Audubon ALASKA

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

Chapter 4: Fishes

Shortcut to metadata for

Map 4.1.1 Osmerids

MAPPING METHODS (MAP 4.1.1)

Fishes from the *Osmeridae* family are comprised of capelin, eulachon, rainbow smelt, longfin smelt (*Spirinchus thaleichthys*), night smelt (*S. starksi*), surf smelt (*Hypomesus pretiosus*), and unidentified smelts (*Osmeridae*).

The relative abundance for osmerids was estimated by mapping datasets from bottom-trawl surveys which employed consistent methodologies and sampled waters within the US Exclusive Economic Zone (EEZ) of the EBS (Conner and Lauth 2016, Hoff 2016), Aleutian Islands (Raring et al. 2016), Gulf of Alaska (von Szalay and Raring 2016), Chukchi Sea (Goddard et al. 2014), and Beaufort Sea (Logerwell 2008). Data points for capelin, eulachon, and smelt presence and absence were extracted, and each was mapped separately based on catch-per-unit-effort (CPUE) displaying kilograms per hectare. To delineate concentration areas, data points for each species were then classified into quartiles and general polygons were drawn around the top 25% for each species to obtain areas of higher concentration.

We then compared those trawl-survey catch areas for all three species to bycatch in Gulf of Alaska and Bering Sea groundfish fisheries (Alaska Fisheries Science Center 2016) to either corroborate concentration areas or expand them. Data points for each species were mapped by catch amount (kilograms) and binned using quartiles. General polygons were drawn around the top quartile for each species.

Finally, concentration-area polygons for each species, drawn from trawl-survey data, were then merged to concentration areas drawn from observer data. For capelin, this resulting concentration area was also merged to the known concentration areas in Bristol Bay and the northern part of Norton Sound, observations that were taken from National Oceanic and Atmospheric Administration (1988). We were unable to find other concentration-area data to combine with the resulting trawl-survey and observer data concentrations for eulachon and smelt so those were not expanded.

Smelt and eulachon spawning areas were obtained from the Alaska Department of Fish and Game's Anadromous Waters Catalog (Johnson et al. 2015).

The general distribution polygon for capelin is a broad delineation of this species range and was created by combining digitized distribution data from National Oceanic and Atmospheric Administration (1988) and Thorsteinson and Love (2016).

Spawning areas for capelin were interpreted from maps from Brown (2002) showing general, historical spawning areas as large circles extending offshore. To narrow their scope, those very general areas were mapped and then clipped to within 2 miles (3 km) of shore since capelin are known to move inshore to spawn in shallow areas on coarse sand and/or gravel beaches. We then merged those areas to spawning locations obtained from National Oceanic and Atmospheric Administration (1988).

The sea-ice data shown on this map approximate median monthly sea-ice extent. The monthly sea-ice lines are based on an Audubon Alaska (2016) analysis of 2006–2015 monthly sea-ice extent data from the National Snow and Ice Data Center (Fetterer et al. 2016). See Sea Ice Mapping Methods section for details.

Data Quality

Trawl-survey data sampling was conducted within the US EEZ, therefore there is little to no coverage on the Russian side of the Bering Sea. The interpolation of the trawl-survey data estimates the distribution of osmerids during the summer months and may not represent the year-round distribution.

Bottom-trawl surveys in the Aleutian Islands were conducted every three years between 1983–2000 and then on even years between 2002–2016. Surveys on the Bering Sea slope were conducted on even years between 2002–2016 except for 2006 and 2014. Surveys of the EBS shelf were conducted from 1982–2016. Surveys of the northern

Bering Sea occurred between 1982–2010. Gulf of Alaska surveys were conducted in 1984 and 1987; every 3 years over 1990–1999, and then on odd years from 2001–2015. Bottom-trawl surveys in the Beaufort and Chukchi Seas occurred in 2008 and 2012, respectively. Data for the Beaufort and Chukchi Seas do not represent multi-year surveys or long-term trends like data for the Bering Sea.

MAP DATA SOURCES

Relative Abundance (Concentration): Oceana (2017c) based on Alaska Fisheries Science Center (2016), Conner and Lauth (2016), Hoff (2016), Goddard et al. (2014), Logerwell (2008), National Oceanic and Atmospheric Administration (1988), Raring et al. (2016), and von Szalay and Raring (2016)

Capelin Distribution: National Oceanic and Atmospheric Administration (1988); Thorsteinson and Love (2016)

Smelt and Eulachon Spawning: Johnson et al. (2015)

Capelin Spawning: Brown (2002); National Oceanic and Atmospheric Administration (1988)

Sea Ice: Audubon Alaska (2016) based on Fetterer et al. (2016)

Reference list available here.

Map 4.1.2 Pacific Herring

MAPPING METHODS (MAP 4.1.2)

The general adult distribution area for Pacific herring is a compilation of previous data from National Oceanic and Atmospheric Administration (1988) and updated with new distribution data from Thorsteinson and Love (2016). The juvenile distribution area was obtained from National Oceanic and Atmospheric Administration (1988) but we were unable to update juvenile-specific distribution areas with new information.

Major wintering grounds and pre- and post-spawning migration patterns in the Bering Sea and Bristol Bay were digitized from maps in Tojo et al. (2007).

Spawning areas include digitized data from Tojo et al. (2007), which documents historical spawning locations. Those areas were combined with spawning areas directly obtained from the Alaska Department of Fish and Game Most Environmentally Sensitive Areas (MESA) Project (Alaska Department of Fish and Game Habitat and Restoration Division 2001), which documents the most sensitive areas for a suite of marine species.

Herring Savings Areas were digitized from the most recent Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area (North Pacific Fishery Management Council 2016a). Herring Savings Areas are management areas that may be closed for certain time periods to commercial trawling if bycatch of Pacific herring exceeds 1% of the total biomass. These areas overlap important migration and overwintering areas and have been in place to reduce Pacific herring bycatch since 1991.

Data Quality

Trawl-survey data sampling was conducted within the US EEZ, therefore there is little to no coverage on the Russian side of the Bering Sea. The interpolation of the trawl-survey data estimates the distribution of osmerids during the summer months and may not represent the year-round distribution.

Bottom-trawl surveys in the Aleutian Islands were conducted every three years between 1983–2000 and then on even years between 2002–2016. Surveys on the Bering Sea slope were conducted on even years between 2002–2016 except for 2006 and 2014. Surveys of the EBS shelf were conducted from 1982–2016. Surveys of the northern

Bering Sea occurred between 1982–2010. Gulf of Alaska surveys were conducted in 1984 and 1987; every 3 years over 1990–1999, and then on odd years from 2001–2015. Bottom-trawl surveys in the Beaufort and Chukchi Seas occurred in 2008 and 2012, respectively. Data for the Beaufort and Chukchi Seas do not represent multi-year surveys or long-term trends like data for the Bering Sea.

MAP DATA SOURCES

Distribution (Regular Use and Concentration): National Oceanic and Atmospheric Administration (1988); Thorsteinson and Love (2016)

Major Wintering Grounds: Tojo et al. (2007)

Pre- and Post-Spawning Migration: Tojo et al. (2007)

Spawning: Alaska Department of Fish and Game Habitat and Restoration Division (2001); Tojo et al. (2007)

Herring Savings Areas: North Pacific Fishery Management Council (2016a)

Reference list available here.

Map 4.2 Walleye Pollock

MAPPING METHODS (MAP 4.2)

The relative abundance of walleye pollock was estimated by interpolating datasets from bottom-trawl surveys, which employed similar and consistent methodologies and sampled waters within the US Exclusive Economic Zone (EEZ) of the Bering Sea (Conner and Lauth 2016, Hoff 2016), Aleutian Islands (Raring et al. 2016), Gulf of Alaska (von Szalay and Raring 2016), Chukchi Sea (Goddard et al. 2014), and Beaufort Sea (Logerwell 2008). Data points for walleye pollock presence and abundance were extracted and mapped based on catch-per-unit-effort (CPUE), displaying kilograms per hectare. To obtain continuous coverage across the study area, data points were interpolated using the Inverse Distance Weighted (IDW) tool in ArcGIS version 10.5 based on CPUE values. A radius of the 12 nearest points was set as the search distance and interpolation was limited to the study area boundaries of the trawl surveys.

Walleye pollock spawning locations were created based on information from Bacheler et al. (2012), and Cianelli et al. (2012) and digitized from summary figures depicting modeled distribution of spawning patterns based on long-term egg and larvae collection.

The general distribution polygon is based on the Essential Fish Habitat (EFH) designation from (National Oceanic and Atmospheric Administration 2016b) for walleye pollock. This area is described as the general distribution for both late juveniles and mature adults, located in the lower and middle portion of the water column along the entire shelf (33–660 feet [~10–200 meters]) and slope (660–3,300 feet [200–1,000 meters]) throughout the Gulf of Alaska, Bering Sea, and Aleutian Islands.

Data Quality

The interpolation of the trawl-survey data estimates the distribution of walleye pollock during the summer months and may not represent the year-round distribution. The bottom-trawl surveys sample the pollock residing near the seafloor and may not be representative of pollock distribution throughout the water column. Data from acoustic surveys that estimate pollock abundance in the midwater component of the Bering Sea are not represented on the map. Additionally, pollock is a transboundary species but due to the study area sampled in bottomtrawl surveys, distribution in Russian waters is not represented on this map. Pollock are distributed across the Bering Sea shelf to

Cape Navarin and southward along the Siberian coast (T. Honkalehto pers. comm.) but the bottom-trawl survey data only sampled waters within the US EEZ. Data for those areas are not yet published.

According to the source of the datasets (National Oceanic and Atmospheric Administration 2016b), bottom-trawl surveys in the Aleutian Islands were conducted every 3 years from 1983–2000 and on even years from 2002–2016. Surveys on the Bering Sea slope were conducted on even years from 2002–2016, except for 2006 and 2014. Surveys on the eastern Bering Sea shelf were conducted from 1982–2016. Surveys for the northern Bering Sea occurred in 1982, 1985, 1991, and 2010. Gulf of Alaska surveys were conducted in 1984 and 1987; every 3 years from 1990–1999, and on odd years from 2001–2015. Bottom-trawl surveys in the Beaufort and Chukchi Seas occurred in 2008 and 2012, respectively. Data for the Beaufort and Chukchi Seas do not represent multi-year surveys or long-term trends like data for the Bering Sea.

MAP DATA SOURCES

Relative Abundance: Oceana (2017e) based on Conner and Lauth (2016), Hoff (2016), Goddard et al. (2014), Logerwell (2008), Raring et al. (2016), and von Szalay and Raring (2016)

Spawning: Cianelli et al. (2012); Bacheler et al. (2012)

Distribution: National Oceanic and Atmospheric Administration (2016b)

Reference list available here.

Map 4.3 North Pacific Cods

MAPPING METHODS (MAP 4.3)

The general-distribution polygon for Pacific cod is the Essential Fish Habitat (EFH) designation from National Oceanic and Atmospheric Administration (2016b). This distribution is described as located in pelagic waters along the entire Bering Sea shelf (0–660 feet [0–200 meters]) and upper (660–1,650) [200–500 m]) slope throughout the Bering Sea and Aleutian Islands, wherever there are soft substrates consisting of mud and sand.

Spawning areas for Pacific cod were digitized from Figure 5 in Neidetcher et al. (2014) showing concentrated spawning in the Bering Sea and Aleutian Islands from 2005–2007. During the course of the study, spawning concentrations were identified along the Aleutian Islands, north of Unimak Island, near the Pribilof Islands, and the Bering Sea shelf edge along the 660-foot (200-m) isobath. Observers identified the highest percent spawning (>35%) in 2005 in the western Aleutians at Attu Island, in the central Aleutians at Atka Island, and along the Bering Sea shelf north of Unimak Island, seaward of the Pribilof Islands and along the northern outer shelf. Spawning locations from this paper were shown as data points coded by daily percent. Percentages ranged from 15–35%, but in order to show just presence or absence, polygons were drawn around aggregated points in the figure. Therefore spawning polygons depict only presence of spawning, not magnitude of spawning.

The general distribution of saffron cod is a combination of three data sources, merged together. The first is the EFH area for adult and late juvenile saffron cod (National Oceanic and Atmospheric Administration 2016b), described as located in pelagic and epipelagic waters along the coastline, within nearshore bays, and under ice along the inner (0–165) [0 to 50 m]) shelf throughout Arctic waters and wherever there are substrates consisting of sand and gravel. The second is data from Smith (2010) and Audubon Alaska (2009) showing nearshore distribution in the US Beaufort Sea. The third is based on combined bottom trawl survey data for the Bering Sea (Conner and Lauth 2016, Hoff 2016), Chukchi Sea (Goddard et al. 2014), and Beaufort Sea (Logerwell 2008). Data points for saffron cod presence or absence were extracted and mapped based on catch-per-unit-effort (CPUE) displaying kilograms per hectare. A polygon was then drawn around all aggregated data points with a CPUE value above the average for the dataset.

Spatial data for saffron cod were not abundant. The main spawning area is from National Oceanic and Atmospheric Administration (1988), which documented spawning areas in Kotzebue Sound, nearshore areas of the Seward Peninsula, and Norton Sound areas.

The general distribution for Arctic cod is a combination of two datasets. The first was digitized from Thorsteinson and Love (2016). This study describes that Arctic cod are very abundant in the US Chukchi and Beaufort Seas. The second is based on combined bottom-trawl survey data for the Bering Sea (Conner and Lauth 2016, Hoff 2016), Chukchi Sea (Goddard et al. 2014), and Beaufort Sea (Logerwell 2008). Data points for Arctic cod presence or absence were extracted and mapped based on CPUE displaying kilograms per hectare. A polygon was then drawn around all aggregated data points with a CPUE value above the average for the dataset to indicate areas of either presence or absence.

Spatial information about Arctic cod spawning is limited. Arctic cod spawn under the ice in winter, making it difficult for scientists to identify spawning habitat and locations. One location was mapped based on text descriptions from Craig et al. (1982) where spawning Arctic cod were observed northwest of Prudhoe Bay, but other locations are unknown.

Data Quality

Because saffron cod and Arctic cod spawn under the ice in winter, information about specific spawning locations is limited. More information is needed, especially for Artic cod spawning locations in the Beaufort Sea. Saffron cod and Arctic cod distribution are both partially based on summer-trawl survey data and therefore may not be fully representative of the year-round distribution.

Bottom trawl surveys in the Bering Sea slope were conducted on even years from 2002–2016, except for 2006 and 2014. Surveys in the EBS shelf were conducted from 1982–2016. Surveys for the northern Bering Sea occurred from 1982–2010. Bottom-trawl surveys in the Beaufort and Chukchi Seas occurred in 2008 and 2012, respectively. Data for the Beaufort and Chukchi Seas do not represent multi-year surveys or long-term trends like data for the Bering Sea.

MAP DATA SOURCES

Pacific Cod Distribution: National Oceanic and Atmospheric Administration (2016b)

Pacific Cod Spawning: Neidetcher et al. (2014)

Saffron Cod Distribution: Audubon Alaska (2009); National Oceanic and Atmospheric Administration (2016b); Oceana (2017a) based on Conner and Lauth (2016), Hoff (2016), Goddard et al. (2014), and Logerwell (2008); Smith (2010)

Saffron Cod Spawning: National Oceanic and Atmospheric Administration (1988)

Arctic Cod Distribution: Oceana (2017a) based on Conner and Lauth (2016), Hoff (2016), Goddard et al. (2014), and Logerwell (2008); Thorsteinson and Love (2016)

Arctic Cod Spawning: Craig et al. (1982)

Reference list available here.

Map 4.4 Atka Mackerel

MAPPING METHODS (MAP 4.4)

The relative abundance of Atka mackerel was estimated by interpolating datasets from bottom-trawl surveys, which employed consistent methodologies and sampled waters within the US Exclusive Economic Zone (EEZ) of the Bering Sea (Conner and Lauth 2016, Hoff 2016), Aleutian Islands (Raring et al. 2016), Gulf of Alaska (von Szalay and Raring 2016), Chukchi Sea (Goddard et al. 2014), and Beaufort Sea (Logerwell 2008). Data points for Atka mackerel presence or absence were extracted and mapped based on catch-per-unit-effort (CPUE) displaying kilograms per hectare. To obtain continuous coverage across the study area, data points were interpolated using the Inverse Distance Weighted (IDW) tool in ArcGIS version 10.5 based on CPUE values, and interpolation was limited to the study area boundaries of the trawl surveys.

Nesting sites were created directly from site coordinates found in Appendix 1 from Lauth et al. (2007b). A radius of the 12 nearest points was set as the search distance.

EFH areas for Atka mackerel were obtained directly from National Oceanic and Atmospheric Administration (2016b). Areas for adult Atka mackerel EFH were displayed since these are considered the general distribution for this life stage. These areas are located wherever there are gravel and rock beds and kelp, along the inner (0 to 165-feet [0 to 50 m]), middle (165 to 330 feet [50 to 100 m]), and outer shelf (330 to 660 feet [100 to 200 m]) throughout the GOA and Bering Sea/Aleutian Islands (North Pacific Fishery Management Council 2016a).

Data Quality

Atka mackerel data are available throughout the US portions of the project area, although Atka mackerel are most highly concentrated around the Aleutian Islands and are less present further north, and as you move further offshore. Trawl-survey data sampling was conducted within the US EEZ, therefore there is little to no coverage on the Russian side of the Bering Sea. The interpolation of the trawl-survey data estimates the distribution of Atka mackerel during the summer months and may not represent the year-round distribution.

Bottom-trawl surveys in the Aleutian Islands were conducted every 3 years from 1983–2000, and on even years from 2002–2016. Surveys on the Bering Sea slope were conducted on even years from 2002–2016, except for 2006 and 2014. Surveys in the EBS shelf were conducted from 1982–2016. Surveys for the northern Bering Sea occurred from 1982–2010. Gulf of Alaska surveys were conducted in 1984 and 1987; every 3 years from 1990–1999, and on odd years from 2001–2015. Bottom trawl surveys in the Beaufort and Chukchi Seas occurred in 2008 and 2012, respectively. Data for the Beaufort and Chukchi Seas do not represent multi-year surveys or long-term trends like data for the Bering Sea.

MAP DATA SOURCES

Relative Abundance: Oceana (2017b) based on Conner and Lauth (2016), Hoff (2016), Goddard et al. (2014), Logerwell (2008), Raring et al. (2016), and von Szalay and Raring (2016)

Nesting Sites: Lauth et al. (2007b)

Essential Fish Habitat: National Oceanic and Atmospheric Administration (2016b)

Reference list available here.

Map 4.5 Yellowfin Sole

MAPPING METHODS (MAP 4.5)

The relative abundance of yellowfin sole was estimated by interpolating datasets from bottom-trawl surveys, which employed similar and consistent methodologies and sampled waters within the US Exclusive Economic Zone (EEZ) of the Bering Sea (Conner and Lauth 2016, Hoff 2016), Aleutian Islands (Raring et al. 2016), Gulf of Alaska (von Szalay and Raring 2016), Chukchi Sea (Goddard et al. 2014), and Beaufort Sea (Logerwell 2008). Data points for yellowfin sole presence and absence were extracted and mapped based on catch-per-unit-effort (CPUE) displaying kilograms per hectare. To obtain continuous coverage across the study area, data points were interpolated using the Inverse Distance Weighted (IDW) tool in the Spatial Analyst toolbar in ArcGIS version 10.5 based on CPUE values. A search radius of 12 points was set as the maximum distance and interpolation was limited to the study area boundaries of the trawl surveys.

Migration patterns, feeding, spawning, and over-wintering areas were digitized based on maps from Wilderbuer et al. (1992) depicting the seasonal migration patterns and distribution of yellowfin sole in the Bering Sea.

Data Quality

Yellowfin sole distribution within the waters of the US EEZ is well documented with over 30 years of data from the trawl-survey database. However, because surveys were only conducted within the US EEZ, we lack coverage outside of US waters. The interpolation of the trawl-survey data estimates the distribution of yellowfin sole during the summer months and may not represent the year-round distribution.

Bottom-trawl surveys in the Aleutian Islands were conducted every 3 years from 1983–2000 and on even years from 2002–2016. Surveys on the Bering Sea slope were conducted on even years from 2002–2016 except for 2006 and 2014. Surveys in the EBS shelf were conducted from 1982–2016. Surveys for the northern Bering Sea occurred from 1982–1993 and also in 2010. Gulf of Alaska surveys were conducted in 1984 and 1987; every 3 years from 1990–1999, and on odd years from 2001–2015. Bottom-trawl surveys in the Beaufort and Chukchi Seas occurred in 2008 and 2012, respectively. Data for the Beaufort and Chukchi Seas do not represent multi-year surveys or long-term trends like data for the Bering Sea.

MAP DATA SOURCES

Relative Abundance: Oceana (2017f) based on Conner and Lauth (2016), Hoff (2016), Goddard et al. (2014), Logerwell (2008), Raring et al. (2016), and von Szalay and Raring (2016)

Feeding: Wilderbuer et al. (1992)

Spawning: Wilderbuer et al. (1992)

Wintering: Wilderbuer et al. (1992)

Migration: Wilderbuer et al. (1992)

Reference list available here.

Map 4.6 Pacific Halibut

MAPPING METHODS (MAP 4.6)

The relative abundance of Pacific halibut was estimated by interpolating datasets from bottom-trawl surveys. These surveys employed similar and consistent methodologies and sampled waters within the US Exclusive Economic Zone (EEZ) of the Bering Sea (Conner and Lauth 2016, Hoff 2016), Aleutian Islands (Raring et al. 2016), Gulf of Alaska (von

Szalay and Raring 2016), Chukchi Sea (Goddard et al. 2014), and Beaufort Sea (Logerwell 2008). Data points for Pacific halibut presence and absence were extracted and mapped based on catch-per-unit-effort (CPUE) displaying kilograms per hectare. To obtain continuous coverage across the study area, data points were interpolated using the Inverse Distance Weighted (IDW) tool in ArcGIS version 10.5 based on CPUE values. A radius of the 12 nearest points was set as the search distance and interpolation was limited to the study area boundaries of the trawl surveys.

Spawning areas for Pacific halibut were digitized from maps from St-Pierre (1984), who documented spawning locations from the Aleutian Islands to British Columbia. Nursery locations were drawn from Figure 3.1 in Sohn (2016), who documented settlement locations for age 0–1 Pacific halibut. General migration patterns in the Bering Sea were drawn based on text descriptions from Best (1977), a mark and recapture study assessing seasonal migrations.

Data Quality

Trawl-survey data sampling was conducted within the US EEZ, therefore there is little to no coverage on the Russian side of the Bering Sea, even though Pacific Halibut is obviously a transboundary species. Future studies may address the lack of survey data outside of US waters. Pacific halibut summer distribution is estimated through interpolation of trawl survey data, and may not represent year-round distribution.

Bottom-trawl surveys in the Aleutian Islands were conducted every 3 years from 1983–2000, and on even years from 2002–2016. Surveys on the Bering Sea slope were conducted on even years from 2002–2016, except for 2006 and 2014. Surveys in the EBS shelf were conducted from 1982–2016. Surveys for the northern Bering Sea occurred from 1982–2010. GOA surveys were conducted in 1984 and 1987; every 3 years from 1990–1999, and on odd years from 2001–2015. Bottom-trawl surveys in the Beaufort and Chukchi Seas occurred in 2008 and 2012, respectively. Data for the Beaufort and Chukchi Seas do not represent multi-year surveys or long-term trends like data for the Bering Sea.

MAP DATA SOURCES

Relative Abundance: Oceana (2017d) based on Conner and Lauth (2016), Hoff (2016), Goddard et al. (2014), Logerwell (2008), Raring et al. (2016), and von Szalay and Raring (2016)

Spawning Areas: St-Pierre (1984)

Nursery Locations: Sohn (2016)

Migration: Best (1977)

Reference list available here.

Map 4.7 Pacific Salmon

MAPPING METHODS (MAP 4.7)

Pacific salmon ocean distribution was created by combining data for all five Pacific salmon species from multiple sources in order to obtain coverage throughout our entire study area. Arctic distribution is a compilation of the ranges of all five species from Thorsteinson and Love (2016). Maps from Augerot and Foley (2005) and data from State of the Salmon (2004) filled in missing distribution information for Russian waters, and remaining distribution information for the Bering Sea, Aleutian Islands, and Gulf of Alaska were obtained from National Oceanic and Atmospheric Administration (2016b).

Coastal staging areas were created based on the Alaska Department of Fish and Game's Anadromous Waters Catalog (Alaska Department of Fish and Game 2016). To create the coastal areas, all anadromous waters for Chinook salmon, sockeye salmon, coho salmon, pink salmon, and chum salmon were selected. A 3-mile (5-km) buffer was then drawn around all anadromous waters and the land was erased, resulting in 3-mile (5-km) buffers around the mouths of all anadromous waters. This same approach was used in the Bering Strait Marine Life and Subsistence Use Data Synthesis (Oceana and Kawerak 2014).

Salmon-bearing watersheds were created with data from the Atlas of Pacific Salmon (Augerot and Foley 2005) and updated with data from the Anadromous Waters Catalog (Alaska Department of Fish and Game 2016). The Atlas of Pacific Salmon identified nearly 2,000 watersheds used by one or more of the five species of Pacific salmon, however, many salmon-bearing Arctic rivers were not represented. Using the updated Anadromous Waters Catalog (Alaska Department of Fish and Game 2016), we selected all watersheds that contained known anadromous streams and then combined the two datasets. This resulted in 2,009 salmon-bearing watersheds in Alaska and Russia.

Migration information was digitized directly from Figure 6 in Farley et al. (2005), depicting the seaward migration routes for juvenile Chinook, sockeye, coho, pink, and chum salmon along the eastern Bering Sea shelf from August through October 2002.

Concentration areas are based on NOAA's Environmental Sensitivity Index (ESI) maps (National Oceanic and Atmospheric Administration 2011), which summarize the most at-risk coastal resources to identify particularly valuable and vulnerable biological resources. Areas for all five Pacific salmon were combined together and categorized as either concentration areas or high-concentration areas.

The sea-ice data shown on this map approximate median monthly sea-ice extent. The monthly sea-ice lines are based on an Audubon Alaska (2016) analysis of 2006–2015 monthly sea-ice extent data from the National Snow and Ice Data Center (Fetterer et al. 2016). See Sea Ice Mapping Methods section for details.

Data Quality

Salmon are easier to observe during the spawning phase of their life cycle, so information about behavior and distribution in fresh water is therefore more abundant than information from their ocean phase. However, we were able to piece together enough information to get a broad sense of ocean patterns. Because salmon have run, location, and species-specific behaviors, the scale of this map does not lend itself to an in-depth analysis of those intricacies. Smaller, region-specific maps would be required to investigate those complexities. In terms of data gaps, we were unable to find a complementary dataset to the Alaska Anadromous Waters Catalog for Russia or much information about ocean behavior or distribution of salmon on the Russian side of the Pacific.

MAP DATA SOURCES

Distribution: Augerot and Foley (2005); National Oceanic and Atmospheric Administration (2016b); State of the Salmon (2004); Thorsteinson and Love (2016)

Staging Areas: Alaska Department of Fish and Game (2016)

Salmon-Bearing Watersheds: Alaska Department of Fish and Game (2016); Augerot and Foley (2005)

Migration: Farley et al. (2005)

Concentration Areas: National Oceanic and Atmospheric Administration (2011)

Sea Ice: Audubon Alaska (2016) based on Fetterer et al. (2016)

Reference list available here.