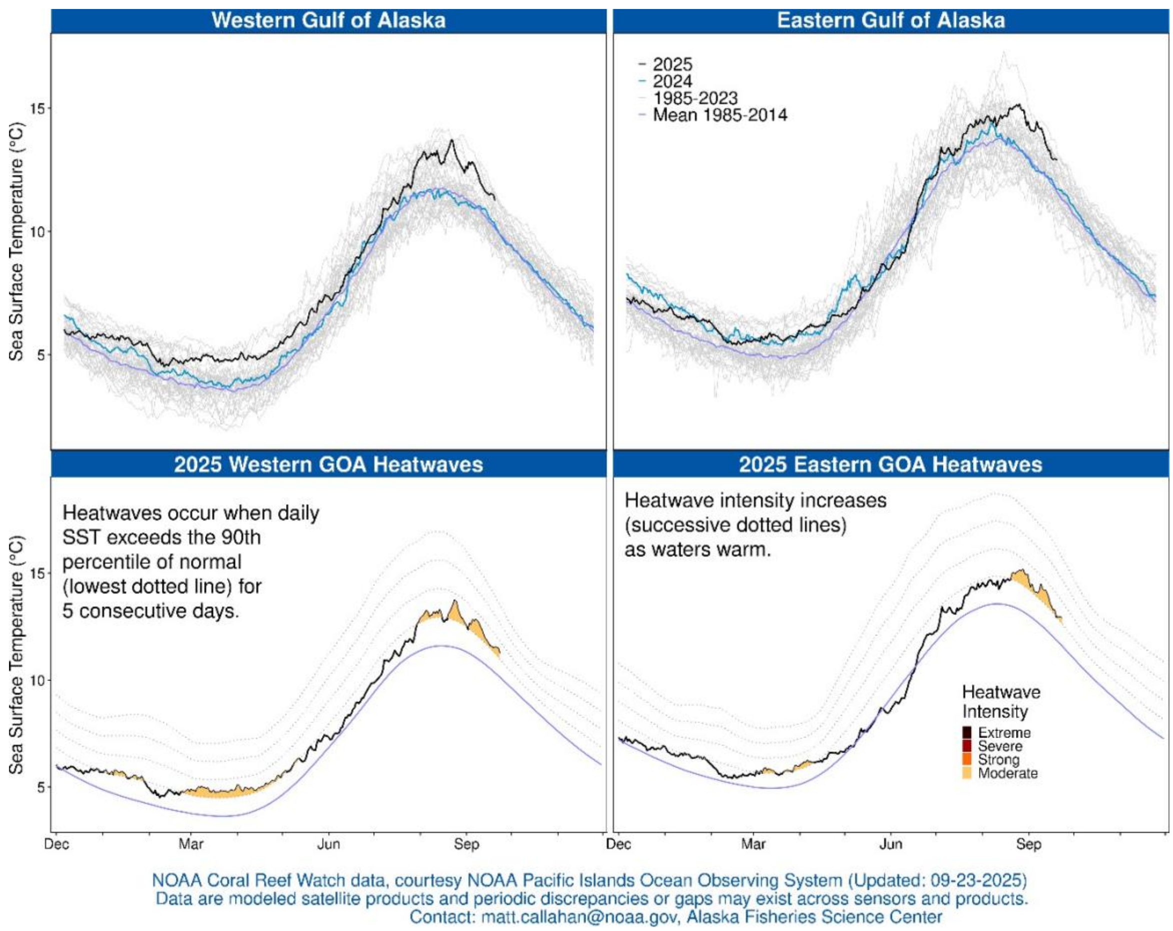


Figure 8. Daily mean SST for 2025 and 2025 compared to long-term mean (1985-2015) for the western and eastern Gulf of Alaska (GOA) from satellite derived SST estimates.

Figure courtesy of Matt Callahan, NOAA AFSC.

Contribution/credit: Jens Nielsen, Jeanette Gann, and Matt Callahan (NOAA AFSC)

Weekly averaged satellite Chl-a estimates in the spring from the Gulf of Alaska using OC-CCI ocean color data show small eddy associated blooms in late March 2025, and a somewhat stronger bloom over the shelf in May 2025 (Figure 9). Additional information from the ESR indicates that peak bloom in the eastern Gulf of Alaska occurred in mid-June (about a month past mean peak bloom timing), and overall eastern Gulf of Alaska chl-a biomass estimates were slightly lower than average for April-June 2025 (Gann, personal comm). However, satellite coverage during April and May in this region was relatively low due to cloud cover which may have impacted read values. Western Gulf of Alaska bloom timing was about average for the long-term (1998-2024) mean at ~May 21, 2025 with biomass values slightly higher than average.

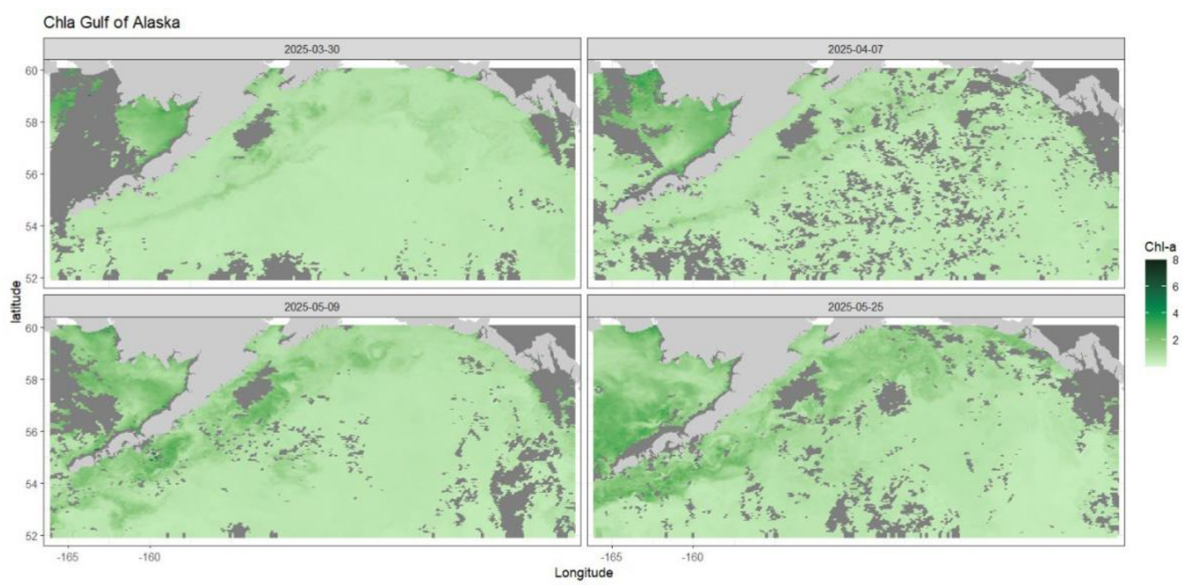


Figure 9: Weekly averaged satellite Chl-a estimates (greens) from the Gulf of Alaska using OC-CCI ocean color data. Figure courtesy of Jens Nielsen and Matt Callahan (NOAA AFSC).

2025 Highlighted Surveys in the Gulf of Alaska

Many of the 2025 AFSC and PMEL surveys in the Gulf of Alaska are described in the link: https://www.fisheries.noaa.gov/alaska/science-data/2025-alaska-fisheries-science-center-field-season-and-program-updates. Select excerpts are included below. Credit: NOAA Fisheries.

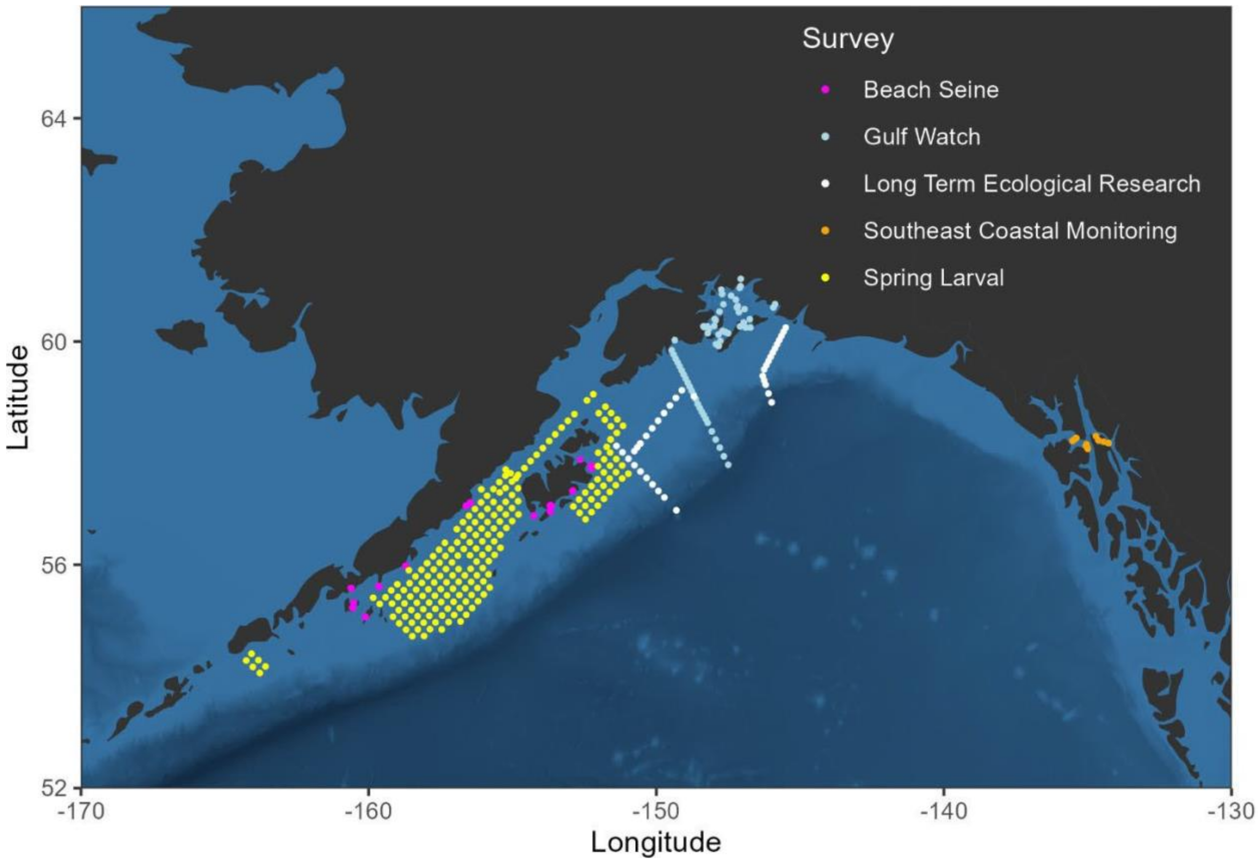


Figure 10: Surveys including physical oceanography, lower trophic level and juvenile fish sampling. Survey stations from the Gulf of Alaska including beach seine (pink), Gulf Watch Alaska (light blue), Northern Gulf of Alaska Long-term Ecological Research Site (white), Southeast Coastal Monitoring (orange), and the Spring Larval Survey (yellow). Figure courtesy of the Recruitment Processes Alliance (RPA, NOAA AFSC).

<u>2025 Winter Acoustic-Trawl Pre-spawning Pollock Surveys in the Gulf of Alaska</u>

This survey uses acoustics and targeted trawling on acoustic backscatter to estimate the abundance and distribution of pre-spawning walleye pollock (Gadus chalcogrammus) in winter spawning regions of the Gulf of Alaska. This effort informs fish stock assessment models and catch allocation.

Contact: Darin Jones and Sandy Parker-Stetter (NOAA AFSC)

Pacific Cod IBM Survey

This is the final year of a 4-year study validating the Juvenile Pacific Cod Individual Based Model (IBM) developed under the GOA-Integrated Research Program. The IBM predicts strength of juvenile Pacific cod settlement in the nearshore throughout the Gulf of Alaska based on annual oceanographic conditions and cod ecology (Figure 10). Abundances of age-0 and age -1 Pacific cod from field sampling are being compared IBM-predicted settlement fractions for each nearshore nursery area in the GOA to validate the model predictions. Habitat-abundance relationships, daily ages from otoliths, and genetics will also be used to refine the model predictions. This is a multi-faceted project led by RECA staff in collaboration with REFM, CICOES, UAF, ABL Genetics.

Contacts: Johanna Page and Katharine Miller (NOAA AFSC)

AFSC Longline Survey

The Alaska Fisheries Science Center of NOAA Fisheries conducts the Longline Surveys on a rotating bases throughout Alaska (Figure 11). The survey sampled the Gulf of Alaska in 2025. The research objective is to conduct a fisheries-independent survey of groundfish resources in Alaskan waters. The AFSC Longline Survey is specifically designed to provide a relative population index for assessing sablefish, or black cod, but the data that is collected is also useful for several other groundfish species. The survey occurs in fish habitats that are not well sampled by trawl surveys due to the deep depths and rough bottoms where gear is deployed.

Survey contact: Pat Malecha, Kevin Siwicke, Chris Lunsford, and Daniel Goethel (NOAA AFSC)

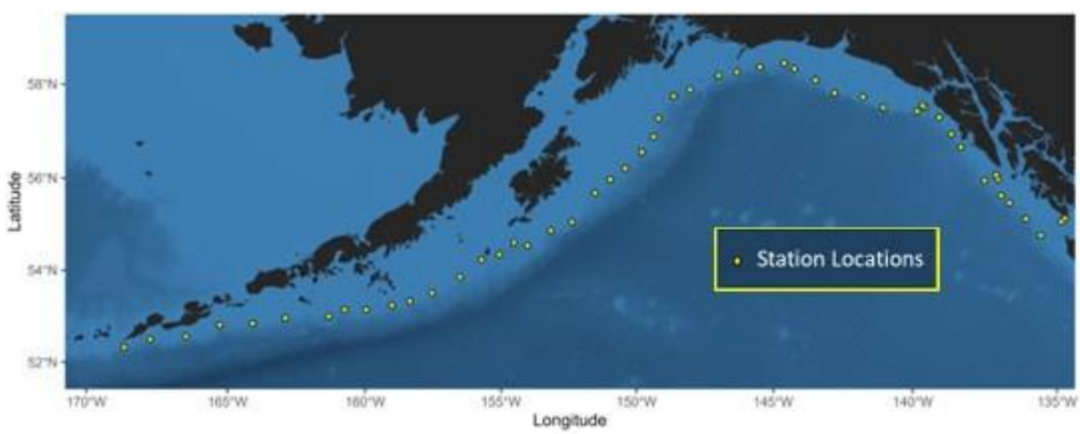


Figure 11. Survey area and station map for 2025 AFSC Longline Survey in the Gulf of Alaska. The survey samples groundfish populations from 150-1000 m along the continental shelf and upper slope.

3. China

There was no report.

4. Republic of Korea

1. National Institute of Fisheries Science (NIFS)

Real-time Information System for Aquaculture Environment (RISA)

NIFS operates real-time water temperature observations at 31 monitoring stations and, through the RISA system, also provides data from 108 observation sites managed by local government. The water temperature observations conducted by NIFS are mostly measured at depths of 0.5m–5.0m, while the instruments operated by local government record temperatures within the depth range of 0.5–2.5m. Both NIFS and local government are plan to progressively enhance the RISA monitoring programs, including measurements of salinity and dissolved oxygen, to better support aquaculture management.

2. Korea Meteorological Administration (KMA)

Ocean weather observation system around the Korea Peninsula

The Korea Meteorological Administration (KMA) operates 47 marine data buoys in the seas around the Korean Peninsula. These buoys collect essential meteorological and oceanographic parameters, including wind speed and direction, atmospheric pressure, humidity, sea surface temperature (SST), wave height, and wave direction. In 2025, KMA expanded its observation network by deploying both large-scale and small-scale marine data buoys. This expansion includes one 10-meter buoy installed in the coastal region of the Yellow Sea and twelve 2-meter buoys positioned along various coastal areas. These buoys play a critical role in monitoring marine meteorological conditions and are extensively used for weather forecasting and sea-weather warnings.

3. Korea Hydrographic and Oceanographic Agency (KHOA)

Real-time Korea Ocean Observing Network

Korea Hydrographic and Oceanographic Agency (KHOA) operates the Korea Ocean Observing Network (KOON), which consists of tidal stations, ocean stations, ocean research stations, ocean buoys, and surface current stations. KOON, comprised of 140 stations, provides real-time ocean information with improved data quality to meet the needs of maritime policy, the maritime industry, public activities, marine climate change, and oceanographic research. KHOA currently operates 55 tidal stations, 2 ocean stations, 3 ocean research stations, 36 ocean buoys, and 44 HF radar stations. Additionally, KHOA has commissioned the 4,000-ton research vessel, the R/V *Onbada*, thereby establishing the foundation for deep-sea marine surveys and research in the global ocean.

5. Japan

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

Zooplankton play a key role in marine ecosystems, not only by linking primary production by phytoplankton to higher trophic levels such as fish, but also as a crucial component of the biological pump, which transports carbon dioxide from surface waters to the mesopelagic zone through vertical migration and fecal pellet sinking. As zooplankton communities respond sensitively to environmental changes, their ecological functions are expected to shift significantly under climate change. Therefore, clarifying the relationship between zooplankton variability and environmental conditions is essential for understanding changes in marine ecosystems. Since 1949, the Japan Fisheries Research and Education Agency (FRA) has been collecting and archiving zooplankton samples, primarily in the western North Pacific, to study marine environments and zooplankton communities in the Shiogama field station (Fig.1). To date, approximately 290,000 samples have been collected. These samples have been gathered by a wide range of institutions, including prefectural fisheries research institutes, universities, the Japan Meteorological Agency, and international research organizations. The archive includes the Odate Collection (Fig.2). The samples collected during CSK (Cooperative Study of the Kuroshio and its Adjacent Regions), a UNESCO-sponsored international cooperative survey (Fig.3) was transferred from Tokai University to Shiogama field station in this year.

(a) (b)

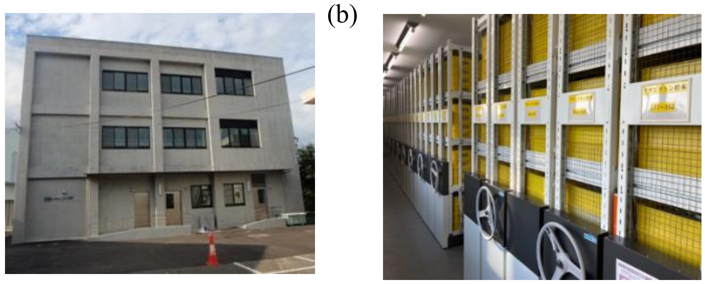


Fig. 1 Sample storage building at Shiogama field station of FRA Fishery Resources Institute. Exterior (a) and inside (b) of the Building.

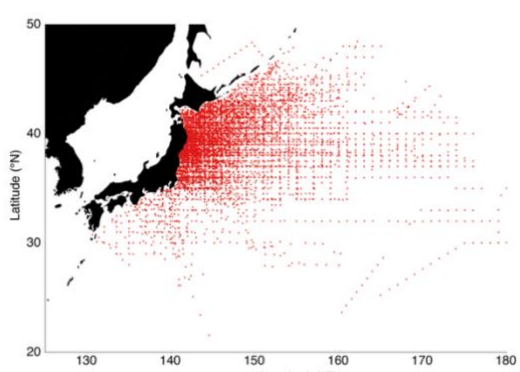
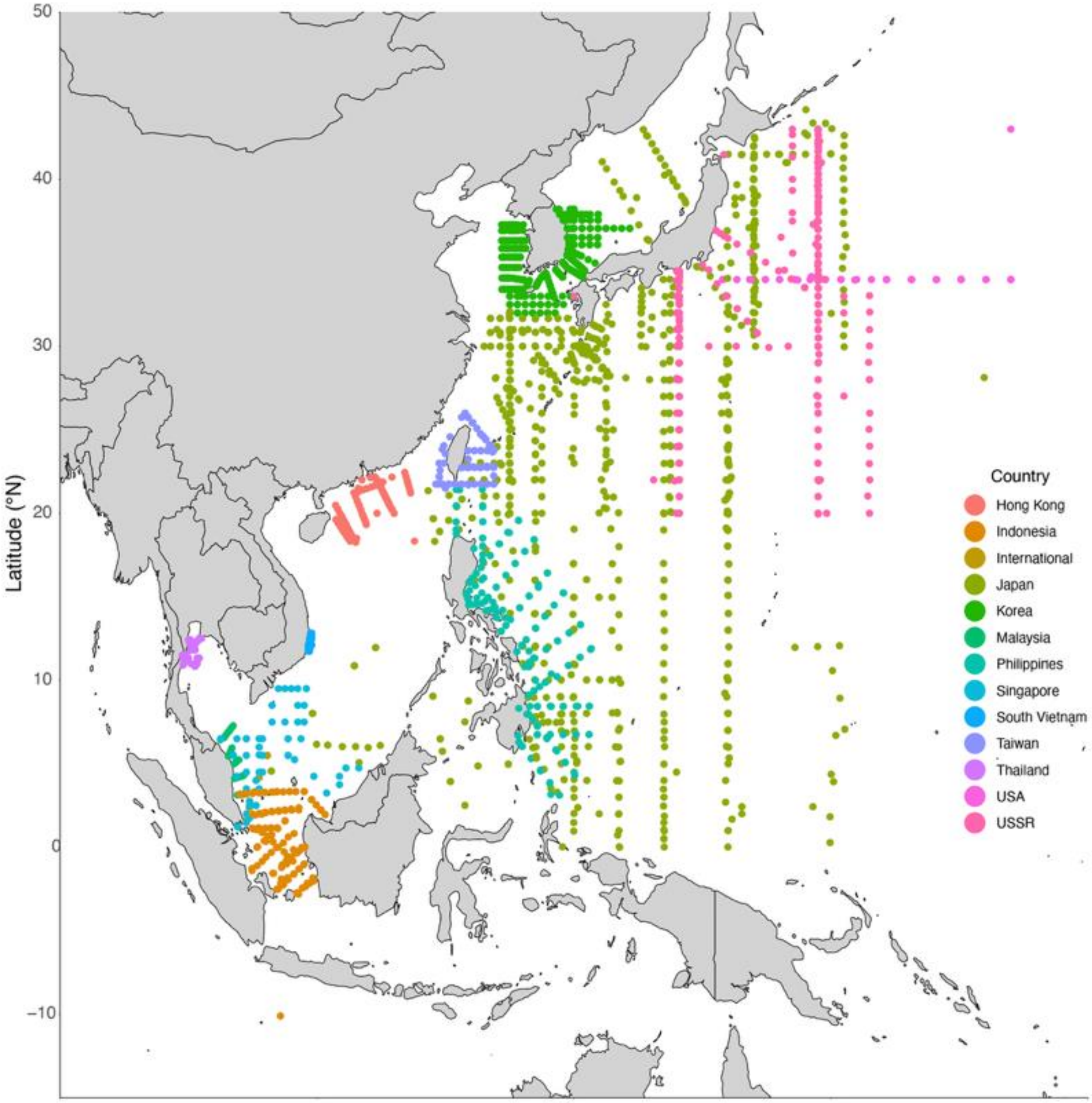


Fig. 2 Sample stations of the Odate collection collected from 1949-1990. The total number of sample is 17326.


50
40
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−10
Latitude (°N)
90
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130
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170
Longitude (°E)
Country
Hong Kong
Indonesia
International
Japan
Korea
Malaysia
Philippines
Singapore
South Vietnam
Taiwan
Thailand
USA
USSR

Hokkaido University

Hiroto Abe, Faculty of Fisheries Sciences

Maps of monthly-mean SST anomaly are shown in Fig. 1. In November 2024 and February 2025, positive sea surface temperature (SST) anomalies exceeding 4 °C are observed in the Oyashio-Kuroshio confluent region. These anomalies are caused by the meandering and northward shift of the warm Kuroshio Extension, which has continued for seven years since 2017. The large meandering of the Kuroshio ends by May 2025, and the positive anomalies disappear at the same time. Subsequently in August, positive anomalies exceeding 2 °C are widespread around Japan, particularly in the waters around northern Japan. Figure 2 shows a time series of SST anomalies over more than 20 years in boxed regions in western and eastern Hokkaido. As previously reported in the national report, SST is on an upward trend, with a persistent positive deviation of 1 to 3 °C from 2023 to 2025.

To investigate the in-situ water temperatures, mooring data obtained at Funka Bay, Hokkaido, was used. As shown in Fig. 3, this bay is located in the southwest of Hokkaido with 90 – 100 meters deep, and is an area rich in fisheries resources such as scallops, cod, flat fish, salmon, and octopus. Hokkaido University has been using a mooring system at St. 30 in the central part of Funka Bay to continuously monitor water temperature, dissolved oxygen, and current velocity since 2012. Figure 4 shows the time series of water temperature at a depth of 10 m and at a depth of 70 m, close to the seabed. Each five-year period is shown in a different panel. Clear seasonal variations are found, with temperatures exceeding 20 °C in the summer at 10 m. However, in recent years, water temperatures have tended to rise, sometimes approaching 25 °C. Seasonal variations are also evident at 70 m. Looking at April, when water temperatures are seasonally at their lowest, they ranged from 2 to 4 °C in the early 2010s, 3 to 6 °C in the late 2010s, and 2 to 5 °C in the early 2020s. Water temperatures at 70 m do not exhibit a simple linear trend. Previous research has shown that winter water temperatures are primarily determined by the amount of cold Oyashio water (Figure 3b) that flows in during the winter and originates from the Sea of Okhotsk. It has been reported that, particularly in the late 2010s, warm eddies separated from the Kuroshio Extension approached the coast of Hokkaido, preventing the inflow of Oyashio water and resulting in positive water temperature anomalies (Abe et al., 2023).

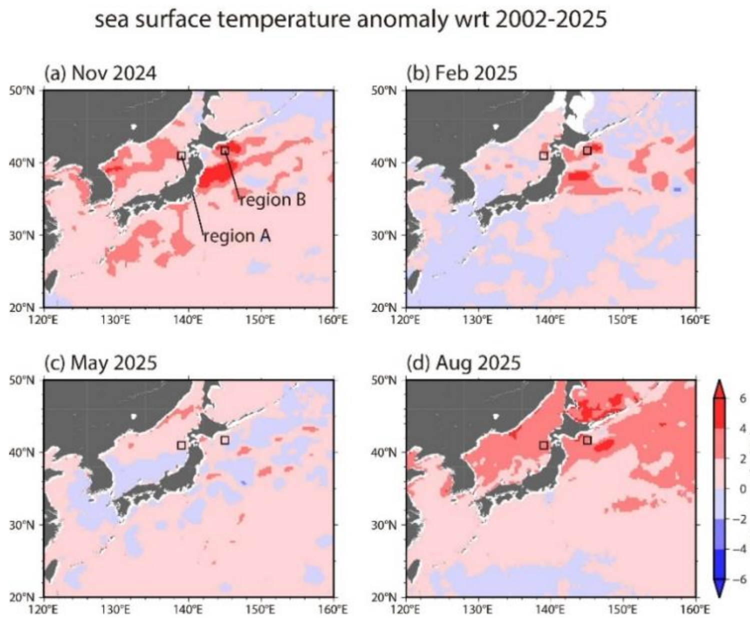

Fig. 1. Maps of monthly-mean SST anomaly in (a) November, (b) February, (c) May, (d) August of the last one year with respect to monthly climatological SST over 2002 – 2025. SST data observed by satellites (Aqua/AMSR-E and GCOM-W/AMSR2), downloaded from G-Portal, data server of JAXA (Japan Aerospace Exploration Agency), have been used.

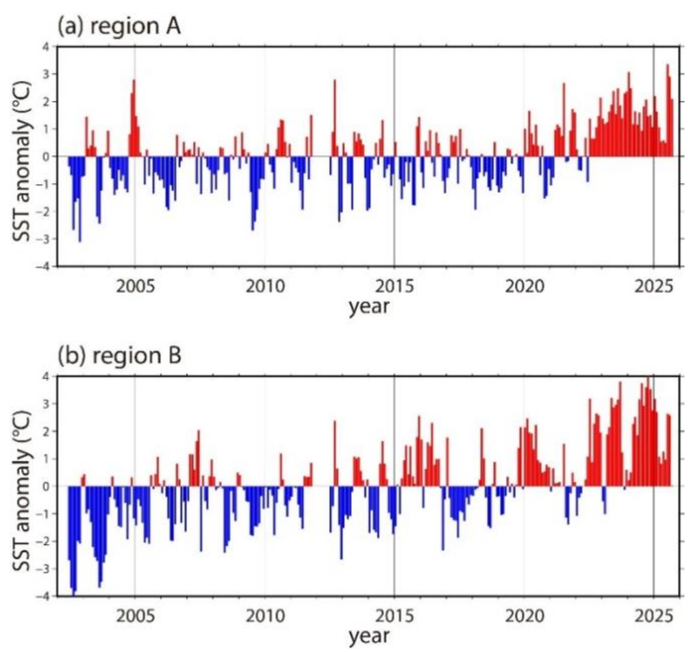

Fig. 2. Time series of monthly-mean SST anomaly with respect to monthly climatological SST over 2002 – 2025 averaged over the box regions shown in Fig. 1. SST data observed by satellites (Aqua/AMSR-E and GCOM-W/AMSR2), downloaded from G-Portal, data server of JAXA (Japan Aerospace Exploration Agency), have been used.

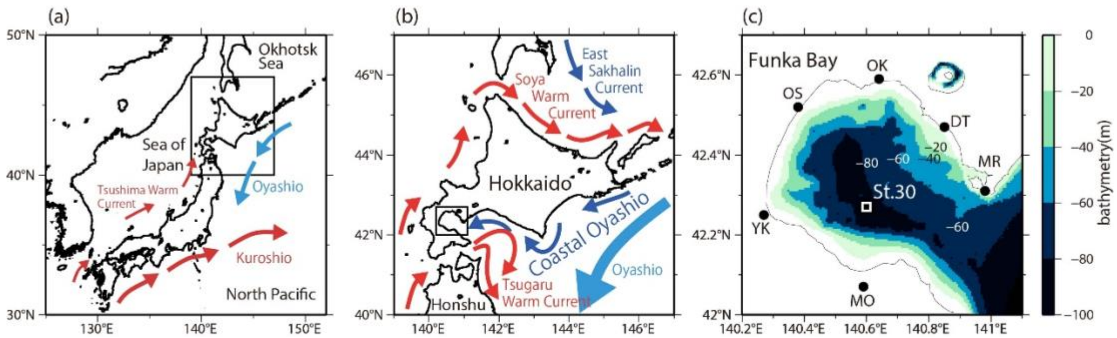

Fig. 3. Location of Funka Bay, Hokkaido, Japan. We have monitored ocean environment using mooring at a regular station, called as St. 30 since 2012.

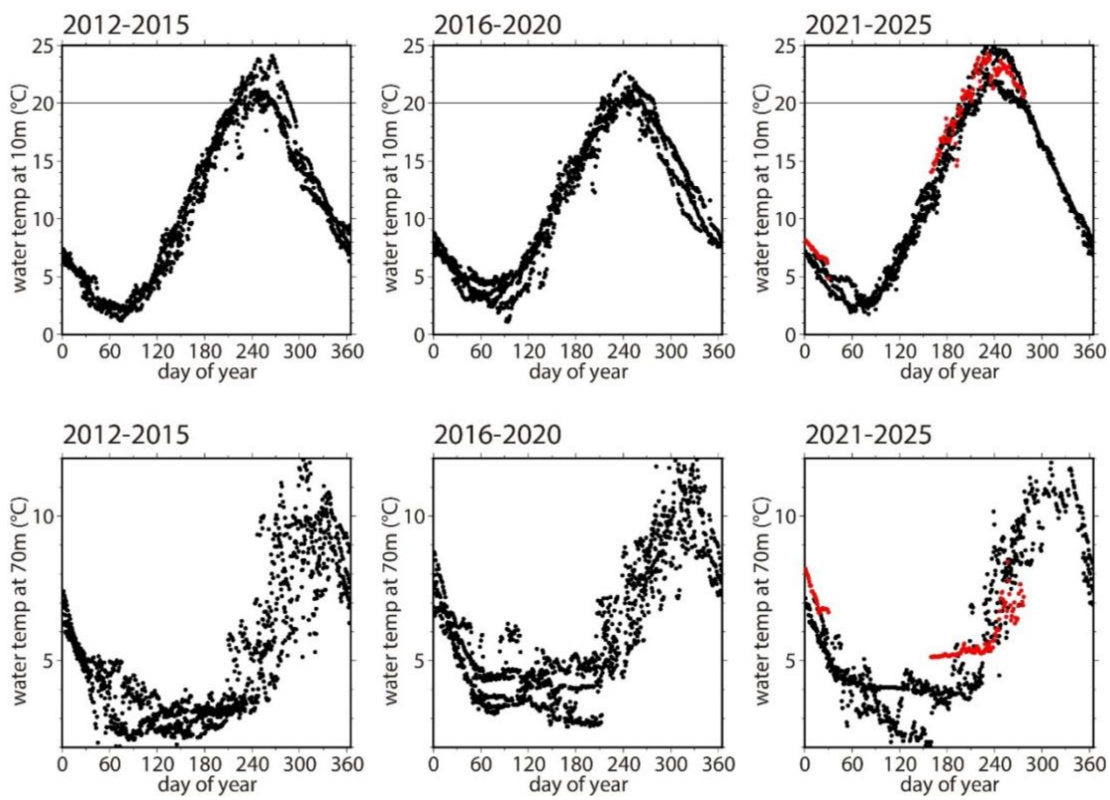

Fig. 4. Time series of daily-mean water temperature at 10 m and 70 m depth measured by mooring observation at a regular station of Funka Bay, Hokkaido, Japan. See Fig. 3 for its location. The years are 2012 – 2015, 2016 – 2020, 2021 – 2025 for the left, middle, and right panels, respectively. Red one shows time series of 2025.

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

Minoru Kitamura, RIGC JAMSTEC

JAMSTEC is in charge of variety of ocean monitoring programs. Three time-series programs are herein reported.

1. K2 Biogeochemical Time-series, the western subarctic Pacific

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 (Honda et al., 2017). 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. In 2001, sediment trap experiment using mooring system was started. 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: CTD casts up to 10-m above the seafloor, 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, zooplankton samplings, and etc. In 2025, recovery and redeployment of the K2 mooring and hydrographic observations were successfully carried out in August. And next recovery of the mooring system will be planned in 2027 April. The K2 biogeochemical time-series was nominated for POMA2025.

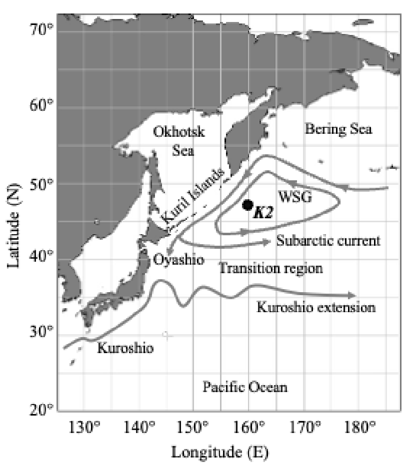

Fig. 1. Location of time-series station K2 with surface current system (modified from Qiu, 2023). WSG is the Western Subarctic Gyre.

1.1. Sea surface temperature (SST) around K2

Satellite derived SSTs around K2 (1982–2024) were compiled (Fig. 2). From January to August in 2024, SSTs were similar to those in 2023. After that, SSTs from September to December in 2024 were prominently lower than those in 2023. Comparing with the long-term mean (1982–2024), SSTs in August and September of 2024 were >0.8˚C higher whereas those in other months showed similar values.

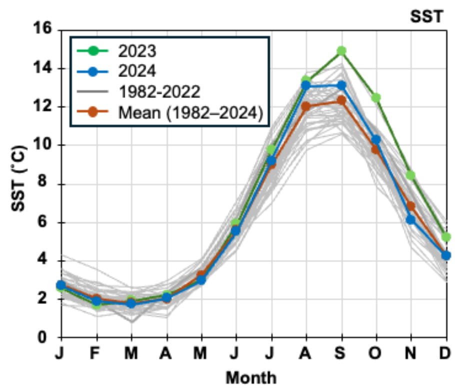

Fig. 2. Monthly mean SST for 2024 compared with 2023 and long-term mean (1982-2024) around K2 from satellite derived SST estimates.

Caused by the lower SSTs from September to December in 2024, annual mean SSTs were decreased down from 2023 to 2024 (Fig. 3). From the time-series of annual mean SSTs, we can see that there is a long-term trend with ocean temperature rising at a rate of 1.35˚C per 100 years. This rate (1.35˚C/100 years) was strongly influenced by remarkably high values obtained from 2022 and 2023. When the two data were eliminated, the rising rate of ocean temperature was estimated as 0.78˚C per 100 years. Time-series of SST anomalies showed that 2024 was a continuation of a warm period that started from 2021 (Fig. 4). Values of SST anomaly in 2024, however, were lower than those in 2022 and 2023.

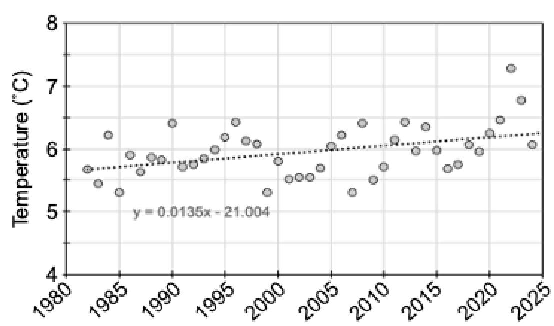

Fig. 3. Time-series of annual mean SSTs around K2.

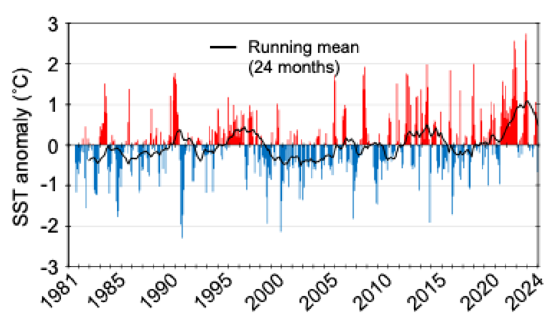

Fig. 4. Time-series of monthly mean SST anomalies around K2.

1.2. Bottom water temperature at K2

By means of moored CTD data obtained at 34 m above the seafloor from 2010 to 2023, decadal change of environment near the seafloor was investigated (Uchida et al., 2025). Only the pressure and temperature data were available, but unfortunately, conductivity data was not used because it was too unstable. Before and after deployments of mooring system, hydrocasts of shipboard CTD (SBE9plus and SBE35) and the mooring CTD (SBE37) were carried out simultaneously. From comparisons of the two data obtained by shipboard and mooring CTDs, the mooring CTD was calibrated. Detailed methods for the calibration were reported by Uchida et al. (2008). As a result of the mooring observations, decadal warming of bottom water temperature ($3.3 \pm 0.1 \times 10^{-3}$ ˚C/10 years) was recognized at K2. This warming was probably due to increasing of geothermal heating effect caused by slowing of the northward abyssal flow.

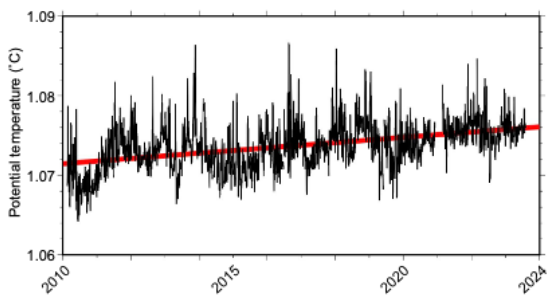

Fig. 5. Time-series of temperature at 34 m above the seafloor at K2 from 2010 to 2023.

1.3. Surface chlorophyll-*a* concentration around K2

Satellite derived monthly mean chlorophyll-*a* concentrations (Chl-a) around K2 from 2000 to 2024 were compiled (Fig. 5). In 2023, prominently high Chl-a were observed from late summer to autumn with its peak in October. In 2024, however, higher Chl-a were observed during summer with its peak in July. Peak concentrations were decreased down from 2023 (2.4 mg m^{-3}) to 2024 (1.4 mg m^{-3}). Although seasonal dynamics of Chl-a in 2024 was similar to that for long-tern mean (2000–2024), summertime concentrations in 2024 were 1.2–1.9 times higher than those for the long-term mean. Previously, Chl-a were decreased down from autumn to winter. But in 2024, re-increasing of Chl-a was detected from November to December and its concentration was the highest value among previously collected December data since 2000.

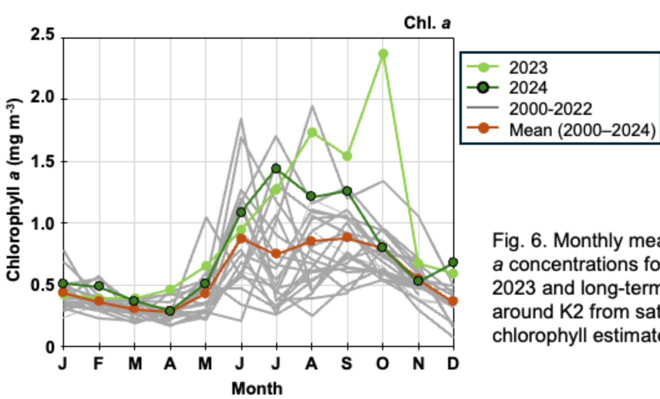

Fig. 6. Monthly mean surface chlorophyll *a* concentrations for 2024 compared with 2023 and long-term mean (2000-2024) around K2 from satellite derived chlorophyll estimates.

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 (32°22.04′N, 144°24.93′E). Originally, this mooring had a sediment trap at 4900 m in depth (2014–2019), but the current system has two sediment traps at 1000 and 4900 m. In July 2025, the JAMSTEC mooring was successfully recovered but we couldn't redeploy it due to rough sea state during the July cruise. Redeployment of the mooring system will be planned in February 2026.

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 are installed to bottom of the buoy and the mooring wire rope above 300 m in depth. A down faced ADCP is also attached at bottom of the surface buoy. Next recovery and redeployment will be planned in 2025 autumn.

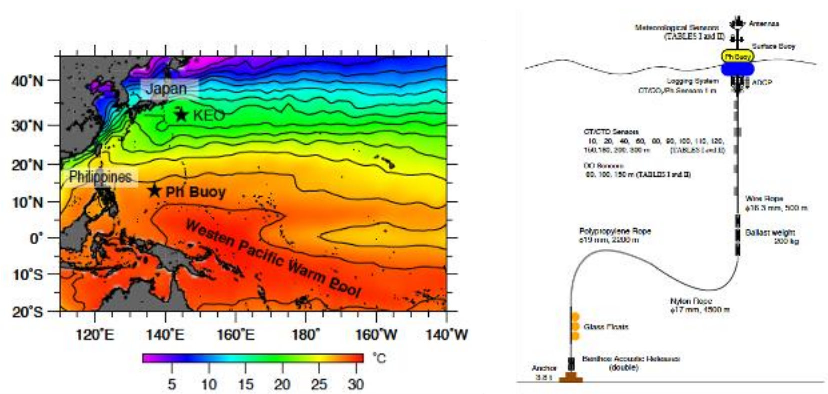

Fig. 7. Location of the Ph buoy (left) and schematic diagram of the buoy (right).

References

Honda et al. (2017) Comparison of carbon cycle between the western Pacific subarctic and subtropical time-series stations: highlights of the K2S1 project. *Journal of oceanography*, 73, 647–667.

Uchida et al. (2008) In situ calibration of moored CTDs used for monitoring abyssal water. *Journal of atmospheric and oceanic technology*, 25, 1695–1702.

Uchida et al. (2025) Possible increase in the practical salinity of IAPSO standard seawater. *Journal of atmospheric and oceanic technology*, 42, 745–760.

6. Russia

Monitoring Activities in Russian Federation ***(Vladimir Kulik, TINRO and Vyacheslav Lobanov, POI)***

1 Fishery-independent surveys by VNIRO (TINRO)

These surveys are conducted regularly by the Pacific branch (TINRO) of the State Research Center Federal State Budget Scientific Institution "Russian Federal Research Institute of Fisheries and Oceanography" (VNIRO)
TINRO vessels conducted 522 midwater trawls during fishery-independent surveys in the North-Western part of the Pacific Ocean in 2024 (Fig. 1).
48 of those trawls were conducted in the High Seas.
Each midwater trawl station is accompanied by hydrological and hydrobiological stations just before or after the trawling.

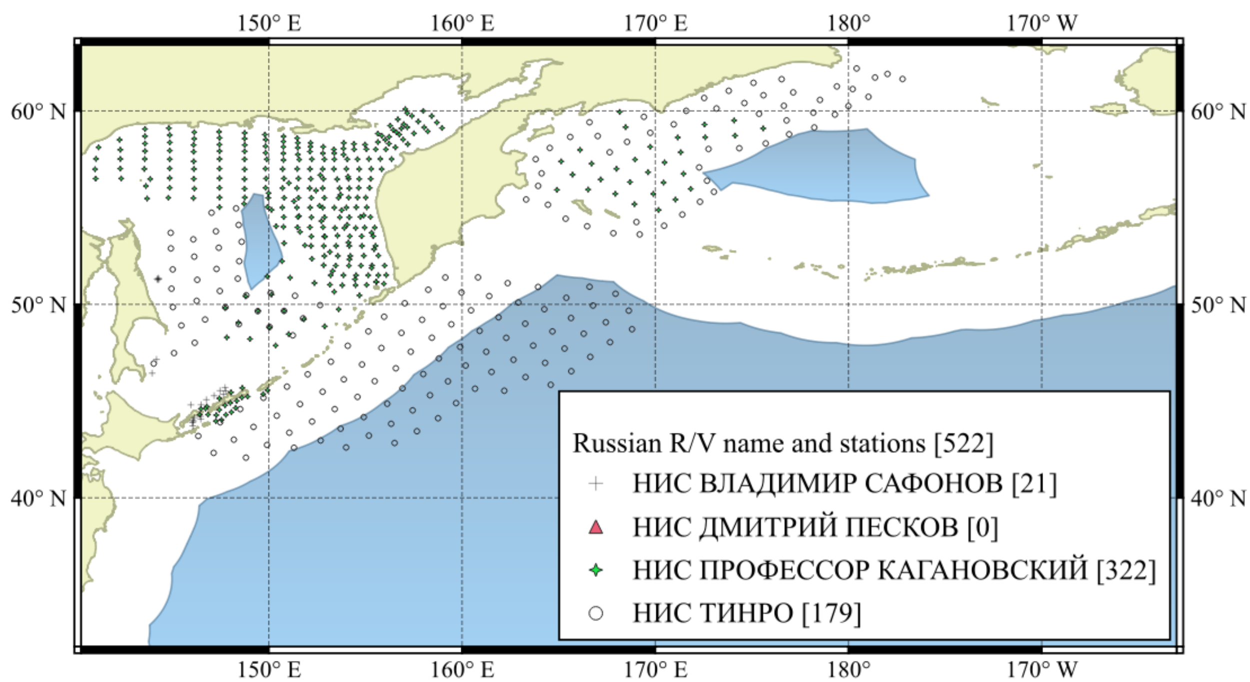

Fig. 1. Midwater trawls, conducted by TINRO R/Vs in 2024

There were 704 bottom trawls conducted by TINRO R/Vs in 2024, which were saved in the database in TINRO (Fig. 2).
Other surveys are in progress or have not been processed yet.

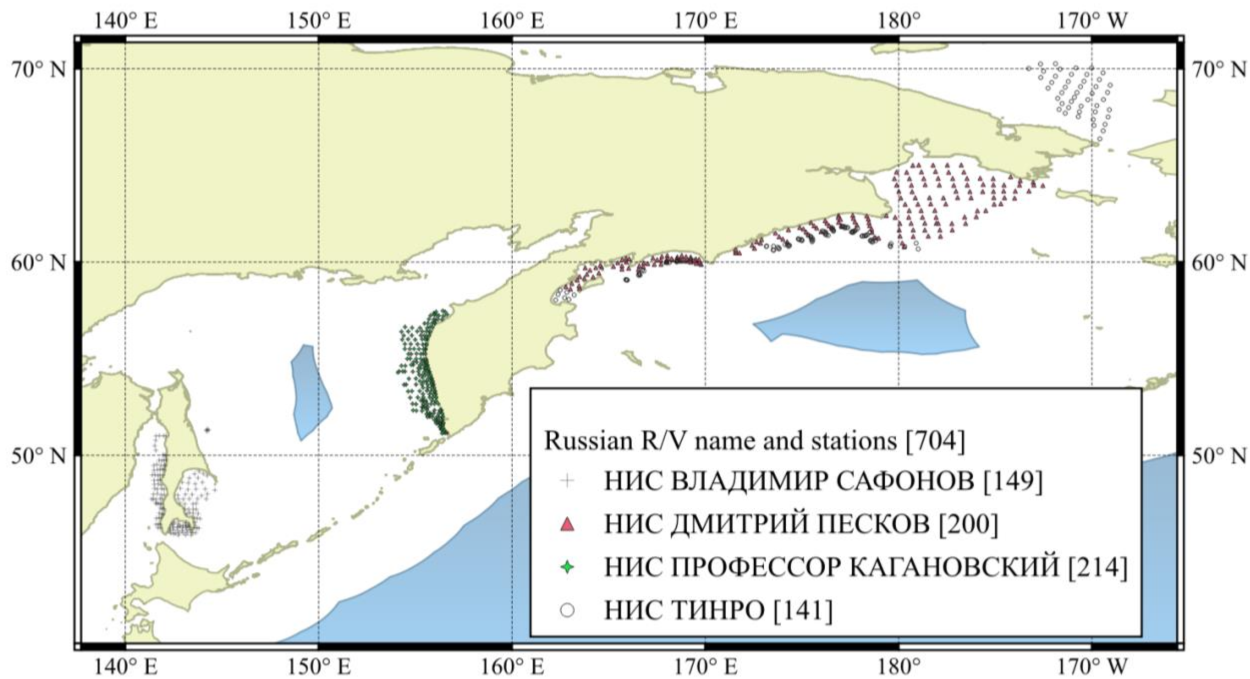

Fig. 2. Bottom trawls conducted by TINRO R/Vs in 2024

2 Peter the Great Bay shelf monitoring

V.I. Il'ichev Pacific Oceanological Institute (POI) has been deploying mooring system with CTD logger and current meter at 20 depth to the south of Russkiy Island in the Pater the Great Bay every year in Summer-Fall season since 2008 (Fig. 3). Since 2019 till 2025 it has been deployed for a whole year cycle. Meridianal CTD section from the mooring site down to the slope has been done in the cruises crossing the bay 2-4 times a year.

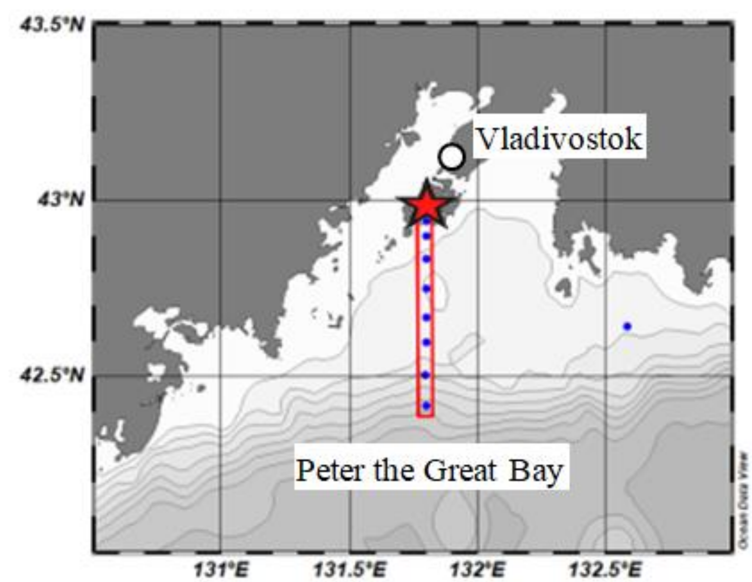

Fig. 3 Location of POI mooring site (star) and cross-shelf CTD section (dotted line) in the Peter the Great Bay

Main processes controlling water dynamics in the Peter the Great Bay are slow upwelling in summer associated with summer monsoon (dominant southern winds), Razdolnaya River run off and Vladivostok city impact. Formation of hypoxia is very frequent in the bay recent years. Only outer part of the bays is ventilated by mesoscale eddies formed along Primorye Current. During transition period between summer and winter monsoon western and northwestern winds are dominant. This cause strong upwelling along the shelf and advection of open sea water across the shelf of the bay ventilating its northern area and removing hypoxic water. During winter season a strong cooling and ice formation results in thermohaline convective mixing of the bay water and generation of extremely dense water on the shelf which cascades down the slope ventilating deep and bottom layers of the sea. The goal of this monitoring project is to look at seasonal variations of water mass structure and dynamics, to fix extreme parameters and understand mechanisms of inter-annual changes.

3 NEAR-GOOS Climate Monitoring Section

This project has been started by POI jointly with Japan Meteorological Agency (JMA) as a pilot project of the North-East Asian Regional Global Ocean Observing System (NEAR-GOOS) in 2011. Since then every year (usually in October-November period) two vessels of each partner implement observations along the section crossing the sea, each partner in its country waters and then exchanging the data they obtain information on the whole cross basin section (Fig. 4). This allows to monitor water mass properties and control long-term changes of the sea caused by climate changes and anthropogenic impacts.

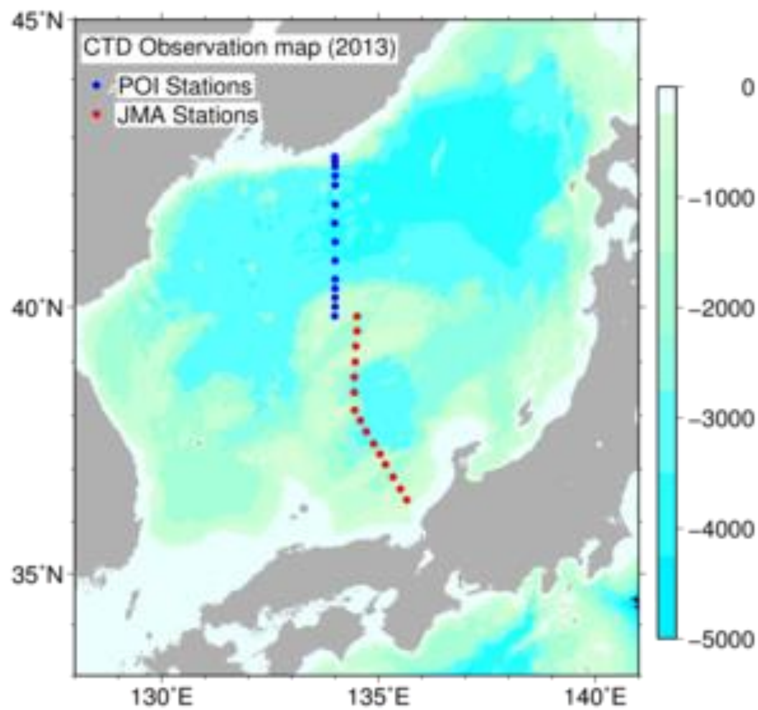

Fig. 4. Scheme of NEAR-GOOS climate monitoring section

Observed elements include CTD and water sampling down to the bottom. Observed parameters are: Temperature, Salinity, Oxygen, Nitrate, Nitrite, Silicate, pH, Total inorganic carbon, Alkalinity.

Observation have been implemented every year during 2011-2021 and then were temporarily terminated because of logistic problems from Russian side. It is planned to resume monitoring in November 2025. Data are available at https://ds.data.jma.go.jp/gmd/goos/data/rrtdb/cross-section/cross-section.html
Some results obtained during this project are the following:

1. Continuing long-term increasing trend of bottom water temperature *(Lobanov et al., 2022)*
2. Structural changes of DO vertical profile *(Nakano et al., 2019)*
3. Water mass structure of northern cyclonic gyre *(Sergeev et al., 2022)*
4. Marginal benthic fronts *(Sergeev et al., 2024)*
5. Acidification, eutrophication and deoxygenation of the northern part of the sea *(Tishchenko et al., 2021)*
6. Changes in Intermediate Water formation *(Senjyu and Shiota, 2023)*

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), Hiroto Abe (Japan), Kazuaki Tadokoro (Japan), Minoru Kitamura (Japan), Jack Barth (USA), Clare Ostle (CPR), Hak Ryul You (Korea), Vyacheslav B. Lobanov (Russia), Vladimir V. Kulik (Russia) **[online members]** Ji-Seok Hong (Korea)

AGENDA ITEM 8: UPDATES/RECAP FROM THE PREVIOUS MEETING

The Chair reviewed the previous meeting.

AGENDA ITEM 9: UPDATES FROM EXPERT GROUPS

1. Activities of North Pacific CPR: Clare Ostle

This year marks the 26th consecutive year of data collection, the figure below (figure 1) shows the sample coverage:

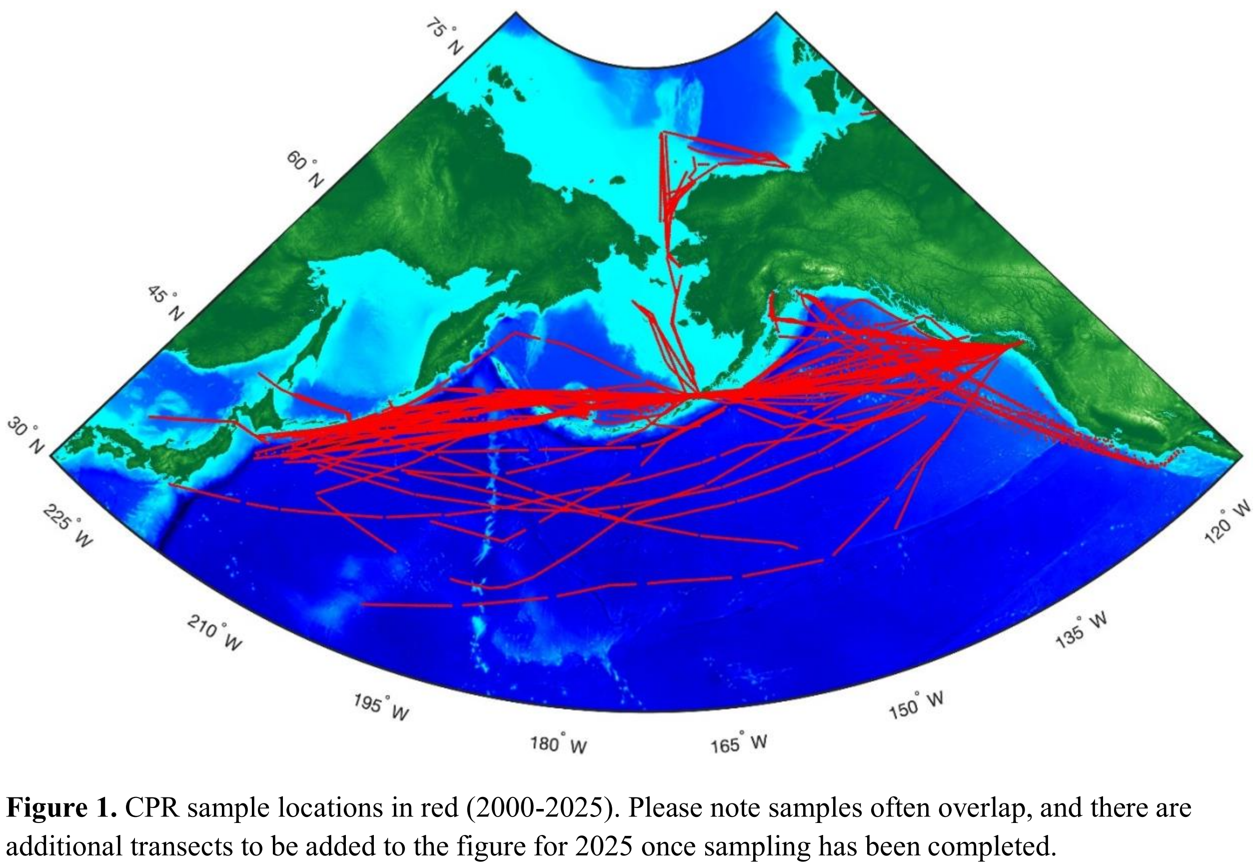

Figure 1. CPR sample locations in red (2000-2025). Please note samples often overlap, and there are additional transects to be added to the figure for 2025 once sampling has been completed.

Funding remains consistent (though with some delays) with support from the USA (NPRB, EVOS TC), Canada (DFO) and in-kind support from Japan (University of Hokkaido). The delays in funding has proved difficult, as we have several small local suppliers that we must pay to have the CPR offloaded from the volunteer vessels, serviced, and get the samples back for analysis. We do not want to damage these relationships which are crucial to ongoing success. The CPR survey runs as economically efficiently as we can, and we are able to cushion some delays in funding, but we are reliant on funds coming through within a reasonable timeframe to keep things running smoothly.

Two new NPRB research projects started in January 2024 (funded 2024-2027). One of these projects, entitled "Extending the North Pacific Continuous Plankton Recorder survey into the Western Arctic Ocean, PI C. Ostle", has led to a paper that is currently in preparation describing large blooms of *Alexandrium spp.* in the Bering Sea and Arctic Ocean. We have developed molecular procedures to confirm the species ID from CPR samples, using genetic techniques and have confirmed the species is *Alexandrium catenella*, which is a potentially toxic dinoflagellate that can cause paralytic shellfish poisoning. The other project is entitled "Through the Looking Glass: Zooplankton and seabird community structure in a changing North Pacific, PI B. Hoover", in which we are collaborating with colleagues at the Farallon Institute (CA, USA) to investigate microplastics and seabirds in the Gulf of Alaska. This revisits the earlier project which ran from 2002-2006 and that collected seabird observations from CPR transects.

The CPR survey sampled the east-west transect in March to September, and the north-south transect, monthly, from March to September in 2025. The Arctic Ocean CPR survey sampled in July and October of 2025. Identification and counting of plankton samples is ongoing. We continue to deploy next generation PlankTag sensors that measure temperature, salinity, and fluorescence on the CPRs on both the east-west and north-south routes.

Monthly abundances from the North Pacific CPR Survey for selected plankton can be generated for user-specified regions using this extraction tool:
https://www.dassh.ac.uk/lifeforms/

Recent publications, reports and articles:

Boldt, J. L., E. Joyce, S. Tucker, and S. Gauthier, editors. Submitted. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2023. Canadian Technical Report of Fisheries and Aquatic Sciences.

Jones, N. 2024. Researchers parse the future of plankton in an ever-warmer world. Yale Environment 360. PI Dr. Clare Ostle was interviewed for Yale Environment 360, which features areas of this project: https://e360.yale.edu/features/plankton-climate-change.

Kléparski, L., C. Ostle, S. D. Batten, N. Djeghri, C. Hauri, R. Pagès, and S. Strom. (2025) Limnology and Oceanography. How marine heatwaves are reshaping phytoplankton in the Northeast Pacific.

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. https://doi.org/10.1016/j.scitotenv.2022.161222

Ostle C, P. Hélaouët. 2023. The Continuous Plankton Recorder as a platform for sensor development PICES Press 31 (2), 64-65.

Ostle, C., and Batten, S. 2024. Continuous Plankton Recorder Data from the Northeast Pacific, 2002-2023. Pages 77-79 in Ferris, B. E., editor, Ecosystem Status Report 2024: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, Anchorage, Alaska. https://www.fisheries.noaa.gov/resource/data/ecosystem-status-report-2023-gulf-alaska

Nixey, C. 2024. Plankton are much more interesting than you might think. The Economist. PI Dr. Clare Ostle was interviewed for the article, in which many aspects of CPR activities were discussed, including areas of this project. https://www.economist.com/britain/2024/08/08/plankton-are-much-more-interesting-than-you-might-think.

Ostle, C., and Batten, S. (*submitted*) NOAA Ecosystem Status Report 2025: Continuous Plankton Recorder Data from the Aleutian Islands and Southern Bering Sea: Lower Trophic Levels in 2024. https://www.fisheries.noaa.gov/resource/data/ecosystem-status-report-2023-aleutian-islands

Ostle, C., and Batten, S. (*submitted*) NOAA Highlight Report 2025: Continuous Plankton Recorder Data from the Eastern Bering Sea: Lower Trophic Levels in 2024. https://www.fisheries.noaa.gov/resource/data/ecosystem-status-report-2023-eastern-bering-sea

Ostle, C., and Batten, S. (*submitted*) NOAA Ecosystem Status Report 2025: Continuous Plankton Recorder Data from the Gulf of Alaska: Lower Trophic Levels in 2024. https://www.fisheries.noaa.gov/resource/data/ecosystem-status-report-2023-gulf-alaska

Powell, K., and C. Ostle. 2023. Where I work. Nature 613:406. https://doi.org/10.1038/d41586-023-00024-1

Ratnarajah, L., R. Abu-Alhaija, A. Atkinson, S. Batten, N. J. Bax, K. S. Bernard, G. Canonico, A. Cornils, J. D. Everett, M. Grigoratou, N. H. A. Ishak, D. Johns, F. Lombard, E. Muxagata, C. Ostle, S. Pitois, A. J. Richardson, K. Schmidt, L. Stemmann, K. M. Swadling, G. Yang, and L. Yebra. 2023. Monitoring and modelling marine zooplankton in a changing climate. Nature Communications 14. Springer US. https://doi.org/10.1038/s41467-023-36241-5

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. https://doi.org/10.1016/j.pocean.2023.103082

2. Activities of FUTURE: Jennifer Boldt

On the Development of a Transdisciplinary International Science Program to Advance Ocean Sustainability: the PICES FUTURE Program

- Objective: Evaluate the success of FUTURE in addressing the Science Plan; has the program evolved to meet changes and needs? Identify gaps in scientific advancement; Determine cause of gaps; Provide lessons learned for large-scale science programs
- Lead Author: Shion TAKEMURA / Mitsutaku MAKINO
- Other Authors: FUTURE SSC members
- Target Journal: *ICES Journal of Marine Science*
- PUBLISHED!

https://academic.oup.com/icesjms/article/82/9/fsaf145/8248246

3. Activities of AP-CREAMS: Vyacheslav B. Lobanov

1. AP-CREAMS tasks and their implementation

The AP-CREAMS (Advisory Panel on Circulation Research in the East Asian Marginal Seas) was established in October 2005 with the following tasks:

1. To initiate and coordinate studies on hydrography, circulation, and biology, as well as on variability of oceanographic and biological properties in the PICES area of the East Asian Marginal Seas;
2. To estimate climate-scale and long-term changes in abiotic and biotic environments of this region;
3. To facilitate the establishment of permanent observation and data exchange networks in this region;
4. To convene workshops/sessions to evaluate and compare the results of national and international research programs.

Primarily the activity of the AP-CREAMS is focused on the Northeast Asian marginal seas, which are sensitive to climate change and anthropogenic impacts, where intensive national activities take place, and where a strong need for international coordination and collaboration to study the variability of hydrodynamics, biogeochemistry, ecosystems, fisheries, and influence of human activities at multiple scales in the area exists.

Research activities among PICES member countries in the region of the Northeast Asian marginal seas have a permanent character and need ongoing coordination, as the interests of different countries tightly overlap. Some ideas on further development of international surveys and observation networks have already been discussed by AP-CREAMS though specific details, such as joint standard sections, format of data exchange, operational information on planned and ongoing cruises, extension of the target area, etc. are not yet developed.

2. Meetings of the AP-CREAMS are organized 2-3 times each year with exchange of results of international and national activities and plans. In 2025 the AP organized 3 business meetings:

i) inter-sessional AP business meeting (online) on April 7, 2025
ii) pre-PICES-2025 AP business meeting (online) on October 3, 2025
iii) PICES-2025 AP business meeting in Yokohama, Japan, on November 9, 2025 (hybrid)

3. Scientific session proposed by AP-CREAMS for PICES-2025 and initially supported by SB had a title "Changing Asian Marginal Seas: from marine science to societal needs, current challenges for integrative science and UN Ocean Decade". However after recommendation of SB to merge 3 session proposals together it was transformed to "Changing ecosystem structure under global climate change: monitoring, detecting, modeling, and socio-ecological impacts" (S2 on Nov 11-12, 2025).

4. Cooperation with other organizations

i) two Co-Chairs of AP-CREAMS (Drs. Lobanov and Nam) were recently selected as Vice Chairpersons of IOC/WESTPAC (2025-2027)

ii) co-chairs of AP-CREAMS (Drs. Zhang and Nam) have been leading IOC/WESTPAC Asian Marginal Seas program as Co-Chairs seeking for synergetic activities;

iii) Northwest Pacific Action Plan (UNEP/NOWPAP) and CEARAC representative Dr. Takafumi Yoshida has been attended AP-CREAMS as an observer to discuss joint activities

iiii) IMBER representatives provide updating information on their activities in Asian Marginal Seas.

5. Publications/Press

PICES Press Winter 2025, Vol. 33, No. 1 – CREAMS 30th Anniversary & CSK-II Joint Workshop

6. Revision of AP-CREAMS AP Terms of References

During recent years, in addition to the primary tasks, AP-CREAMS started activity in new directions, as a contribution to PICES/FUTURE and in response to their request:

i) to pursue an integrative approach, to include multiple disciplines beyond the physics and chemistry to cover the whole social-ecological-environmental-system framework developed by FUTURE,
ii) to extend geographic coverage to include all North-East Asian Marginal Seas beyond the EAST-I and EAST-II regions, and
iii) to prioritize involvement of ECOPs in its activity.

Correspondingly, the AP members drafted new terms of reference, as below (changes are highlighted in italics):

1. To coordinate programs to study marine ecosystems and their variability in the East Asian Marginal seas and their interaction with the western North Pacific in a light of global change;
2. To facilitate the establishment of permanent observation and data exchange networks in this region;
3. To convene workshops/sessions/mentoring and build knowledge networks to advance, evaluate and compare results from the program and its linkages to broader PICES activities;

4. Develop recommendations for PICES to better collaborate within PICES, and with indigenous and international initiatives relevant to the Asian marginal seas;
5. To enhance capacity building, knowledge dissemination, and cooperation with other international marine organizations/programs in the region with relevant expertise (e.g., IOC/WESTPAC, NOWPAP, NEAR-GOOS etc.);
6. To provide more opportunities for ECOPs to join.

7. Justification of the AP-CREAMS focus area

To understand the processes in the Asian Marginal seas and their impact on adjacent areas of the Pacific it is important to consider the wider area, to account for physical-biological connectivity across the western North Pacific and to evaluate potential climate impacts across a broader PICES domain with a focus on its marginal seas. In addition to Northeast Asian marginal seas the proposed extension would cover the Okhotsk Sea, western part of the Northwestern Pacific and western part of the Bering Sea, including regions 16, 17, 18, 22 and narrow northwestern part of region 23 (Fig. 1). This extension is also timely because of increasing human activity along new maritime routes in the Arctic and their gateways which must pass the Northeast Asian marginal seas and currently developing new international research programs like Cooperative Study of Kuroshio-2 (CSK-2) by IOC/WESTPAC, when branches of the Kuroshio impacting marine ecosystems in the broader western Pacific areas including the marginal seas. However, the AP will keep its balance among and primary focus on the initial marginal seas to not dilute the specificity of CREAMS.

The extension will:

1. provide more opportunities for the PICES community to be involved in the AP-CREAMS activity (e.g., bringing more attention to the workshops/sessions/mentorships the AP-CREAMS convenes),
2. enhance capacity of the AP-CREAMS to better coordinate programs to study the marine ecosystem, its variability in the core areas (19, 20, and 21) as well as the influence, exchange and interactions of ecosystem components between the core area and the extended areas. The extension will also facilitate the establishment of permanent observation and data exchange networks in a larger western North Pacific and its marginal seas, and disseminate more knowledge on the extended area.

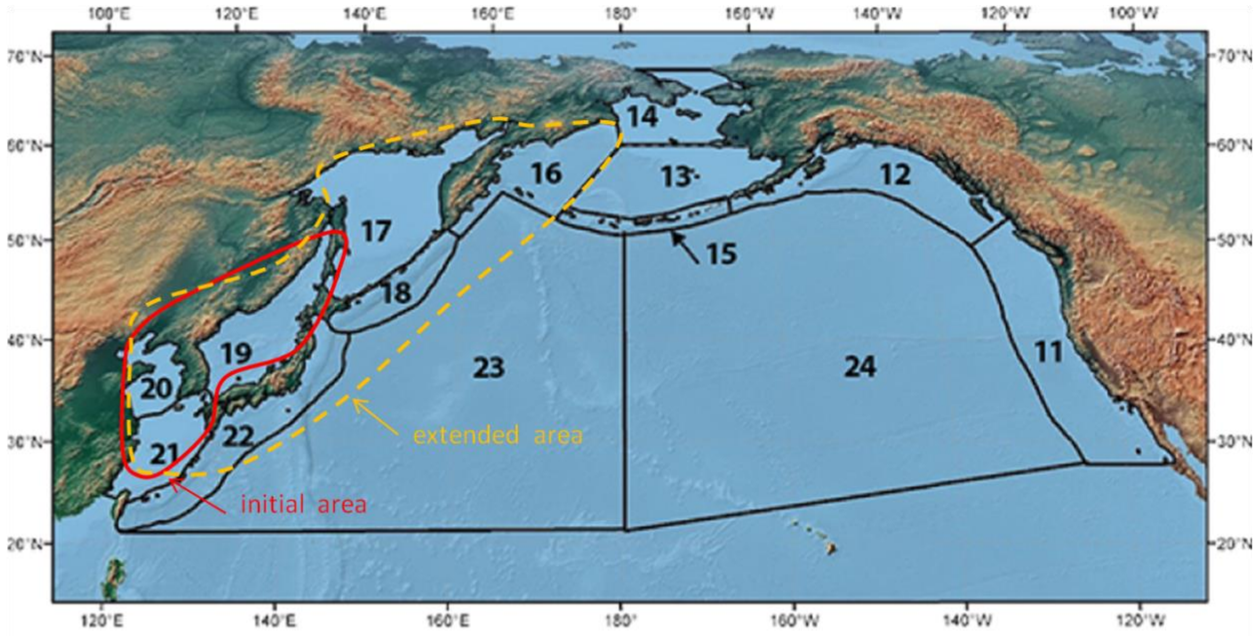

Figure 1. AP-CREAMS initial focus area (red line) and proposals of its extension (yellow dashed line) overlapped on PICES NPESR regions map

Considering the goals of PICES, the extension will:

1. better promote and coordinate marine research in the western North Pacific marginal seas (not limited to the core areas 19-21 but also the extended areas),
2. advance more scientific knowledge about the ocean environment, global weather and climate change, living resources and their ecosystems, and the impact of human activities, focused on the western North Pacific marginal seas, and better promote the collection and rapid exchange of scientific information on more issues

The extension will not overlap in spatial extent with other existing PICES EGs AP-ARC and AP-NPCOOS because of AP-CREAMS will focus on the areas off the coast (not near the coast, thus be separated from focus of AP-NPCOOS) and mid-latitude Asian marginal seas (not Pacific Arctic and its Gateway and thus be separated from focus of AP-ARC).

Below we present a few cases for better understanding that science/knowledge for the core areas of AP-CREAMS (19, 20, and 21) is linked to that for the extended areas (16, 17, 18, and 22).

Case 1. Interannual variability of winter sea levels induced by local wind stress: Interannual variations of sea level averaged over the core area (Areas 19, 20, and 21) are significantly affected by sea surface wind patterns, particularly on the extended area (Area 17). See Figure 2 below originating from Han et al. (2020).

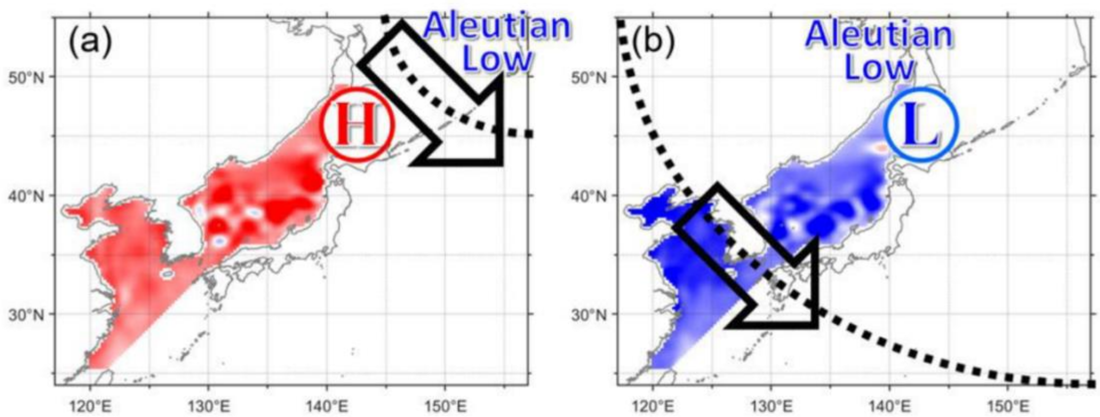

Figure 2. Schematic diagrams accounting for the winter NorthEast Asian Marginal Seas (NEAMS, Areas 19, 20, and 21) mean sea level anomalies. (a) A stronger winter monsoon with northwesterly wind or southeastward wind stress (black arrows) and associated atmospheric pressure gradients (black dotted lines) in the southern Sea of Okhotsk (Area 17); e.g., the northeastward retreat of the Aleutian Low obstructs the outflow transport from the Area 19 into the Pacific by Ekman dynamics to yield a higher (red) NEAMS sea level during Period H (period of positive NEAMS mean sea level anomaly). (b) In contrast, a stronger winter monsoon in the southern Area 19 obstructs the inflow transport from the Pacific to the Area 21 and to the Area 19 to yield a lower (blue) NEAMS sea level during Period L (period of negative NEAMS mean sea level anomaly). Source: Han et al. (2020)

Case 2. Hydrographic structure and material concentrations, and their variability within and beyond the Area 19 linked to processes outside the core area (extended area): Hydrographic structure and material (e.g., ^{134}Cs) concentrations, and their natural and human-induced variations in the core area (Area 19) are significantly affected by those in the extended areas (Areas 17, 18, and 22) as well as the other core areas (Areas 20 and 21) via the current systems shown in Figures 3 and 4 originating from Yasuda (2003) and Inoue et al. (2023).

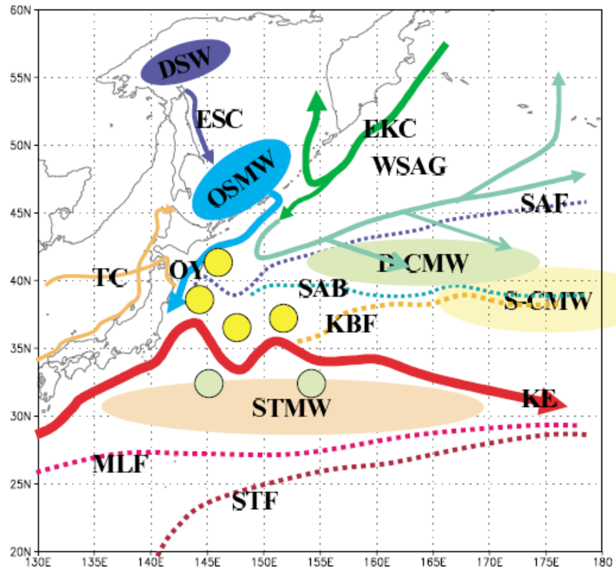

Figure 3. Schematic illustration of the near-surface current, front and water-mass structures in the Kuroshio-Oyashio transition area. EKC: East Kamchatka Current, WSAG: Western Subarctic Gyre, ESC: East Shakalin Current, OY: Oyashio, KE: Kuroshio Extension, TC: Tsushima Warm Current, SAF: Subarctic Front, SAB: Subarctic Boundary, KBF: Kuroshio Bifurcation Front, STF: Subtropical Front, MLF: Mixed Layer Front, STMW: Subtropical Mode Water, S-CMW: Shallow Central Mode Water, D-CMW: Dense Central Mode Water, DSW: Dense Shelf Water, OSMW: Okhotsk Sea Mode Water. The yellow circles denote warm-core rings and light green ones cold-core rings. Source: Yasuda (2003)

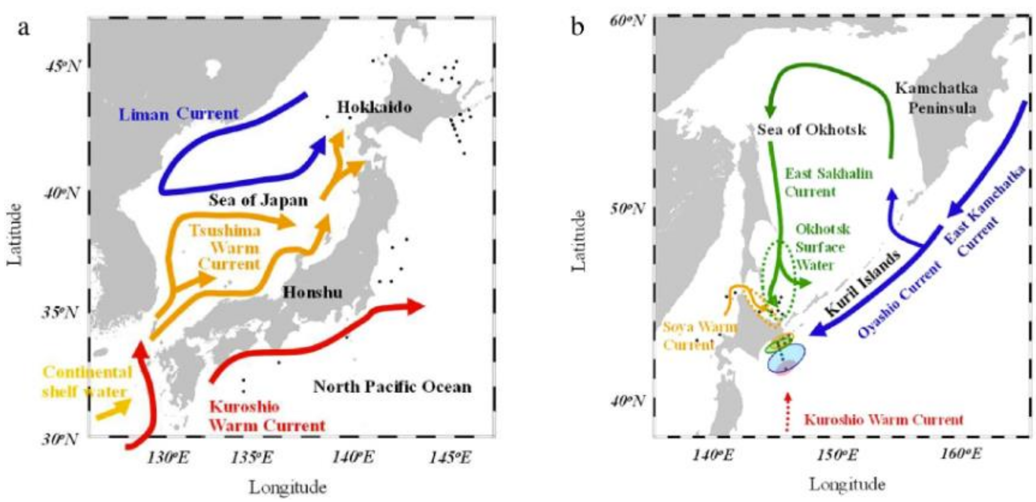

Figure 4. (a) Seawater sampling locations around the Honshu and (b) Hokkaido islands in Japan, along with the major current systems. Source: Inoue et al. (2023)

References

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Inoue, M., Mashita, K., Kameyama, H. et al. Subarctic-scale transport of ^{134}Cs to ocean surface off northeastern Japan in 2020. Sci Rep 13, 7524 (2023). https://doi.org/10.1038/s41598-023-34775-8

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4. Activities of AP-NPCOOS: Jae Hyong Park

Program for W10

"An Examination of Shelf Data Collected by Moorings and Other Fixed Stations in the North Pacific Ocean"

Dates (Tentative): November 9, 2025

Duration: Half day

09:00 — 12:30 : Invited speaker and Group Discussion Session

Agenda for group discussion:

- Updates and overview of available long-term mooring data (10+ years) from each member country
- Preliminary findings on subsurface marine heatwaves (SMHWs) from each country
- Methods for systematic examination of SMHWs in mooring data
- Preparation of a shared document summarizing our process and findings for dissemination to other groups
- Planning for the next year's follow-up workshop

2026 PICES Summer School on "Ocean Biologging": Proposal

Hosted by Hokkaido University Fisheries Sciences, Hakodate, Hokkaido, Japan.

Dates (Tentative): September 14-18, 2026 (Students arrive September 13th)

Potential Funding sources:

- The total estimated summer school cost for 15 students is $18,000.

- Japan Fisheries Research and Education Agency (FRA) and Nagasaki University will support $12,000. We anticipate funding from PICES for the remaining cost ($6,000) and students travel support (for instance, $15,000 in total for 15 students).

Resources Requested from PICES

- PICES support identifying partial funding contributions from international organizations (e.g. ICES, NPRB, SOLAS, SCOR, NOWPAP, IMBER, etc.).
- PICES hosting of web page for summer school information and updates and applications.

PICES staff support for administration of web page and application processing

AGENDA ITEM 10: UPDATES FROM INTERNATIONAL ORGANIZATIONS

1. Activities of the US IOOS/NANOOS/CeNCOOS/SCCOOS: Jack Barth

The U.S. Integrated Ocean Observing System (IOOS) is a national-regional partnership working to provide new tools and forecasts to improve safety, enhance the economy, and protect health. Integrated ocean information is available in near real-time, as well as retrospectively to understand and predict coastal events and conditions IOOS funds coastal observing infrastructure, modeling, products, and connections to users

2. Activities of the NEAR-GOOS: Hak Ryul You

The NEAR-GOOS is a regional pilot project of GOOS from 1996 for a long-term operation, implemented by China, Japan, the Republic of Korea and Russia as one activity of IOC Sub-Commission for the Western Pacific (WESTPAC).

Plans for 2026

- ✓ NEAR-GOOS Annual Meeting: May 2026, Vladivostok (3 days)
- ✓ UN Ocean Decade WG officially launched; global experts begin shaping ToR and actionable plans.
- ✓ Technical/Science Workshop involving government agencies, research institutes, and universities to promote practical technical cooperation.
- ✓ Side workshops to be considered alongside GOOS, IOC, and WESTPAC meetings for continued collaboration and information exchange.

AGENDA ITEM 11: OTHER BUSINESS

1. New Chair Election

    - Dr. Kym Jacboson was elected as the new MONITOR Chair, replacing Dr. Sung Yong Kim

2. New Proposals for PICES-2026 Session/Workshop Selection
    a. Session abstract preparation for the frontier observations, including low-cost instruments and new observations for physics and the ecosystem.

The DAY 2 meeting was adjourned

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.

<u>Judging Guidelines for Oral Presentations</u>

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.

<u>Eligibility</u>

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

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