Audubon ALASKA

Ecological Atlas of the Bering, Chukchi, and Beaufort Seas, 2nd Edition: Metadata

Chapter 2: Physical Setting

Shortcut to metadata for

Map 2.1 Ocean Currents

MAPPING METHODS (MAP 2.1)

This map shows a generalized representation of typical surface flow patterns across the project area, with deep circulation noted where known. Terrestrial influence on ocean currents is depicted by indicating inputs of fresh water and terrestrial organic matter.

Ocean current data were compiled from several publications including Aksenov et al. (2011), Arctic Monitoring and Assessment Programme (1998), Brugler et al. (2014), Coachman et al. (1975), Grebmeier et al. (2015), Pickart and Corlett (2016), Pisareva et al. (2015), Spall et al. (2008), Stabeno et al. (1999), Takahashi et al. (2011), University of Alaska Fairbanks Institute of Marine Science (2009), Weingartner (2006), Weingartner et al. (2005a), and Weingartner et al. (2005b), as well as based on personal communication with oceanographers Seth Danielson and Phyllis Stabeno.

Locations where upwelling frequently occurs were compiled from Llinas et al. (2009), Pickart et al. (2009), Pickart et al. (2013), Sapozhnikov et al. (2011), and Walkusz et al. (2012).

Because of the importance of terrestrial inputs of fresh water and dissolved and particulate carbon and nitrogen to ocean ecosystems (e.g. Dunton et al. (2012), McClelland et al. (2016)), we have shown annual average discharge of major rivers. These data are based on US Geological Survey streamflow data from gauging stations as close to river mouths as available (US Geological Survey 2016) and annual discharges published in Benke and Cushing (2005). In addition, we have shown interpolated measurements of ^{13}C depletion—an indication of terrestrial versus marine carbon—in sediments across the Beaufort and Chukchi shelves (Dunton et al. 2012). Sediment sampling data from Dunton et al. (2012) were interpolated by Audubon Alaska (2016a) using the inverse distance weighted tool in ArcGIS 10.3 Spatial Analyst with a power of one and nine nearest neighbors.

Data Quality

The generalized approach to displaying ocean current data on this map means that seasonal shifts in the positions of currents, as well as local flow variations, were omitted to preserve clarity at the scale of the entire map. The generalized surface current data are comprehensive across the project area. Deep circulation, however, is less well understood and information on this map is incomplete. Upwelling is shown in areas where it is known to commonly occur; upwelling likely also occurs in areas not depicted on the map. The ^{13}C sediment data cover the Beaufort and Chukchi shelves but were unavailable for other portions of the map.

MAP DATA SOURCES

Ocean Currents: Aksenov et al. (2011); Arctic Monitoring and Assessment Programme (1998); Brugler et al. (2014); Coachman et al. (1975); Grebmeier et al. (2015); P. Stabeno (pers. comm.); Pickart and Corlett (2016); Pisareva et al. (2015); S. Danielson (pers. comm.); Spall et al. (2008); Stabeno et al. (1999); Takahashi et al. (2011); University of Alaska Fairbanks Institute of Marine Science (2009); Weingartner (2006); Weingartner et al. (2005a, b)

Upwelling: Llinas et al. (2009); Pickart et al. (2009, 2013); Sapozhnikov et al. (2011); Walkusz et al. (2012)

^{13}C Depletion in Sediments: Audubon Alaska (2016a) based on Dunton et al. (2012)

Reference list available here.

Map 2.2a Sea Ice Advance

MAPPING METHODS (MAPS 2.2a–2.2.b)

Sea ice data are shown on two seasonal maps, one showing spring and summer sea ice retreat (March–September) and the other showing fall and winter sea ice advance (September–March). Each map shows monthly ice extent lines from two time periods: 2006–2015 and 1981–2010. In addition, historical March and September monthly ice extents from 1850 are shown. Areas where polynyas, recurring leads, or landfast ice occur are also shown.

Approximate median monthly sea-ice extent lines for 2006–2015 were analyzed by Audubon Alaska (2016c) using monthly sea-ice extent data downloaded from the NSIDC (Fetterer et al. 2016). For each month, the downloaded monthly ice-extent line shapefiles were merged across years (2006–2015) and converted to points, generating a point cloud for each month during this time period. Within each monthly point cloud, we found the midpoint of the northernmost and southernmost points along each 1-degree line of longitude across the project area; the midpoints were then connected and the resulting line smoothed.

The 1981–2010 median monthly sea-ice extent lines were downloaded from NSIDC (Fetterer et al. 2016). The southernmost winter ice-extent line was compiled from the Fetterer et al. (2016) 1980–2015 monthly ice-extent medians by Audubon Alaska (2016d). Historical ice extents from March and September 1850 were downloaded from Scenarios Network for Alaska and Arctic Planning (2016).

The polynyas and recurring leads data show the maximum areas in which polynyas and recurring leads are known to occur. The data come from several sources: Audubon Alaska et al. (2017), Carmack and MacDonald (2002), Oceana and Kawerak (2014), Stringer and Groves (1991), and an Audubon Alaska (2009) compilation of data from Eicken et al. (2005).

Landfast ice data were compiled by Audubon Alaska (2016b) based on landfast ice data available from Audubon Alaska et al. (2017), Carmack and MacDonald (2002), Eicken et al. (2009), National Oceanic and Atmospheric Administration (1988), National Snow and Ice Data Center et al. (2006), National Snow and Ice Data Center and Konig Beatty (2012), Oceana and Kawerak (2014), Satterthwaite-Phillips et al. (2016), and Spiridonov et al. (2011).

Data Quality

Sea-ice extent data are of high quality, based on remote sensing images covering the entire project area, at a spatial resolution of 15.5 miles (25 km). The extents encompass the area where the sea-ice concentration is measured at 15% or greater.

The polynya, recurring leads, and landfast ice data are of medium quality, compiled from several sources that have only partial coverage of the map area. Taken together, these data sources have good coverage of the map area with the exception of the Russian portion of the Bering Sea.

MAP DATA SOURCES

Approximate Monthly Sea-Ice Extent (2006–2015): Audubon Alaska (2016c) based on Fetterer et al. (2016)

Median Monthly Sea-Ice Extent (1981–2010): Fetterer et al. (2016)

Southernmost Winter Sea-Ice Extent (1980–2015): Audubon Alaska (2016d) based on Fetterer et al. (2016)

Historic (1850) March and September Ice Extents: Scenarios Network for Alaska and Arctic Planning (2016)

Polynyas and Recurring Leads: Audubon Alaska (2009) based on Eicken et al. (2005); Audubon Alaska et al. (2017); Carmack and MacDonald (2002); Oceana and Kawerak (2014); Stringer and Groves (1991)

Landfast Ice: Audubon Alaska (2016b) based on Carmack and MacDonald (2002), Eicken et al. (2009), National Oceanic and Atmospheric Administration (1988), and National Snow and Ice Data Center et al. (2006); Audubon Alaska et al. (2017); National Snow and Ice Data Center and Konig Beatty (2012); Oceana and Kawerak (2014); Satterthwaite-Phillips et al. (2016); Spiridonov et al. (2011)

Reference list available here.

Map 2.2b Sea Ice Retreat

MAPPING METHODS (MAPS 2.2a–2.2.b)

Sea ice data are shown on two seasonal maps, one showing spring and summer sea ice retreat (March–September) and the other showing fall and winter sea ice advance (September–March). Each map shows monthly ice extent lines from two time periods: 2006–2015 and 1981–2010. In addition, historical March and September monthly ice extents from 1850 are shown. Areas where polynyas, recurring leads, or landfast ice occur are also shown.

Approximate median monthly sea-ice extent lines for 2006–2015 were analyzed by Audubon Alaska (2016c) using monthly sea-ice extent data downloaded from the NSIDC (Fetterer et al. 2016). For each month, the downloaded monthly ice-extent line shapefiles were merged across years (2006–2015) and converted to points, generating a point cloud for each month during this time period. Within each monthly point cloud, we found the midpoint of the northernmost and southernmost points along each 1-degree line of longitude across the project area; the midpoints were then connected and the resulting line smoothed.

The 1981–2010 median monthly sea-ice extent lines were downloaded from NSIDC (Fetterer et al. 2016). The southernmost winter ice-extent line was compiled from the Fetterer et al. (2016) 1980–2015 monthly ice-extent medians by Audubon Alaska (2016d). Historical ice extents from March and September 1850 were downloaded from Scenarios Network for Alaska and Arctic Planning (2016).

The polynyas and recurring leads data show the maximum areas in which polynyas and recurring leads are known to occur. The data come from several sources: Audubon Alaska et al. (2017), Carmack and MacDonald (2002), Oceana and Kawerak (2014), Stringer and Groves (1991), and an Audubon Alaska (2009) compilation of data from Eicken et al. (2005).

Landfast ice data were compiled by Audubon Alaska (2016b) based on landfast ice data available from Audubon Alaska et al. (2017), Carmack and MacDonald (2002), Eicken et al. (2009), National Oceanic and Atmospheric Administration (1988), National Snow and Ice Data Center et al. (2006), National Snow and Ice Data Center and Konig Beatty (2012), Oceana and Kawerak (2014), Satterthwaite-Phillips et al. (2016), and Spiridonov et al. (2011).

Data Quality

Sea-ice extent data are of high quality, based on remote sensing images covering the entire project area, at a spatial resolution of 15.5 miles (25 km). The extents encompass the area where the sea-ice concentration is measured at 15% or greater.

The polynya, recurring leads, and landfast ice data are of medium quality, compiled from several sources that have only partial coverage of the map area. Taken together, these data sources have good coverage of the map area with the exception of the Russian portion of the Bering Sea.

MAP DATA SOURCES

Approximate Monthly Sea-Ice Extent (2006–2015): Audubon Alaska (2016c) based on Fetterer et al. (2016)

Median Monthly Sea-Ice Extent (1981–2010): Fetterer et al. (2016)

Southernmost Winter Sea-Ice Extent (1980–2015): Audubon Alaska (2016d) based on Fetterer et al. (2016)

Historic (1850) March and September Ice Extents: Scenarios Network for Alaska and Arctic Planning (2016)

Polynyas and Recurring Leads: Audubon Alaska (2009) based on Eicken et al. (2005); Audubon Alaska et al. (2017); Carmack and MacDonald (2002); Oceana and Kawerak (2014); Stringer and Groves (1991)

Landfast Ice: Audubon Alaska (2016b) based on Carmack and MacDonald (2002), Eicken et al. (2009), National Oceanic and Atmospheric Administration (1988), and National Snow and Ice Data Center et al. (2006); Audubon Alaska et al. (2017); National Snow and Ice Data Center and Konig Beatty (2012); Oceana and Kawerak (2014); Satterthwaite-Phillips et al. (2016); Spiridonov et al. (2011)

Reference list available here.

Maps 2.3a-p Climate

MAPPING METHODS (MAPS 2.3a–p)

We assessed climate using downscaled, four-dimensional, coupled physical/biological models of ocean variables created by NOAA PMEL (Hermann et al. 2013) available from the Alaska Ocean Observing System (AOOS) Arctic Data Portal. Data were available only for the Bering Sea portion of our project area. These projections were based on ocean climate models that pair a Regional Ocean Modeling System (ROMS) with climate model output extracted for the North Pacific from Coupled Model Intercomparison Project 3 (CMIP3) bias-corrected global climate models (GCMs). The downscaled variables have a spatial resolution of 6x6 miles (10x10 km) and many variables also include projections for multiple depth classes (e.g., density of euphausiids in different sections of the water column). Hermann et al. (2013) describe these downscaled models and compare projections from the Canadian Centre for Climate Modelling and Analysis (CCCma) projection model (2003–2040) to the Coordinated Ocean-Ice Reference Experiments (CORE) hindcast climate model (1965–2009) (Large and Yeager 2008).

We selected seven physical and biological variables. Four of the selected variables were assessed by combining multiple depth classes. We analyzed seawater temperature, large microzooplankton, *Neocalanus* (i.e. large neritic copepods), and euphausiids for shallow waters only (0–200 feet [0–60 m] depth); we also analyzed sea water temperature for deep waters (250–650 feet [75–200 m] depth). The other three variables represented surface (sea-ice area fraction, ice phytoplankton) or bottom (benthic infauna) values.

We used the NetCDF Operator Suite to statistically analyze and summarize the time-series data for each model for each 6x6 mile (10x10 km) raster cell. Using the CORE hindcast model, we analyzed all available time steps (weekly) across the entire model time period to summarize average annual values for each variable. Using the CCCma projection model, we compared the recent time period (26 January 2003 to 30 December 2012) to a future time period (6 January 2030 to 4 December 2039) within the model, summarizing total anticipated change from recent conditions to 2040.

Data Quality

For both hindcast and projection, we used a single GCM and have not expressed uncertainty based on variability among models. Models did not include variables related to fish which is a major limiting factor in understanding coming changes in Bering Sea ecology. For an in-depth discussion of the models and their limitations, see Hermann et al. (2013).

MAP DATA SOURCES

Hindcast and Projection Summaries: Smith and Koeppen (2016) based on Hermann et al. (2013)

Reference list available here.