Supplemental Figures

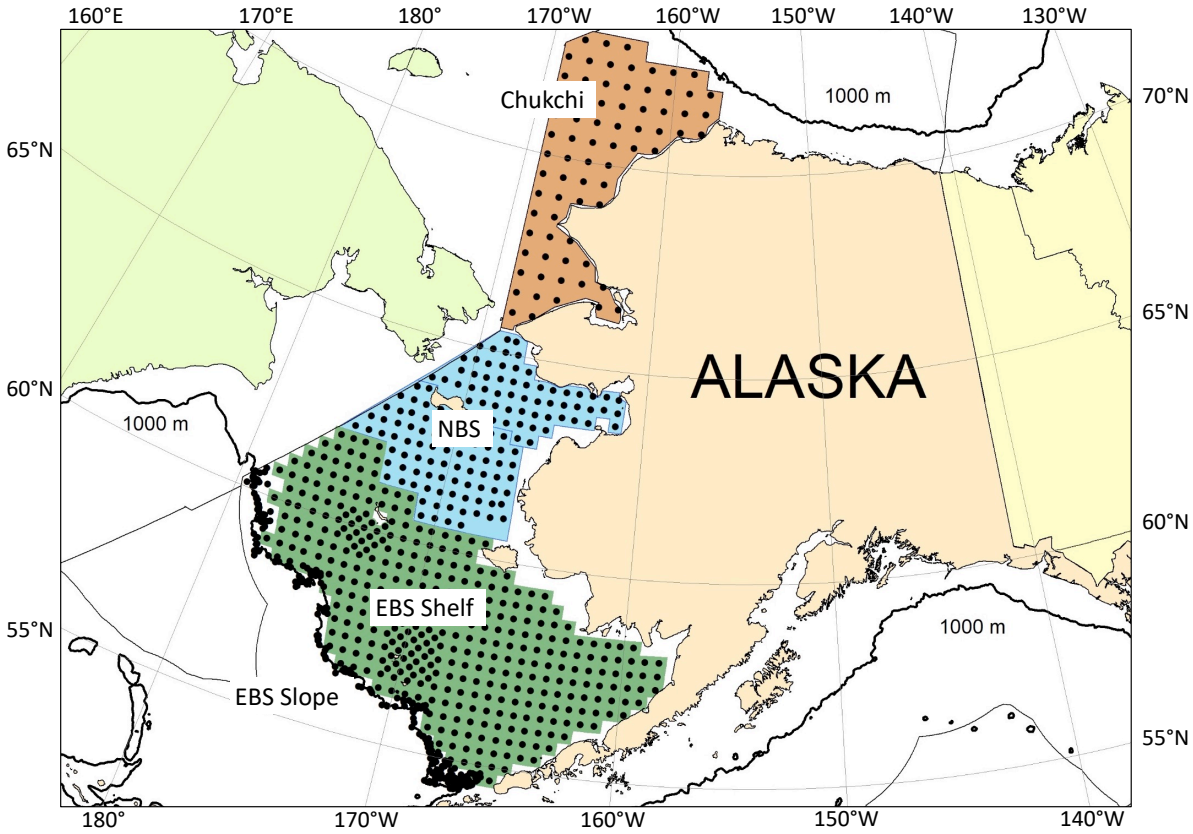

Figure S1. NOAA Alaska Fisheries Science Center (AFSC) bottom trawl survey program. Survey areas and station locations for the Eastern Bering Sea (EBS) shelf, Eastern Bering Sea slope, Northern Bering Sea (NBS), and Chukchi Sea bottom trawl surveys.

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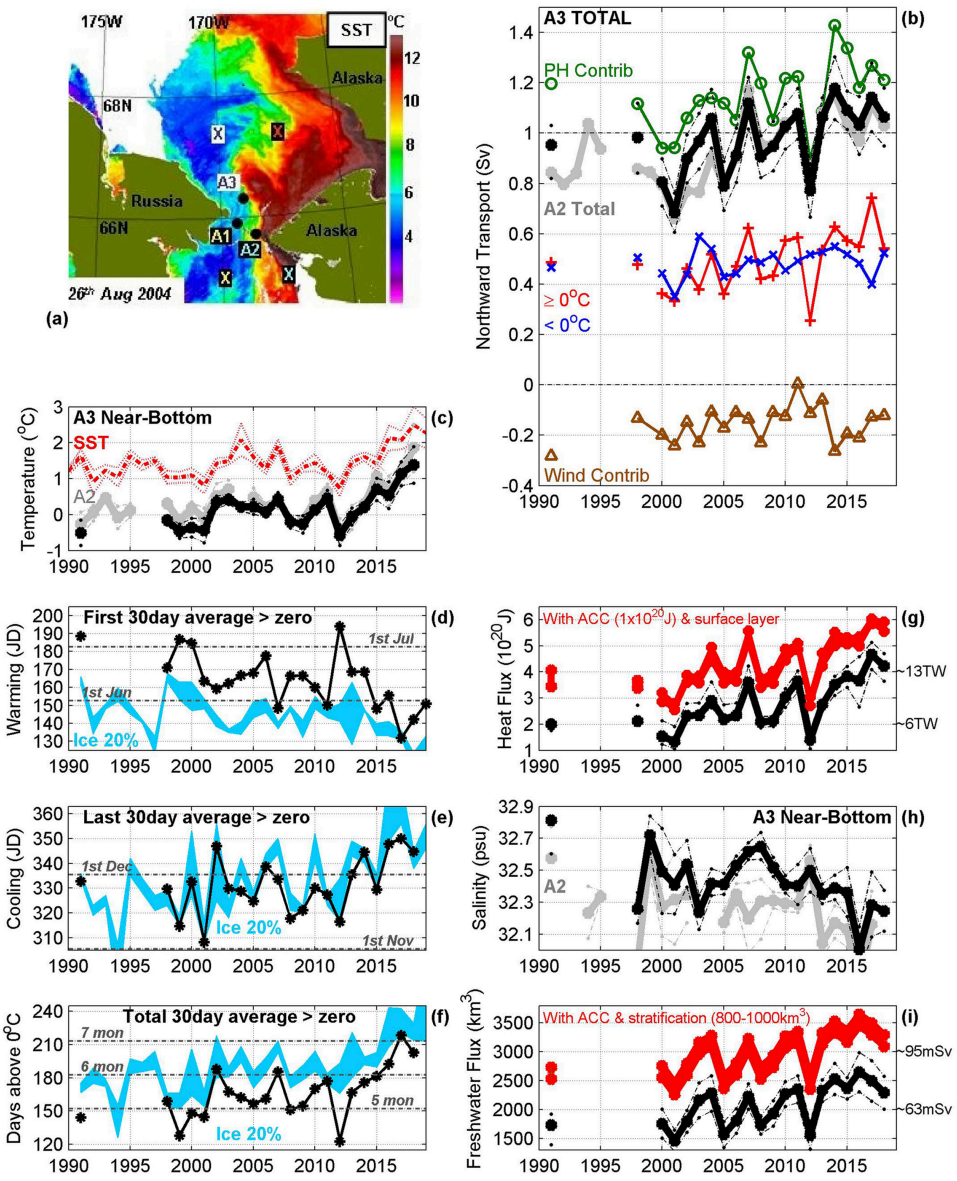

Figure S2. Bering Strait Gateway to the Arctic program. Annual mean Bering Strait properties. (a) Summer satellite (MODIS) sea surface temperature (SST) image of the Bering Strait region showing moorings (black dots) and NOAA National Centers for Environmental Prediction (NCEP) wind points (X). *From Woodgate et al. (2010)* (b) Total northward volume transport estimated from moorings A2 (gray) and A3 with corrections (black, with uncertainty dashed), the latter split into volume colder than (blue crosses) or at/warmer than (red pluses) 0°C, and into the pressure-head (green circles) or local wind-driven (brown triangles) contributions. From A3 (black) and A2 data (gray), annual mean (c) near-bottom temperature with SST (red); (h) salinity; (g,i) heat and freshwater transports respectively, with corrections (red) for the Alaskan Coastal Current (ACC) and surface layer/stratification. From 30-day smoothed A3 data, first (d) and last (e) Julian day (JD) above 0°C and number of days above 0°C (f), showing (blue) when 30-day smoothed satellite Special Sensor Microwave/Imager (SSM/I) ice concentration at A3 first/last falls below 20% (melt-back) (d); rises above 20% (freeze-up) (e), and open water time between these dates (f). *Figures and captions reproduced from Woodgate and Peralta-Ferriz (2021).*

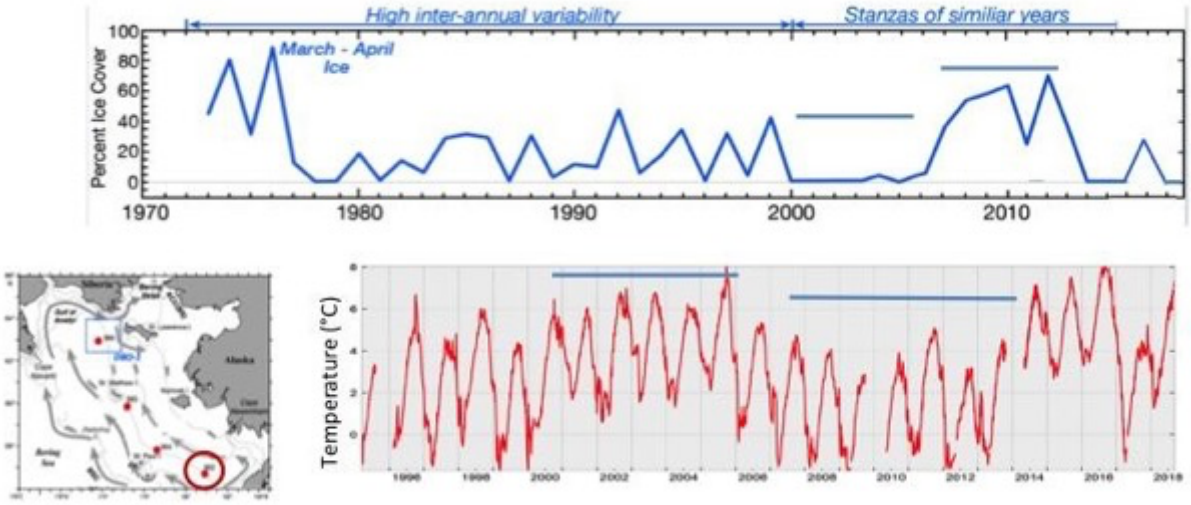

Figure S3. EcoFOCI program. Time series of depth averaged temperature at M2 and its relationship to sea ice in March and April.

Figure S4. JAMSTEC shipboard survey program. Cruise tracks of R/V Mirai between 1998 and 2016 in the Pacific sector of the Arctic Ocean. The ship had cruises in 1998 (trial cruise), 1999, 2000, 2002, 2004, 2006, 2008, 2009, 2010, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020. All data obtained by the cruises are archived in the JAMSTEC DARWIN data site (see Table S1).

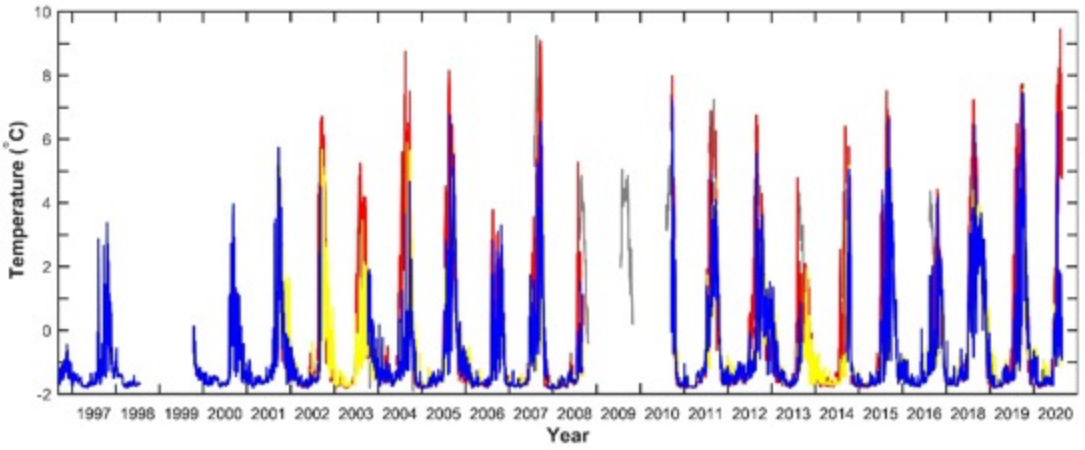

Figure S5. JAMSTEC Barrow Canyon mooring program. Time series of upper ocean temperature (40 m) from the mouth of the Barrow Canyon obtained from JAMSTEC Barrow Canyon moorings. Red, blue, and yellow curves indicate data from stations BCE (Barrow Canyon East), BCC (Barrow Canyon Central), and BCW (Barrow Canyon West), respectively. Gray curves indicate SST data derived from the satellite-borne Advanced Microwave Scanning Radiometer - Earth Observing System sensor (AMSR-E).

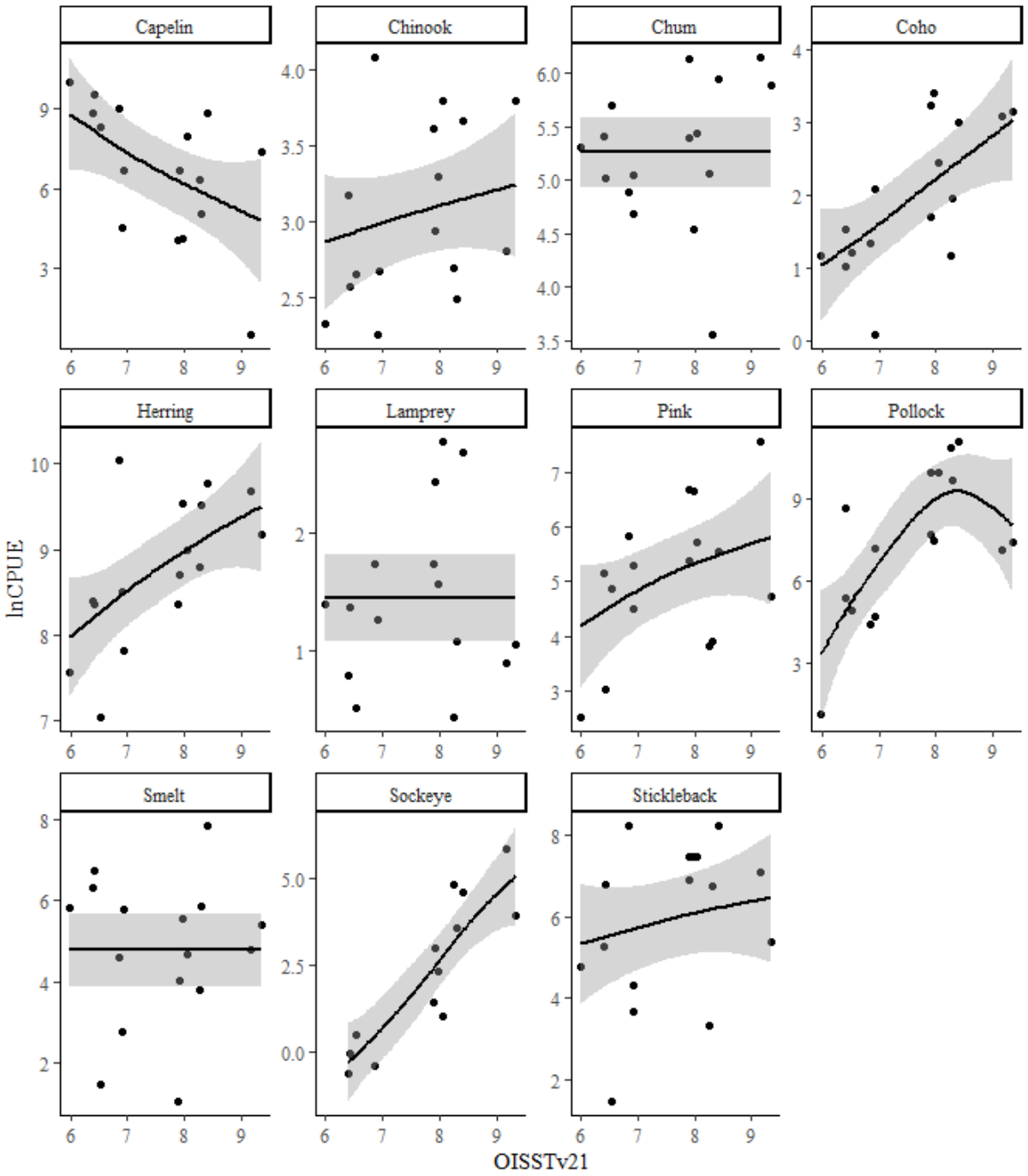

Figure S6. Alaska Fisheries Science Center (AFSC) northern Bering Sea Integrated Ecosystem Assessment Program. General additive model fits (black lines) with 95% confidence intervals (shaded regions) between average summer sea surface temperatures in the northern Bering Sea (OISSTv2.1) and catch rates (lnCPUE) of the primary fish species captured during the northern Bering Sea surface trawl surveys, 2003–2019. *Reprinted from Murphy et al. (2021)*

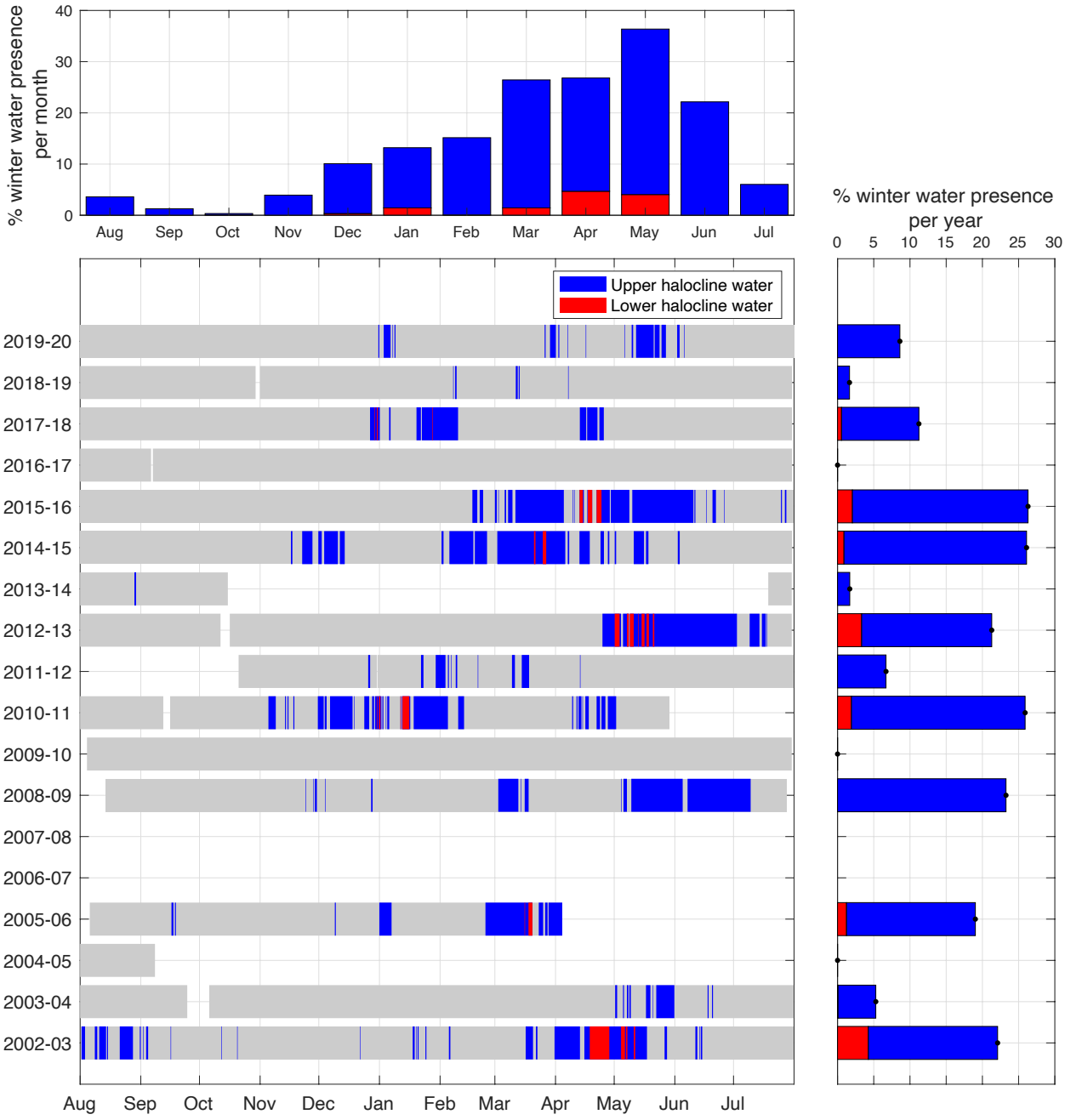

Figure S7. Western Arctic Boundary Current (WABC) program. Presence of Pacific-origin winter water (< –1.6°C) in the WABC. Winter water that will ventilate the upper halocline (salinity <33.5) is marked in blue, and winter water that will ventilate the lower halocline (salinity > 33.5) is marked in red. The presence of the water over the course of each year is indicated, where the grey bar denotes the length of the yearly record. The top row shows the percent presence for each month of the year; the right column shows the percent presence for each year. This shows that the winter water is most prevalent in the spring months. Interannually there is no trend, although there has been a decrease in winter water presence in the WABC during the last three years of the record.

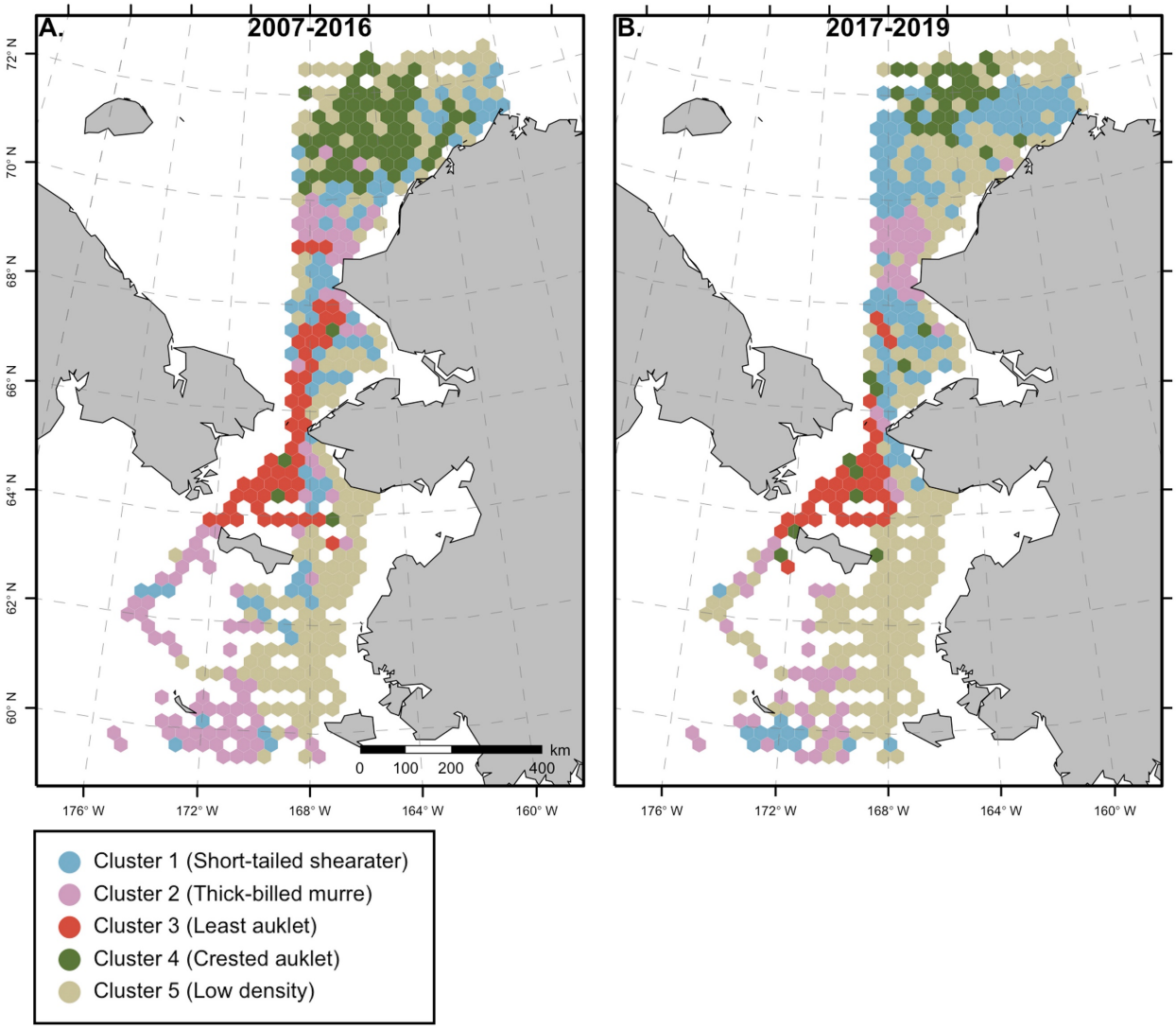

Figure S8. US Fish and Wildlife Service Seabird Survey. Distribution of five identified seabird community types (clusters) during two time periods, based on K-means Cluster Analysis. Colors represent community types referred to by the most abundant species (Clusters 1–4), or by low density and lack of a dominant species (Cluster 5). The figure shows that during the warm years of 2017–2019, seabird communities in the northern Bering and Chukchi Seas shifted in distribution and relative abundance. *From Kuletz et al. (2020)*

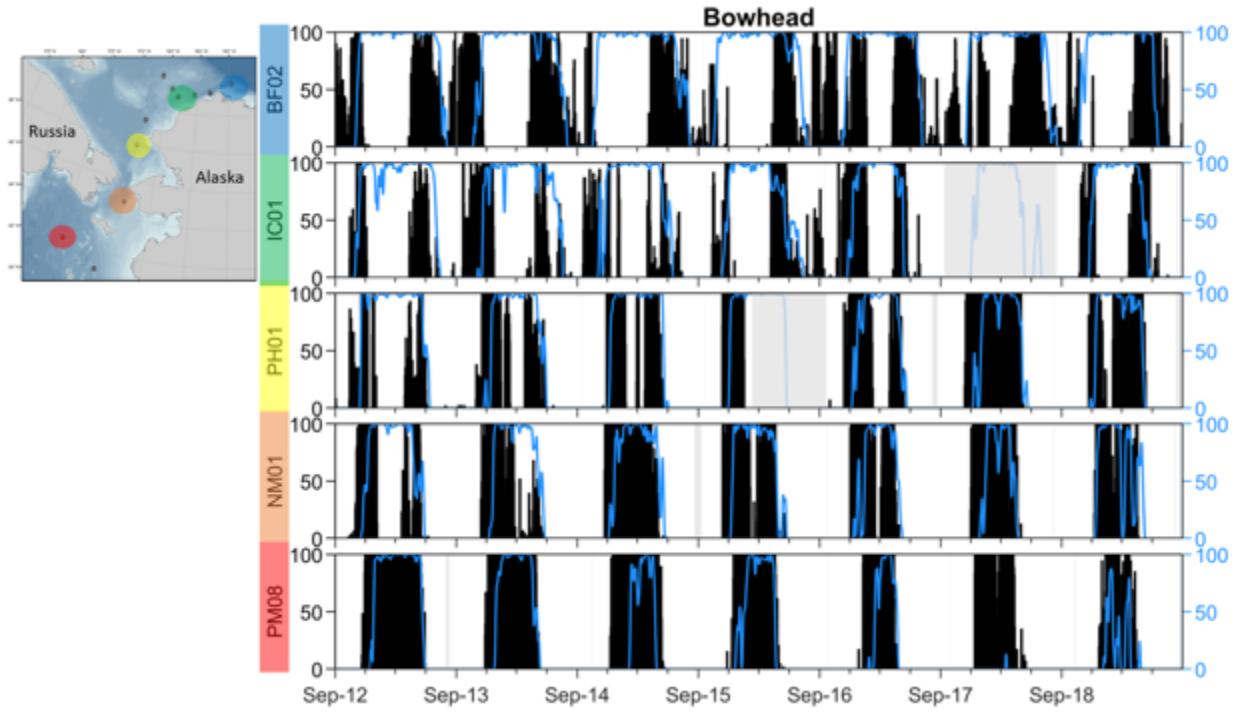

Figure S9. Arctic Long-Term Integrated Mooring Array (ALTIMA) Program. Fractional occurrence of bowhead whale calls as recorded by passive acoustic recorders in the Northern Bering, Chukchi, and Western Beaufort Seas.

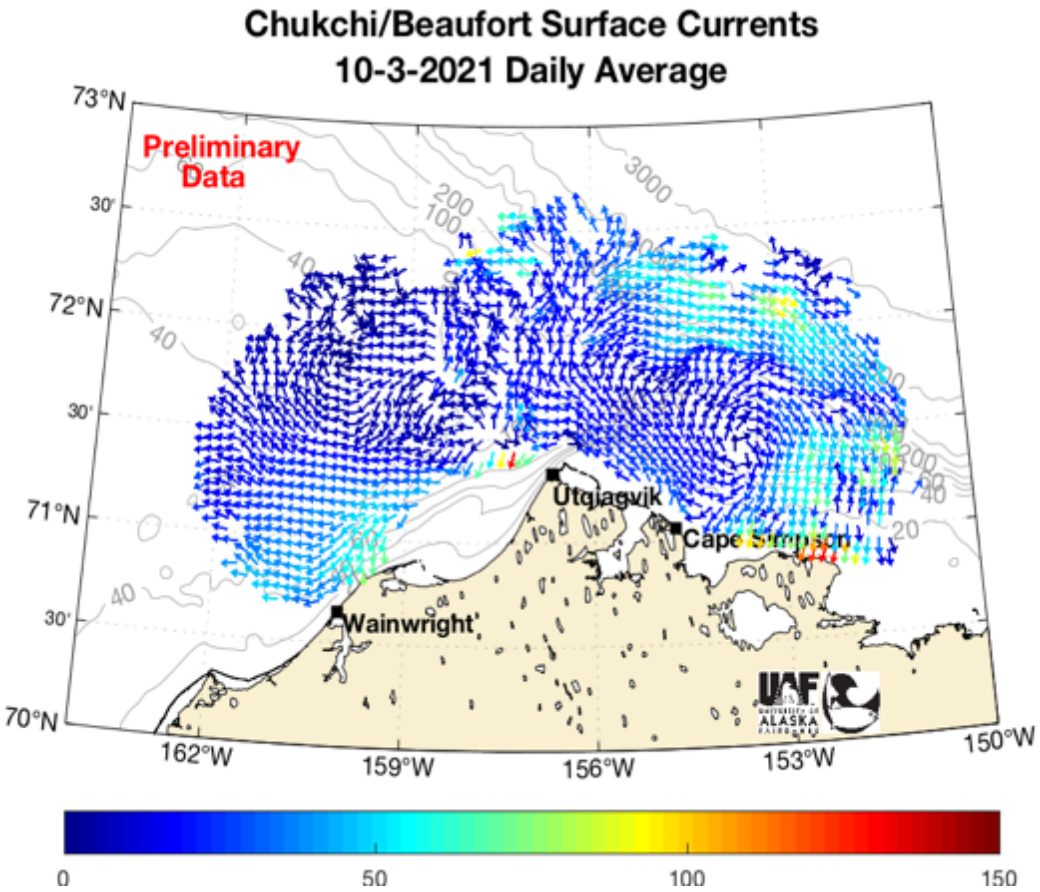

Figure S10. High Frequency Radar (HFR) Program. Example map showing spatial coverage and daily average surface currents from the HFR installation in the Northeast Chukchi and Western Beaufort Seas.

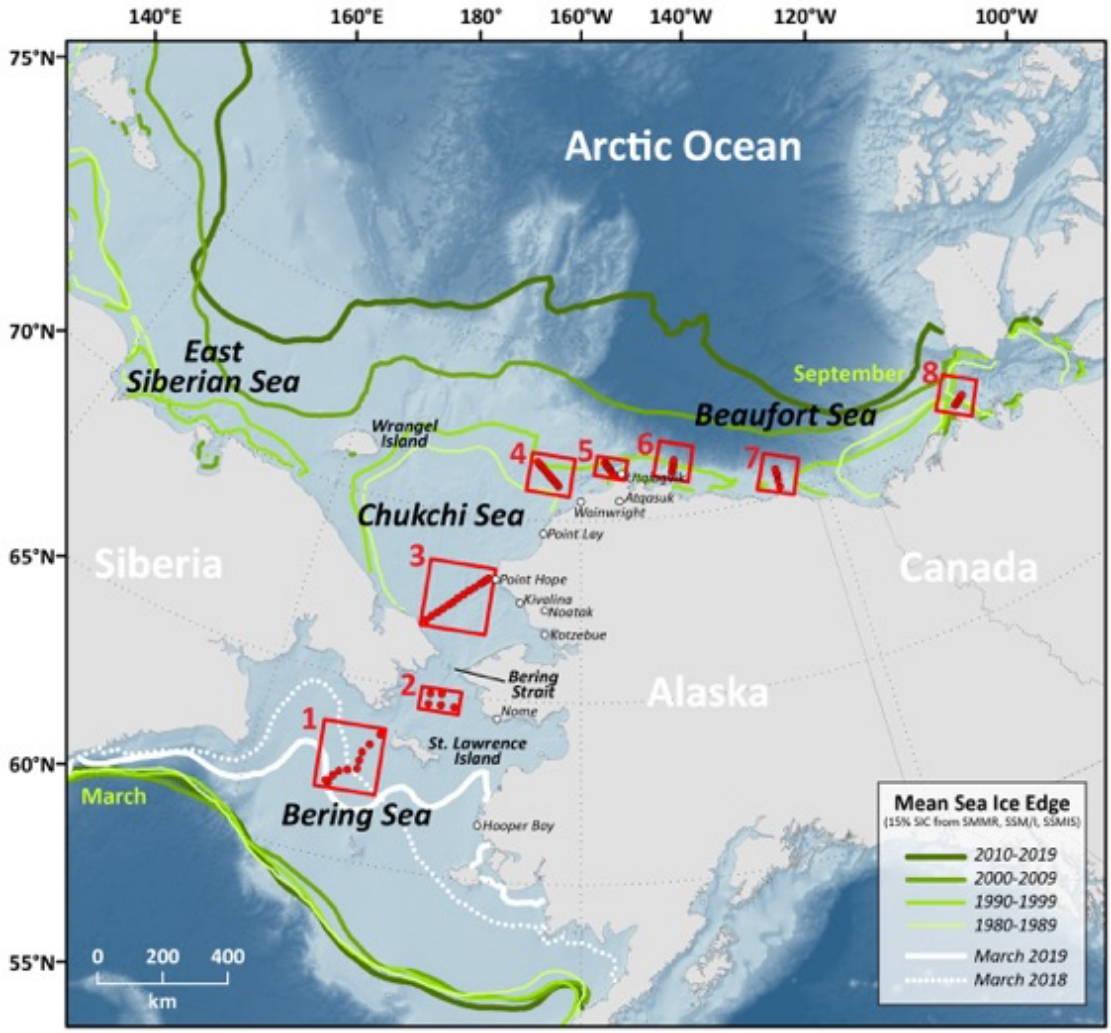

Figure S11. Distributed Biological Observatory (DBO) program. The eight sampling regions of the DBO extending from the northern Bering Sea into the Beaufort Sea in the Pacific Arctic Region that are focused on hotspots of biological productivity and biodiversity. Maximum and minimum median ice extent based on SMMR, SSM/I, and SSMIS satellite-derived sea ice concentrations (1979–2019) are also shown through data processing by Karen Frey, Clark University.

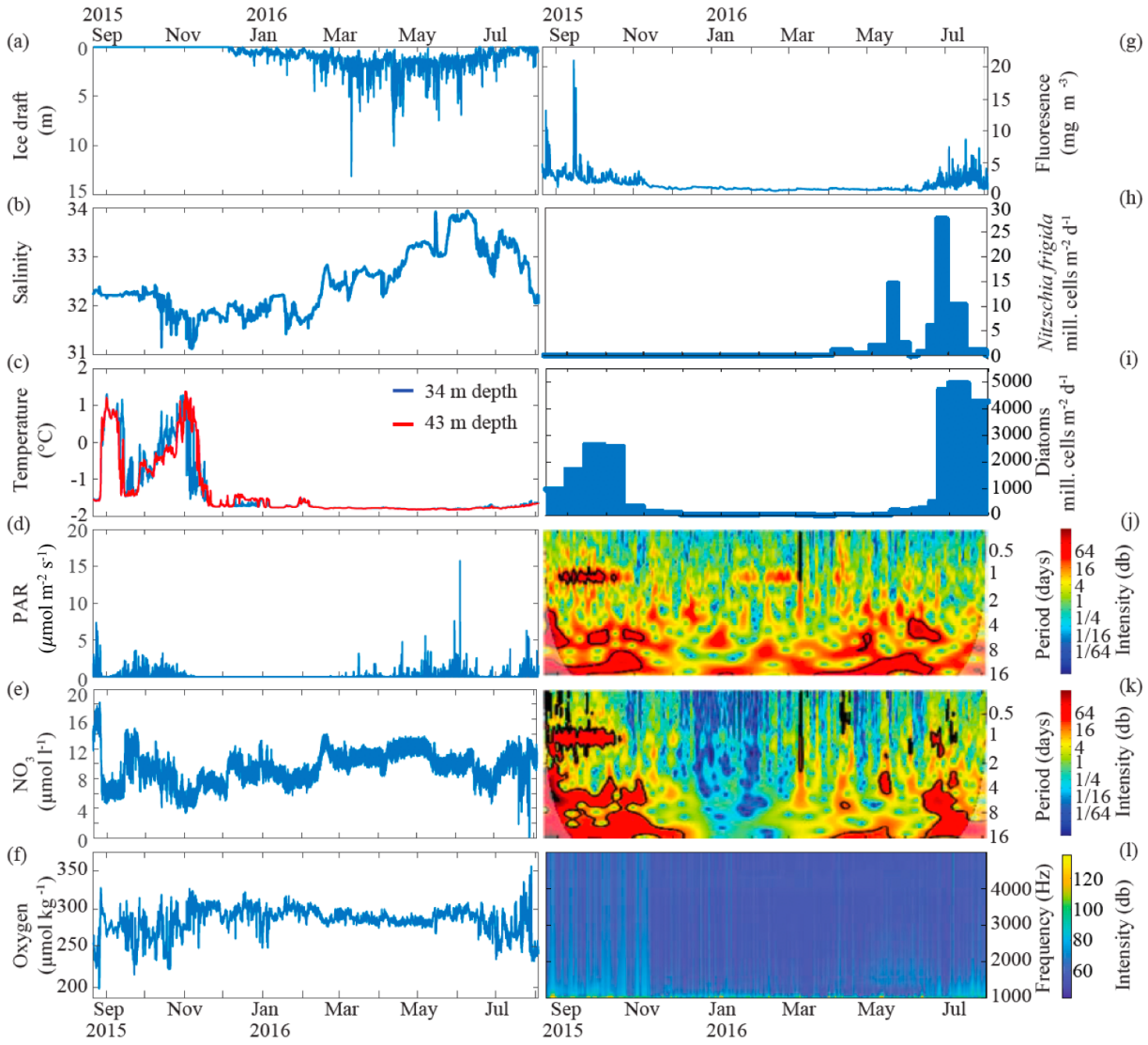

Figure S12. CEO program. "Data from the 2015/16 deployment. Shown are (a) ice draft (m), (b) salinity, (c) temperature (ºC), (d) photosynthetically active radiation (PAR, µE cm-2 s-1), (e) nitrate (NO3, µmolL-1), (f) oxygen (O2, µmol kg-11), (g) fluorescence (mg m-3), Nitzschia frigida flux (million cells m-2 d-1), (i) diatoms (million cells m-2 d-1), (j) acoustic zooplankton fish profiler (AZFP, days) 125 KHz, (k) AZFP 38 KHz (days), and (l) acoustic spectra (Hz). In situ NO3 water samples were collected at times of the CEO deployment and recovery and were analyzed with standard wet chemical determinations of nitrate + nitrite of frozen samples at the Chesapeake Biological Laboratory. Using the calibration samples as anchor points, a drift of 12 µmol l-1 throughout the deployment was found and corrected by linearly detrending the data." *Reproduced from Hauri et al. (2018), with corrected irradiance units.*

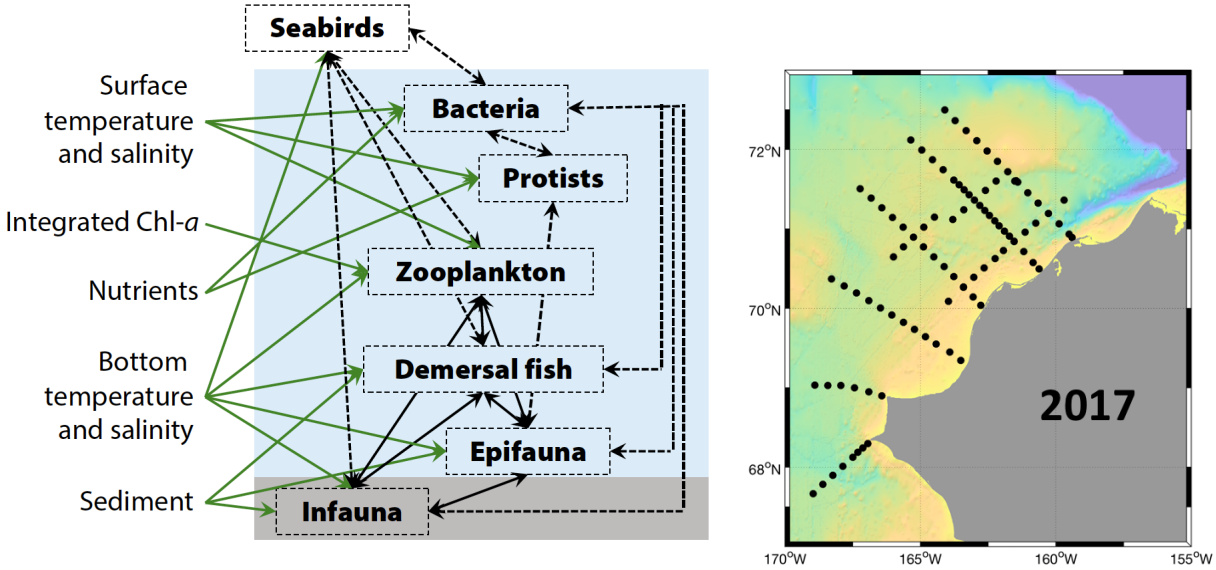

Figure S13. Arctic Marine Biodiversity Observing Network (AMBON) program. Left: Schematic of bottom- up drivers of Chukchi Sea assemblages (green arrows), based on signifi-cant relationships ($p < 0.05$) between environmental vari¬ables and species compo¬sition, and significant multi¬variate correlations among assemblages that were con¬sistent between 2015 and 2017 (black solid lines) or were significant in only one year (dashed lines). Right: Map of the Arctic Marine Biodiversity Observing Network (AMBON) sampling region showing stations sampled in 2017). *Reprinted from Mueter et al. (2021)*

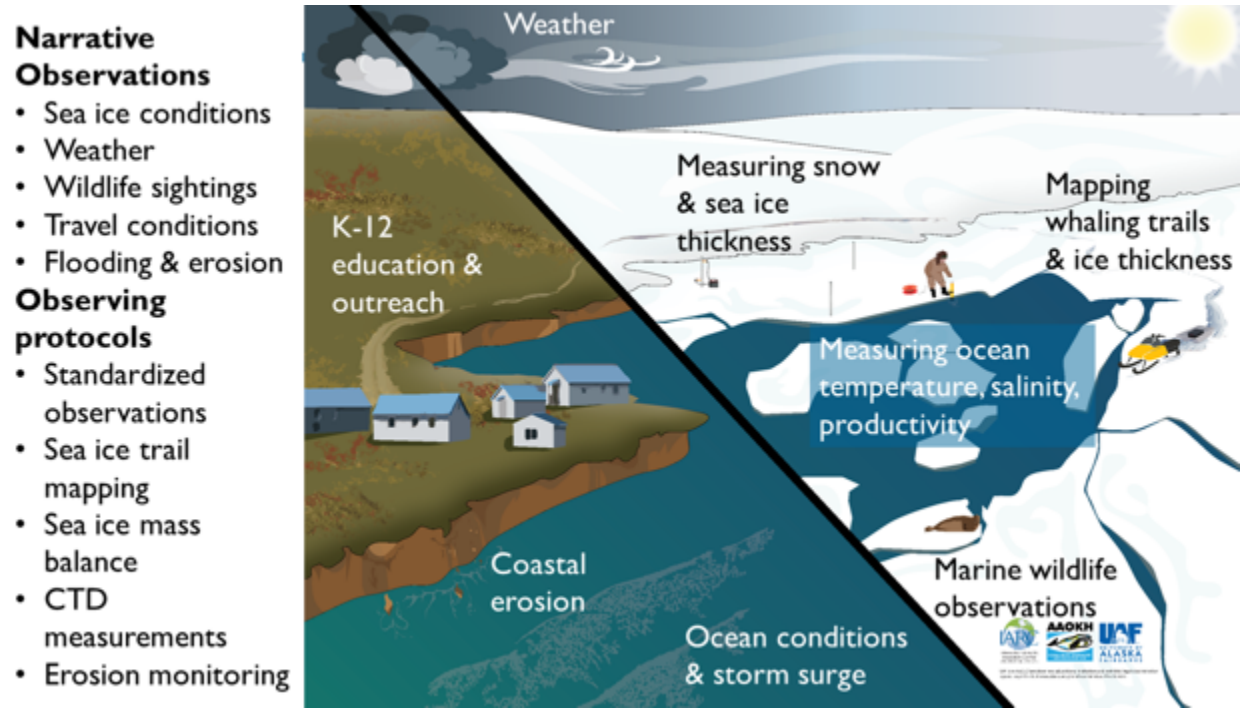

Figure S14. Alaska Arctic Observatory and Knowledge Hub (AAOKH) program. Conceptual model of AAOKH year-round observing activities. AAOKH local observers regularly share information on sea ice and ocean conditions, weather, wildlife, snow machine or boat travel conditions, flooding, and erosion. In addition to descriptive observations, AAOKH observers use standardized protocols in some communities to measure oceanographic or sea ice characteristics. *Graphic prepared with support by Heather McFarland*.

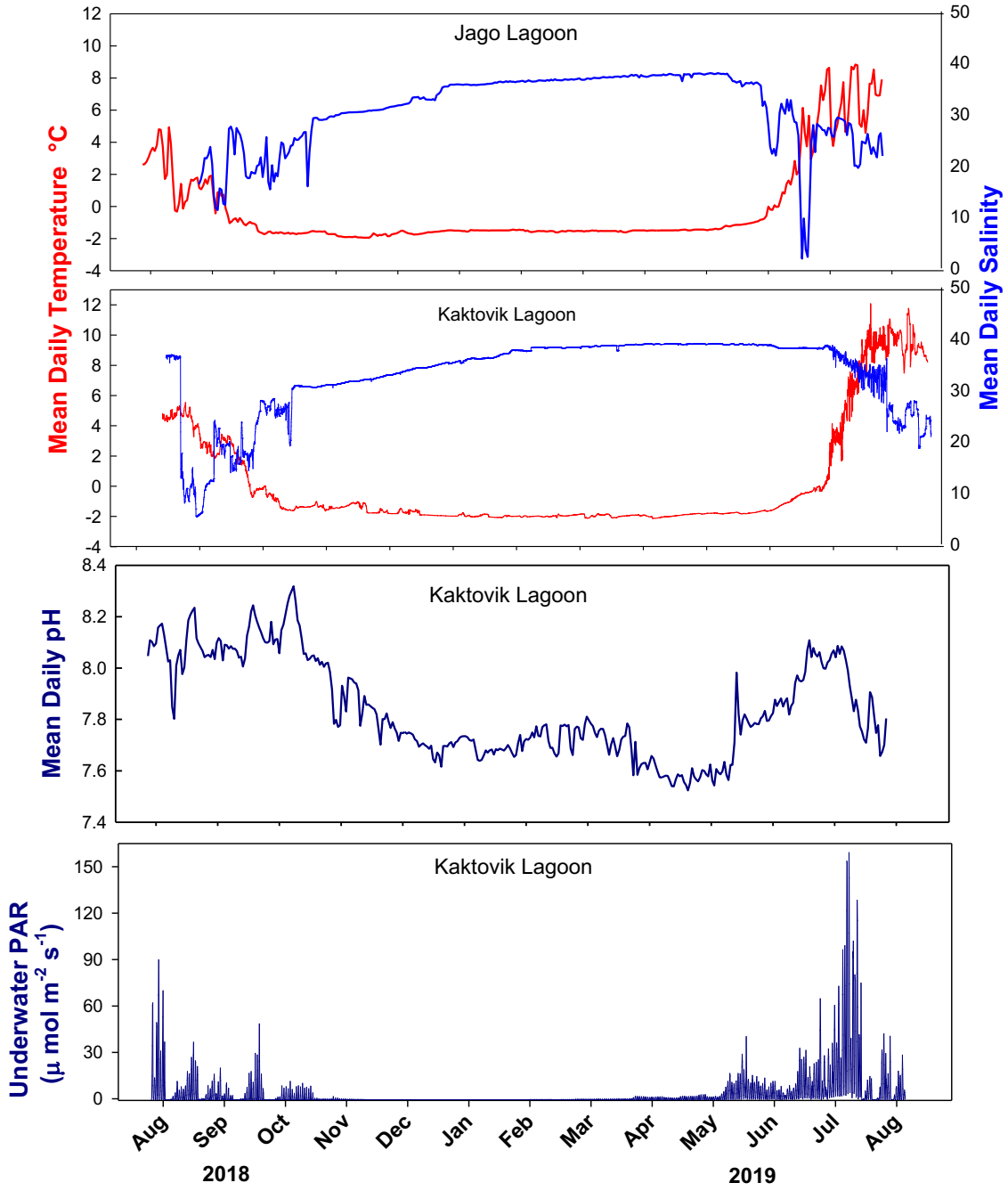

Figure S15. Beaufort Lagoon Observatory (BLO) program. Seasonal variations in water temperature, salinity, pH, and PAR within two adjacent lagoon systems in the eastern Beaufort Sea near Barter Island. The period of total ice cover extends from early November to mid-June. Note positive response of pH during periods of connectivity with terrestrial watersheds and decrease during the period of ice cover in response to heterotrophic processes. Marine benthic fauna experience salinities that approach 0 for a week or more during the spring freshet. Water depth in both lagoons is 3 m.

Supplemental Table

Table S1. Data Archive Locations

Data collections from the programs described herein are available from the following archives.

Program	Data Archives
Alaska Fisheries Science Center (AFSC) Bottom Trawl Surveys	• Haul, catch, length, and age data are stored in the internal AFSC database RACEBASE and available upon request from GAP. • Haul location, CPUE, depth, bottom and surface temperature are published on the NOAA-Fisheries website. • Survey data can also be plotted and visualized on the NOAA AFSC website. • CPUE, biomass, abundance, size, and age data are estimated and provided through the AKFIN database portal. • Pre-2021 CTD data (salinity, temperature, and depth) are hosted by Pacific Marine Environmental Laboratory. 2021 CTD data is currently processed and stored by GAP. • Light data - stored internally in GAP. • Acoustic data stored and maintained by Midwater Assessment and Conservation Engineering (MACE) Program in AFSC. • Special project data: requests are stored in GAP, data available from the project PIs and through the NOAA-Fisheries data portal.
Bering Strait - Pacific Gateway to the Arctic	Quality controlled data, at native collection resolution, are permanently archived at NODC, now NCEI, with metadata at Arcticdata.io and the AOOS data archive. All that information, plus products of annual and monthly values, flux estimates, data plotting and cruise reports, are available via our website.
EcoFOCI: NOAA Ecosystems and Fisheries Oceanography Coordinated Investigations	Depending upon the year and associated projects there are a range of locations for data archives including: NCEI (formerly NODC), PMEL ERDDAP, Arctic Data Center (ADC), UCAR/EOL, BOEM, WHOI GLOBEC Site, AOOS (AXIOM), and the EcoFOCI website.
Native Village of Kotzebue Environmental Program	The Native Village of Kotzebue Tribal Office
R/V *Mirai* Arctic Ocean cruises	*Mirai* cruise data are archived in the JAMSTEC data site (DARWIN)
JAMSTEC Barrow Canyon Mooring Experiment	Mooring data are archived on the JAMSTEC mooring archive
NBS IES: Northern Bering Sea Integrated Ecosystem Survey	Alaska Ocean Observing System - Axiom Research Workspace
Western Arctic Boundary Current Monitoring	Data are archived at the Arctic Data Center
USFWS seabird at-sea surveys	Seabird survey data are archived in the North Pacific Pelagic Seabird Database (NPPSD) hosted by the U.S. Geological Survey: Drew, G.S., Piatt, J.F., 2015, North Pacific Pelagic Seabird Database (NPPSD): U.S. Geological Survey data release (ver. 3.0, February, 2020). These data are also archived under individual

	projects on the Alaska Ocean Observing System (AOOS) Work Spaces and DataOne. BOEM has incorporated the seabird survey data into its regional database for Alaska.
ALTIMA: Arctic Long-Term Integrated Mooring Array	Data will be archived at the National Centers for Environmental Information (NCEI). Currently they are housed at AFSC/MML, with metadata available on the NOAA Fisheries InPort portal
Passive acoustic systems in Bering Strait, Chukchi Sea, and Beaufort Sea	Data are archived at the Arctic Data Center and the Axiom Research Workspace
High Frequency Radar surface current mapping	https://hfrnet-tds.ucsd.edu/thredds/catalog.html and https://dods.ndbc.noaa.gov/thredds/hfradar.html
DBO: Distributed Biological Observatory	Arctic Data Center, National Centers for Environmental Information, DataOne
CEO: Chukchi Ecosystem Observatory	Axiom Research Workspace and Data One
AMBON: Arctic Marine Biodiversity Observing Network	All final AMBON datasets are curated and are publicly available through the MBON data portal
AAOKH: Alaska Arctic Observatory and Knowledge Hub	AAOKH observations have been combined with those from the Seasonal Ice Zone Observing Network and are curated by the Exchange for Local Observations and Knowledge of the Arctic (ELOKA). Observations are available, with conditions, at https://eloka-arctic.org/sizonet/
BLO: Beaufort Lagoon Observatory	Environmental Data Initiative (EDI), Arctic Data Center (ADC), and DataONE network

Supplemental References

The listing below provides key references associated with the monitoring programs described in this paper.

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