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A Refined Description of Essential Fish Habitat for Pacific Salmon Within the U.S. Exclusive Economic Zone in Alaska

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U.S. DEPARTMENT OF COMMERCE
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Alaska Fisheries Science Center
Auke Bay Laboratories
17109 Lena Point Loop Road
Juneau, AK 99801
www.afsc.noaa.gov

U.S. DEPARTMENT OF COMMERCE
John E. Bryson, Secretary
National Oceanic and Atmospheric Administration
Jane Lubchenco, Under Secretary and Administrator
National Marine Fisheries Service
Eric C. Schwaab, Assistant Administrator for Fisheries

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ABSTRACT

In 2005 the North Pacific Fishery Management Council used an improved analytical approach to identify essential fish habitat (EFH) for most species of groundfish and crab, however, due to the lack of available information, the entire U.S. Exclusive Economic Zone (EEZ; 200-nautical miles (nmi) from shore) for each of the five species of Pacific salmon was left intact as EFH. In order to better define EFH within the U.S. EEZ for Pacific salmon found in Alaska (*Oncorhynchus* spp.), we acquired catch, maturity, salinity, temperature, and station depth data for the Bering Sea and Gulf of Alaska from multiple data sources. We analyzed the influence of sea surface salinity (SSS), sea surface temperature (SST), and bottom depth on the distribution of Pacific salmon. Very few significant associations between catch and the three tested environmental variables were found to exist, indicating little to no relationship between species distribution and the three measures of habitat condition; however, many patterns were still evident. By calculating and mapping the coincidence of the 95% range of each environmental variable (SSS, SST, depth) for each of the five species at each maturity stage, our updated EFH descriptions reduce the area of designated EFH for Pacific salmon by 71.3% on average. Juvenile salmon EFH generally consists of the water over the continental shelf within the Bering Sea extending north to the Chukchi Sea, and over the continental shelf throughout the Gulf of Alaska and within the inside waters of the Alexander Archipelago. Immature and mature Pacific salmon EFH includes nearshore and oceanic waters, often extending well beyond the shelf break, with fewer areas within the inside waters of the Alexander Archipelago and Prince William Sound. This has been the first time that salmon data sets from multiple surveys, agencies, and years have been accumulated and formatted for Pacific salmon distribution and habitat analysis. This study summarizes catches > 420,000 Pacific salmon sampled during 5,280 surface trawl and purse seine events in the Alaska EEZ from 1964 to 2009. Distribution was plotted for each salmon species and life history within the Alaska EEZ. To better describe salmon EFH, additional detailed habitat preference analysis was performed with available biophysical data from approximately 84% of the events. Not only will the database resulting from this project be of invaluable use for future research, but a much greater understanding of Pacific salmon distribution in the marine environment has been gained.

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INTRODUCTION

The purpose of this project was to look at new methodologies to refine the geographic scope of the essential habitat for Pacific salmon (*Oncorhynchus* spp.) in marine waters off Alaska. When the North Pacific Fishery Management Council (NPFMC) first identified essential fish habitat (EFH) in 1998, it designated all marine waters within the U.S. Exclusive Economic Zone (EEZ) (0 to 200 nautical miles (nmi) from shore) as EFH for all five species of Pacific salmon (pink, *O. gorbuscha*; coho, *O. kisutch*; sockeye, *O. nerka*; chum, *O. keta*; and Chinook, *O. tshawytscha*). In 2005 the Council used an improved analytical approach to identify EFH for most species of groundfish and crabs, resulting in more refined EFH descriptions (NMFS 2005). However, the Council left marine salmon EFH intact as the entire U.S. EEZ off Alaska. Salmon EFH was identified broadly because (1) no systematic marine salmon survey exists off Alaska, (2) salmon catch in offshore commercial fisheries for other species fluctuates and is not fully understood, and (3) the Alaska Fisheries Science Center (AFSC) did not have the resources to analyze various data sources to determine whether it is possible to better define offshore salmon distributions and relative abundance.

The National Marine Fisheries Service (NMFS) has been criticized repeatedly for the extent of its EFH designations. The EFH for salmon in marine waters is particularly broad, not only off Alaska (NMFS 2005) but also off the U.S. West Coast (http://www.pcouncil.org/salmon/background, Retrieved 24 Sept. 2009) and New England (www.nero.noaa.gov/hcd/salmon.pdf, Retrieved 24 Sept. 2009). This broad identification of EFH greatly reduced its potential utility for management purposes and also reduced the credibility of the EFH program nationwide. The development of an effective methodology to refine the way Pacific salmon EFH is designated off Alaska would enable the NPFMC to amend its salmon fishery management plan accordingly, and might also be applicable for other regions with broad salmon distribution or other highly migratory species.

Salmon use the ocean environment to maximize fitness (Mueter et al. 2002, 2005; Pyper et al. 2005; Quinn 2005). Studies have shown that salmon experience growth and survival patterns at regional spatial scales, suggesting that surrounding environmental conditions such as temperature, salinity, dissolved oxygen, pH, and other attributes affect the overall performance of the fish and can therefore alter ocean distribution patterns (Mueter et al. 2002, 2005; Pyper et al. 2005; Quinn 2005). Temperature, salinity, and dissolved oxygen are all properties of waters that vary in coastal and estuarine systems and fish have responses ranging from preference to tolerance, avoidance, and death (Quinn 2005). For these purposes, one could deduce that each salmon species would have particular migration routes matching geographical location to spatial and seasonal changes in ocean productivity in order to capture the necessary environmental conditions needed to maximize growth and for survival as well as to minimize metabolic and migration induced energy costs (Mueter et al. 2002, 2005; Pyper et al. 2005; Quinn 2005).

For these purposes, and because of data availability, we looked at temperature, salinity, and bottom depth as proxies for the underlying factors affecting salmon migration and hence habitat use within the U.S. EEZ off Alaska. Having an understanding of how the environment influences the distribution and migration of salmon could be valuable for many purposes (e.g., definition of desirable habitats, spatial distribution patterns, and prediction of distributional reactions to environmental changes). However, what is considered habitat and how it relates to spatial variations in abundance for many marine species such as Pacific salmon is still not clear (Rubec et al. 1998). One method of determining important habitat characteristics is to identify differences in habitat features between areas of high and low fish abundance (Scott 1982, 1983; Rubec et al. 1998; Cook and Auster 2005; Bi et al. 2008; Slacum et al. 2008; Vogler et al. 2008; Gallagher and Heppell 2010).

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act state that information and data necessary for identifying EFH is to be described using multiple levels of information, with the goal being to include as many levels of analysis as possible within the constraints of the available data. There are four levels of detail, with Level 1 the lowest to Level 4 the highest. Level 1 consists of presence-absence data. At this level, one may eliminate areas that are not serving as habitat, but inference of habitat use is limited because only the geographical distribution in relation to habitat is known. Level 2 includes data consisting of habitat-specific densities of fish. The EFH described at this level essentially assumes that increased abundances within a specific habitat reflect increased habitat quality. Level 3 includes data on growth, reproduction, or survival rates within habitats. This is difficult information to obtain, but provides a further measure of habitat quality. The highest level of information, Level 4, includes data on the production rates by habitat, or the contribution of a habitat to a spawning stock biomass of a species. Several studies have been published linking marine fish distribution and physical condition of the environment within Levels 1 and 2. Hinz et al. (2006) showed the correlation between flatfish (Plaice, *Pleruonectes platessa*; sole, *Solea solea*; and lemon sole, *Microstomus kitt*) in the English Channel with substrata and depth; flounder (*Platichthys flesus*) have displayed an association with salinity (Riley et al. 1981); John Dory (*Zeus faber*) in the Mediterranean Sea have distributions influenced by water depth and temperature (Maravelias et al. 2007); and the distribution of Atlantic cod (*Gadus morhua*) has been described in several studies to be linked with specific depth and temperature conditions (Perry and Smith 1994). Current defined areas of EFH for Pacific salmon in Alaska's marine waters are essentially at Level 1 (NMFS 2005): the entire U.S. EEZ off Alaska is defined as essential salmon habitat. In order to refine the geographic scope of EFH for all five Pacific salmon species in marine waters within the Alaska EEZ, we followed the methodology proposed in Perry and Smith (1994) to identify associations between habitat (environmental) conditions and the distribution of Pacific salmon. The suggested refinement used those associations, and then applied some more common percentages of each result; 75% and 95% of distribution concentrations could be mapped to display areas containing preferred habitat. Therefore, the objectives of this study were to 1) refine existing Level 1 EFH information by describing the presence/absence and geographic distribution of each species and life history of salmon, and 2) assess their Level 2 EFH habitat-specific densities.

MATERIALS

Fish catch and hydrographical data were compiled from multiple research efforts conducted within the U.S. EEZ off Alaska using systematic surface and midwater trawls and purse seine events at designated survey stations (Table 1). These data include catch in numbers identified by species and maturity state (juvenile, immature, or mature), sea surface salinity (SSS; nearest 0.1 ppt), sea surface temperature (SST; nearest 0.1°C), and station bottom depth (nearest 1 m) for each haul. Data sets used in this analysis include the following: Bering-Aleutian Salmon International Survey (BASIS) transect data of the Alaska Fisheries Science Center (AFSC), Southeast Alaska Coastal Monitoring (SECM) data of the AFSC, Canadian Fisheries and Oceans salmon data of the Department of Fisheries and Oceans Canada (DFOC), Coastal Gulf of Alaska (CGOA) data of the U.S. Global Ocean Ecosystem Dynamics (GLOBEC) program and University of Alaska Fairbanks (UAF), the coastal salmon surveys conducted through the National Marine Fisheries Service (NMFS) and GLOBEC, the AFSC high seas and coastal salmon research, and the Hartt and Dell (1986) historical seining data of the U. S. Section of the International North Pacific Fisheries Commission (INPFC).

The BASIS data were collected through the Ocean Carrying Capacity Program (OCC) of the AFSC. Fisheries and oceanographic data were collected during surface trawl surveys in the Bering and Arctic (Chukchi Sea) Seas (Fig. 1). This data series includes survey data collected from mid-August to early October of 1999 through 2007 off western Alaska All Pacific salmon specimens were identified to species and life history stage (juvenile, immature, or mature). Fish were collected using midwater rope trawls. Trawls were 198-m long, and towed at the surface from 3.5 to 5 knots for 30 minutes, with average horizontal and vertical mouth dimensions of 50-m and 14-m, respectively (Carlson et al. 1999; Farley et al. 1999, 2001a, 2001b, 2003).

The SECM data were collected through the Marine Salmon Interactions (MSI) program of the AFSC. Fisheries and oceanographic data were collected by surface trawl surveys from 21 stations on 4 to 5 research cruises annually in the inside waters of Southeast Alaska (Fig. 2). This data series includes survey data from May through September of 1997 through 2009. All Pacific salmon specimens were identified to species and life history stage (juvenile, immature, or mature). Fish sampling was carried out with a Nordic 264 rope trawl on surface waters. The trawl was 184-m long and had a mouth opening approximately 24-m wide and 18-m deep. For each haul, the trawl was fished across a station for 20 minutes at about 3 knots, covering 1.9 km (Orsi et al. 2009).

The DFOC data were collected by personnel of the Pacific Biological Station of the DFOC. Fisheries and oceanographic data were collected from surface trawl surveys throughout the year in waters within the U.S. EEZ off Alaska, including waters within Southeast Alaska and the Gulf of Alaska (GOA; Fig. 3). This data series includes survey data from 1995 through 2009. All Pacific salmon specimens were identified to species and to one of two life history stages: juvenile or mature. On average, fish samples were collected using a surface rope trawl with a 32-m horizontal and 13-m vertical spread, towed for 4.6 km for 30 minutes (Marc Trudel, DFOC, pers. comm.).

The CGOA data were collected by personnel of U.S. GLOBEC and the UAF. Fisheries and oceanographic data were collected by surface trawl surveys from coastal stations within the GOA, particularly within Prince William Sound (Fig. 4). This data series includes survey data from July through October of 2001 through 2004. All Pacific salmon specimens were identified to species and life history stage (juvenile, immature, or mature). Fish samples were collected with a Nordic 264 surface rope trawl, 198-m long with a 25-m horizontal spread and a 35-m spread vertically (Global Ocean Ecosystem Dynamics, http://globec.org/, Retrieved 3 Nov. 2009).

The GOA coastal salmon surveys were carried out by personnel of NMFS and U.S. GLOBEC. The fisheries and oceanographic data were collected by surface trawl surveys along coastal GOA transects from Yakutat to Kodiak Island (Fig. 5). These surveys were conducted in July and August of 2002 and 2003, and October and November in 2004. All Pacific salmon specimens were identified to species and life history stage (juvenile, immature, or mature). Fish samples were collected with a 198-m long midwater rope trawl. The rope trawl was towed at 3.5 to 5 knots, at or near surface, with a typical spread of 40-m horizontally and 14-m vertically for 30 minutes (Global Ocean Ecosystem Dynamics, http://globec.org/, Retrieved 3 Nov. 2009).

The AFSC high seas and coastal salmon data were collected by personnel of Auke Bay Laboratories. In July and August of 1997 and 1998, fisheries and oceanographic data were collected by surface trawl surveys from Cape St. Elias, extending west past Kodiak and the Alaska Peninsula through Unimak Pass and the Aleutians to Attu Island and parts of the southern Bering Sea (Fig. 6). Stations were sampled from nearshore over shelf to slope and seaward over oceanic depths to examine distribution of salmon in relation to distance from shore and the foregoing marine habitat zones. In August of 2000, the survey changed and only coastal waters of the GOA were sampled: west of Prince William Sound and the western end of Shelikof Strait. Transects sampled during the survey were still perpendicular to shore and generally extended from nearshore across the continental shelf into oceanic waters beyond the 200-m shelf break. All Pacific salmon specimens were identified to species and life history stage (juvenile, immature, or mature). Fish samples were collected using a 198-m long midwater rope trawl. The rope trawl was towed at 4 to 5 knots, at or near the surface, and had a typical spread of 45-m horizontally and 12-m vertically. All tows lasted 30 or 60 minutes and covered 2.8 to 4.6 km (Carlson et al. 1997, 1998; Farley et al. 2000, 2001b).

The historical Hartt and Dell data were collected by personnel of the Fisheries Research Institute (FRI), School of Fisheries, University of Washington under contract to NMFS, as part of the research being done for the purposes of the U. S. Section of the INPFC during the years 1964 – 1968 (Hartt and Dell 1986). Catch and oceanographic data were collected from April through October at stations throughout the entire GOA within the U.S. EEZ, as well as in the eastern Bering Sea (Fig. 7). Fish samples were caught by purse seines, which were about 704-m long by 46-m deep, with a mesh size of 63 mm in the lower half of the net and 51 mm in the upper half. Each seine was set in a semicircle and held in opened fishing position for 30 minutes (Hartt and Dell 1986).

METHODS

Species Distributions

According to the EFH Environmental Impact Statement, EFH is defined as a subset of each species' range, generally between 75 and 95% of the spatial distribution of the entire species' range, for each particular life history stage (NMFS 2005). In order to fulfill EFH guidelines of describing species habitat distribution, and to fulfill Level 1 (presence/absence) EFH description requirements, 95% of the spatial distribution of the entire species' range, for each life history stage, was calculated. In preparation for data analysis, all data sets had to be formatted in a uniform manner. Any hauls with missing geographic coordinates were removed. All hauls with "zero" catches were included in the data set. To characterize each species' range, catch per unit effort (CPUE) was divided by total CPUE for a relative abundance, for each record. The relative abundance estimate column was sorted by lowest relative abundance to highest relative abundance. Any record with a cumulative frequency greater than 5% was considered to be part of the 95% spatial distribution and was used in mapping the species' distribution range, also considered to be the range of the species' EFH under Level 1 guidelines. The spatial analyst method of kriging (http://www.zachchehayeb.com/Site/spatial_stats.html, Retrieved 9 June 2011) was used within ArcView GIS 9.3 to overcome problems created by a lack of sampling in certain areas. This interpolation method was used to estimate values in unsampled locations and to generate maps. For example, several datasets used within this study were collected from surveys using transect sampling. In theory, this would result in "strips" of EFH or species distributions. Through interpolation methods, we were able to estimate values between transect "strips."

The cumulative frequency distribution of the percent total catch was calculated in relation to the latitude and longitude as well (Farley et al. 2009). Available data were divided into two regions because of the unique geographic separation within Alaska waters: western Alaska (eastern Bering Sea (EBS), Arctic Sea, and Chukchi Sea) and the GOA (including waters within the Alexander Archipelago). This gave the ability to see trends in the various species' distributions. Again, this analysis was limited to available data, and may not accurately portray the entire preferred distribution due to limited sampling.

Habitat Associations

In preparation for data analysis, all data sets had to be formatted in a uniform manner. Any hauls with missing geographic coordinates, temperature, salinity, or station depth data were removed. "Zero" catches were then added to all hauls where no fish was caught.

The second Level (2) of EFH description consists of data analyzing habitat-specific densities of fish. In order to identify associations between salmon catch and environmental variables (temperature, salinity, and bottom depth) to fulfill EFH Level 2 requirements, the nonparametric methodology proposed by Perry and Smith (1994) was used. This method essentially calculates two empirical cumulative distribution frequencies (CDF): (i) the frequency distribution of the habitat variable, *f(t)* (bottom depth, salinity, and temperature), and (ii) the frequency distribution of the habitat variable weighted by the catch of fish, *g(t).* The maximum absolute distance between these two distributions was then calculated as a measure of association between the environmental variable and the presence of the fish species.

In this analysis, CPUE was used instead of catch in numbers to standardize the different lengths of time and methods of sampling from the various data sources. The CPUE was calculated as the number of fish caught per 30 minute trawl. Hartt and Dell purse seine data were not used in this analysis.

We first described the frequency distribution of each habitat variable, *f(t)* (bottom depth, salinity, and temperature), through its cumulative distribution function (CDF). All symbols used below are defined in Table 2. The CDF was calculated as following

$$f(t) = \sum_h \sum_i \frac{W_h}{n_h} I(x_{hi}) \qquad (1)$$

with the indicator function,

$$I(x_i) = \begin{cases} 1, & \text{if } x_i \le t; \\ 0, & \text{otherwise.} \end{cases}$$

Secondly, we determined the association of fish caught (identified by species and maturity stage) with a particular habitat condition by calculating the same frequency distribution of the habitat variable weighted by the catch (CPUE) at that particular habitat, *g(t)*. This gives the association of fish catch in a haul with the particular habitat conditions of the haul. This was calculated as following:

$$g(t) = \sum_h \sum_i \frac{W_h}{n_h} \frac{y_{hi}}{\bar{y}_{st}} I(x_{hi}) \tag{2}$$

Large values of $y_{hi} / \bar{y}_{st}$ consistently associated with particular habitat conditions suggest a strong association between the fish species and those habitats.

The third step was to determine the existence of a significant association between catch and the habitat variable. This was accomplished by calculating the maximum absolute vertical distance between the two cumulative distribution functions, *f(t)* and *g(t)*, giving the test statistic (D_{stat}):

$$\max_{\forall t} \left| g(t) - f(t) \right| = \max_{\forall t} \left| \sum_h \sum_i \frac{W_h}{n_h} \left(\frac{y_{hi} - \bar{y}_{st}}{\bar{y}_{st}} \right) I(x_{hi}) \right| \tag{3}$$

If *f(t)* and *g(t)* appear almost identical, this would mean there was almost no association between fish distribution and the habitat variable within the surveyed area.

Because of the stratified sampling design, calculated test statistic values could not be compared with critical values from the Kolmogorov-Smirnov test table. Instead, a Monte Carlo randomization resampling procedure was developed to determine the significance of the calculated test statistic from equation (3). The pairings of $(W_h / n_h)[(y_{hi} - \bar{y}_{st}) / \bar{y}_{st}]$ and x_{hi} were randomized and a new test statistic was calculated from the new pairs using equation (3). Two-thousand iterations were done with a probability value of $P \leq 0.05$. More details of the Monte Carlo resampling technique used for this study can be found in Perry and Smith (1994).

The 2.5th and 97.5th percentiles of each weighted CDF were used to establish the range of Pacific salmon preference for each environmental variable at each maturity stage (Vogler et al. 2008).

EFH Text and Map Descriptions

The legal EFH description for each managed species is represented by the EFH text description, by life history stage. In the NPFMC fishery management plans (FMPs), this text description is also portrayed graphically on a map (NMFS 2005). The EFH Final Rule (50 CFR 600.815(a)(1)(iv)(B)) states: "FMPs must describe EFH in text, including reference to the geographic location or extent of EFH using boundaries such as longitude and latitude, isotherms, isobaths, political boundaries, and major landmarks." In order to fulfill legal obligations of text and map descriptions of EFH, survey stations containing habitat conditions within the preferred 95% range of each weighted CDF of each environmental variable were mapped. This was done at each maturity stage for each of the five species. Preferred habitat (Level 2 EFH) was defined as the areas of coincidence of the 95% preference ranges for all three environmental variables, bottom depth, SSS, and SST for each species in each life history stage.

RESULTS AND DISCUSSION

Very few significant associations between catch and the three tested environmental variables were found, indicating little relationship between species catch distribution and habitat condition; however, many patterns were still evident. By calculating and mapping the coincidence of the preferred 95% range of each environmental variable (SST, SSS, bottom depth) for each of the five species at each maturity stage, areas considered to contain “preferred” or “ideal” habitat conditions in which all three variables coincided were defined. Should these relationships be applied, existing marine salmon EFH descriptions would be reduced by 71% on average (Table 3).

Juvenile Pacific salmon (all species) distributions were influenced by environmental variables. Juvenile coho salmon had a weak association with bottom depth ($P = 0.124$). Juvenile chum salmon were found to be weakly associated with SST ($P = 0.129$). Juvenile sockeye salmon were significantly associated with bottom depth ($P = 0.01$) and salinity ($P = 0.01$). Off western Alaska, juvenile salmon of all five species display the most northern distributions in comparison to immature and mature Pacific salmon, inhabiting waters over the inner and middle continental shelf within the EBS. This includes water along the Alaska Peninsula, generally following the 100 or 150-m depth contour northwest past the Pribilof Islands. North of the Pribilofs, water from the Alaska coast out to the 100-m depth contour, and the U.S. EEZ boundary farther north, is all considered EFH for juvenile salmon. This range extends north through the Bering Strait past Cape Lisburne into the Chukchi Sea. Juvenile salmon in the GOA were generally found over the continental shelf throughout the entire coastal Gulf belt, and within the inside waters of the Alexander Archipelago, particularly within Icy Strait, Chatham Strait, Sumner Strait, Frederick Sound, and Clarence Strait. It appears that the width of the continental shelf affects the distribution of juvenile sockeye, chum, and pink salmon within the GOA. The band of juvenile sockeye, chum, and pink salmon is narrow along the coastal belt off southeastern Alaska, where the continental shelf narrows in some spots to less than 20 nmi. In the northern Gulf, where the continental shelf widens, the band of juvenile salmon is considerably wider (Hartt 1984).

Temperature was weakly associated with the distribution of immature Chinook salmon ($P = 0.055$) and immature sockeye salmon ($P = 0.135$). Immature chum salmon were weakly associated with bottom depth ($P = 0.063$) as well. Immature salmon off western Alaska are generally found farther offshore, often beyond the shelf break over deeper waters, as well as having a more southern distribution. Only immature Chinook salmon have a distribution reaching as far north as their juvenile counterpart. Seventy-five percent of all immature salmon are distributed west of long. 166°W, and all three of the sampled species have distributions reaching as far west as long. 174°W. In general, immature Pacific salmon off western Alaska are found in waters over the continental shelf within the EBS. This includes waters along the Alaska Peninsula, generally following the 1,000 or 2,000-m depth contour northwest past the Pribilof Islands. North of the Pribilofs, immature salmon were located in waters throughout the inner and middle continental shelf, but not near shore, heading as far north as Cape Lisburne within the Chukchi Sea. Within the GOA, immature salmon displayed a preference for offshore waters, often beyond the shelf break into oceanic habitats, extending on average 50 – 100 km beyond the 2,000-m depth contour throughout the entire coastal belt. Notably, fewer areas within the inside waters of the Alexander Archipelago contained desirable habitat conditions for immature salmon, but with waters within Chatham Strait exhibiting ideal immature salmon habitat.

Depth of water had a slight association with the distribution of three species of mature Pacific salmon: Chinook salmon ($P = 0.128$), coho salmon ($P = 0.174$), and sockeye salmon ($P = 0.174$). Distribution of mature sockeye was also weakly associated with salinity ($P = 0.194$), and mature pink salmon had a distribution significantly associated with salinity ($P = 0.014$). In general, mature salmon off western Alaska inhabit marine waters extending beyond the continental shelf to the 2,000-m depth contour within the EBS. North of the Pribilof Islands, mature salmon are found over the inner and middle shelf, as far north as the Lisburne Peninsula in the Chukchi Sea. Similar to immature salmon, mature salmon were found to be more southerly distributed, in addition to occupying inner and middle shelf waters along the southern arm of the Alaska Peninsula. The exception to this distribution is chum salmon, which once again has a distribution reaching as far north as juvenile and immature chum salmon. Documented catches of mature salmon in these data sets are much fewer in number and occurrence in waters off western Alaska than within the GOA. This may be a result of the timing of the surveys, as the highest numbers of mature salmon sampled in the GOA were encountered during winter months, and no winter surveys have occurred in the EBS. Mature salmon within the GOA are found in almost all waters in the Gulf, both nearshore and offshore. This includes the entire continental shelf surrounding the coastal belt, extending on average 80 – 90 km beyond the 2,000-m isobath into oceanic waters.

Marine Habitat Preference, Distribution, and EFH Text Descriptions for Pacific Salmon[1] [*Italicized text states existing EFH Text Description*.]
[*Italicized* ***BOLD*** *text* ***redefines*** *the existing EFH Text Descriptions, where applicable.]*

Marine Juvenile Pink Salmon-

Marine EFH for juvenile pink salmon is the general distribution area for this life stage, located in coastal and marine waters off the coast of Alaska from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. Juvenile pink salmon distribute within ***coastal waters all along the entire shelf (0 to 200 m) from mid-summer until December; then migrate to pelagic waters (upper 50 m) of the slope (200 to 3,000 m).***

Juvenile pink salmon appear to be distributed in the marine environment proportionally to available habitat conditions, as none of the associations between catch and SST, SSS, and bottom depth were significant (Table 4). Juvenile pink salmon display a tolerance for some of the warmest surface temperatures, 6.9° – 15°C. Seventy-five

[1] An EFH Descriptions is specific to a particular life history stage of a fish species managed within a federal Fishery Management Plan (FMP).

percent of the juvenile pink salmon were found in waters above 10.9°C. A broad range of salinity conditions are also tolerated (20.7 – 32.2 ppt).

Juvenile pink salmon found off western Alaska **(**Fig. 7a) are distributed throughout the inner and middle domains of the continental shelf, from the northern extent of Bristol Bay to just past Cape Lisburne in the Chukchi Sea, and are generally distributed farther offshore than juveniles of the other salmon species. These fish are more northerly distributed, with 90% of the sampled fish occurring north of lat. 58°N. While the distribution of juvenile pink salmon appears to span the entire shelf off western Alaska, most areas display relatively low abundance levels. Areas of highest relative abundance were off the eastern side of St. Lawrence Island, along the entrance to Norton Sound, and in the narrow waters of the Bering Strait. Hart and Dell (1986) reported very limited catches (< 3 fish) of juvenile pink salmon in the eastern Bering Sea. These fish were caught during September and October, similar to the sampling months of the BASIS, and primarily along the northern coast of the Alaska Peninsula and Unimak Island between long. 159°W and long. 165°W (Hartt and Dell 1986). Hartt and Dell did not sample areas in which we see a distribution of juvenile pink salmon based on the results from our analysis, however. Pink salmon exhibit fast growth rates, triggering faster offshore movement than seen in sockeye and chum salmon. By fall, pink salmon are distributed much farther offshore than sockeye and chum (Hartt and Dell 1986), which in part could explain why the distribution of juvenile pink salmon in our study are farther from the coast of western Alaska.

While none of the tested habitat variables appeared to be associated with the distribution of juvenile pink salmon, the preferred (central 95% tolerance range) habitat conditions of each environmental variable were mapped to display areas containing preferred habitat. Preferred habitat for juvenile pink salmon off western Alaska (Fig. 7b) encompasses the species' distribution (Fig. 7a) closely, including much of the inner and middle shelf out to the 100-m contour depth. The majority of Bristol Bay down the Alaska Peninsula to Unimak Pass, north to the entrance of Norton Sound, and along the northern coast of St. Lawrence Island display preferred habitat conditions of bottom depth, SST, and SSS. Water within the Bering Strait as well as along the coast from the northern entrance of Norton Sound past Cape Lisburne and into the Chukchi Sea (70.1°N) incorporate these preferred habitat conditions as well.

The majority of juvenile pink salmon within Alaska marine waters are distributed in the GOA (Fig. 7a). Within the GOA, juvenile pink salmon are heavily distributed inshore around the entire Gulf coast, from the southern edge of Kodiak Island in the western half of the GOA to Dixon Entrance on the southern end of the Alexander Archipelago in the eastern half of the GOA. Relative abundance of juvenile pink salmon is highest in nearshore waters, particularly within Shelikof Strait on the west side of Kodiak Island, off Cape Douglas northwest of Afognak Island, and within Montague Strait heading into Prince William Sound. On the eastern side of the GOA (east of Cape Suckling, long. 143.9ºW), juvenile pink salmon are distributed in inside waters of the Alexander Archipelago, as well as coastal waters from nearshore to the shelf break. High abundances of juvenile pink salmon are found within the northern Southeast Alaska waters of Icy Strait and upper Chatham Strait, and along the entire outer coast, from Ocean Cape near Yakutat Bay heading south to Dixon Entrance. It is thought that juvenile pink salmon abundance is high along southeast Alaska coasts from July to September because of the substantial production found in this region during this time (Hartt and Dell 1986). Hartt and Dell (1986) found juvenile pink salmon to be concentrated relatively close to shore throughout the coastal waters of the GOA. They saw high catches in late June in the southern part of their distribution, and higher concentrations close to shore in the northern GOA from July to October, revealing a seasonal increase of abundance around the coast of the GOA in a counterclockwise direction: northward, westward, and southwestward (Hartt and Dell 1986, Quinn 2005). No catches were reported offshore, reinforcing the migration pattern seen in juvenile pink salmon off western Alaska, in which the summer and early fall are spent along the GOA coast, with offshore movement occurring in late fall/early winter (Hartt and Dell 1986).

Preferred habitat for juvenile pink salmon (Fig. 7b) within the GOA includes the entire coastal belt of the Gulf, from nearshore waters to the shelf break from Unimak Pass to just beyond Kodiak Island. From Kodiak Island around the Gulf to Dixon Entrance, juvenile pink salmon are found nearshore to approximately 65 km beyond the 2,000-m isobath within oceanic waters. Within the Alexander Archipelago, waters containing ideal habitat conditions for juvenile pink salmon are found within Icy Strait, Chatham Strait, Sumner Strait, and Frederick Sound.

Marine Immature and Maturing Pink Salmon –

EFH for maturing adult pink salmon is the general distribution area for this life stage, located in ***coastal and*** *marine waters off the coast of Alaska to depths of 200 m and range from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. Mature adult pink salmon* ***are present from fall through the mid-summer in pelagic waters (upper 50 m) of the entire slope (0-200 m) before returning to*** *spawn in intertidal areas* ***and coastal streams.***

Mature pink salmon appear to be proportionally distributed with SSS, SST, and bottom depth (Table 4). While not a significant association, the preferred salinity tolerance range is one of the largest (22.3 – 32.5 ppt) (Table 5) within which mature Pacific salmon are found. The central 95% of mature pink salmon are found to prefer waters between 7.4°C and 14.8°C, displaying a narrower temperature tolerance range than that of juvenile pink salmon.

In contrast to juvenile pink salmon, only a small percentage of the spatial distribution of mature pink salmon (Fig. 8a) is found off western Alaska, in addition to having a more southerly distribution. Eighty percent of the sampled mature pink salmon were caught off western Alaska south of lat. 55.5°N. This small distributional area of mature pink salmon is found within Unimak Pass, and in nearshore waters along the northern coast of the Alaska Peninsula.

What has been calculated as preferred habitat for mature pink salmon (Fig. 8b) off western Alaska encompasses a much larger area than the actual species' distribution range, including the majority of the inner and middle shelf. Waters include all of Bristol Bay down the arm of the Alaska Peninsula to Unimak Pass. At Unimak Pass, the preferred habitat follows the 2,000-m isobath northwest to just beyond the Pribilof Islands. Beyond the Pribilofs (lat. 57°N, long.173.4°W), the area extends northeast to the 50-m isobath, following this contour until St. Matthews Island, then extending to the U.S. EEZ boundary (lat. 62.9°N, long. 174.6°W). North of this point, all waters contained between the west coast of Alaska and the U.S. EEZ boundary, from St. Lawrence Island north through the Bering Strait past Cape Lisburne into the Chukchi Sea (lat. 70.1°N), contain preferred habitat conditions for mature pink salmon as well.

In contrast to the distribution of juvenile pink salmon within the GOA, mature pink salmon within the GOA (Fig. 8a) are primarily found farther offshore around the Gulf coast as well as farther west along the Aleutian Chain, from Adak Island in the Aleutian Chain to Dixon Entrance in the southeast. Mature pink salmon are widely distributed in offshore areas of the GOA and along the southern side of the Aleutian Islands during spring and early summer (Hartt and Dell 1986, Quinn 2005). Higher abundances are found farther from shore, often along the shelf break and in oceanic waters as far offshore as the U.S. EEZ boundary. Throughout July, August, and September, offshore distribution decreases and inshore distribution increase as mature pink salmon migrate to spawn in streams (Hartt and Dell 1986). In the western half of the GOA, higher relative abundances are seen primarily over the shelf and start of the slope. Larger relative abundances are seen off the southern side of Adak Island, offshore from the Gulf side of Kodiak Island, and near the shelf break off the southern end and eastern side of the Kenai Peninsula. In the north central part of the GOA, high abundance is found at the shelf break and over oceanic waters off Cape St. Elias. In the eastern half of the GOA, larger abundances are seen throughout offshore oceanic waters, from the shelf break to the U.S. EEZ boundary. In contrast to the distribution of juvenile pink salmon within the inside waters of Southeast Alaska, mature pink salmon are primarily found over the shelf in outer coastal waters, particularly off Cape Ommaney on the southern end of Baranof Island, and Dall and Forrester Islands near Dixon Entrance.

Within the GOA, preferred habitat areas for mature pink salmon (Fig. 8b) generally correspond to the previously described distributional areas of the species. This area includes the entire coastal belt of the Gulf, from Kodiak Island on the west side of the Gulf to Dixon Entrance in the eastern half. This area essentially includes all waters within this region, from nearshore to beyond the 2,000-m isobath. The farthest this area extends is off Kodiak Island, approximately 190 km beyond the 2,000-m depth contour. Throughout the remaining areas of the GOA, the preferred habitat extends approximately 80 to 100 km beyond the 2,000-m isobath. Southwest of Kodiak Island, smaller areas of water containing ideal habitat conditions are found over the shelf from Unimak Pass to the western edge of Unalaska Island, and off the Alaska Peninsula between Krupeanof Point and Mitrofania Island. While a very small proportion of the species distribution is found within the inside waters of the Alexander Archipelago, the majority of these waters contain ideal habitat conditions for mature pink salmon. These areas include: Icy Strait, Chatham Strait, Sumner Strait, Clarence Strait, and Frederick Sound.

Marine Juvenile Coho Salmon –

Marine EFH for juvenile coho salmon is the general distribution area for this life stage, located in marine waters ***to a depth of 50 m*** *off the coast of Alaska from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.* ***Marine juvenile coho salmon inhabit these marine waters from June to September.***

Marine juvenile coho salmon are weakly associated with bottom depth (P = 0.124), but are proportionally distributed with available salinities and temperatures (Table 4). Juvenile coho salmon are found in warmer temperatures, as 75% of the sampled fish occurred at temperatures above 11.1°C. The central 95% of juvenile coho were collected in salinities ranging between 20 and 32.2 ppt, making this one of the broadest tolerable salinity ranges (Table 5), as well as some of the lowest tolerable salinity conditions that Pacific salmon of any species and life history stage are found. The tolerable juvenile coho salmon temperature range (8.8° – 14.9°C) is also one of the warmest and narrowest for Pacific salmon in all life history stages.

Juvenile coho salmon are distributed (Fig. 9a) throughout the inner shelf off western Alaska, from the arm of the Alaska Peninsula north through the Bering Strait. The southern waters along the inner shelf, beginning in Bristol Bay and following the coast northward to the southern edge of Nunivak Island, support higher relative abundances. The highest relative abundance in the EBS is seen farther south in nearshore waters off Izembek Lagoon along the Alaska Peninsula. North of Nunivak Island through the Bering Strait, juvenile coho salmon are evenly distributed throughout the inner shelf, however, abundance levels are relatively low. Coho salmon generally spend the majority of their marine life along the continental shelf (Quinn 2005).

Preferred habitat of juvenile coho salmon (Fig. 9b) off western Alaska incorporates the nearshore distribution of the species throughout the inner shelf, in addition to offshore waters (bounded by the 150-m depth contour) along the outer shelf from Bristol Bay to the Pribilof Islands. North of the Pribilofs (lat. 58.7°N, long. 173°W), this habitat is found only over the inner shelf to the 50-m isobath. At approximately lat. 59.5°N, long. 173.2°W, just south of St. Matthew's Island, this area cuts east until lat. 60.1°N, long. 170.6°W, where it then extends northwest to the U.S. EEZ boundary. From here, north through the Bering Strait to approximately lat. 70.2°N, all waters contained between the coast of western Alaska and the U.S. EEZ boundary contain ideal habitat conditions for marine juvenile coho salmon.

Juvenile coho salmon are more thoroughly distributed (Fig. 9a) throughout the coastal belt of the GOA, from Unimak Pass at the end of the Alaska Peninsula in the western half of the Gulf to the southern end of the Alexander Archipelago in the eastern half of the Gulf, displaying a seasonal progression in abundance along the coast toward the northwest in the eastern Gulf and southwest along the Alaska Peninsula (Hartt and Dell 1986). In contrast to its distribution off western Alaska, the distribution of juvenile coho salmon within the GOA consists of higher abundance levels, as well as fish being found in deeper waters farther offshore near the 2,000-m isobath. Areas boasting the highest relative abundance are all in coastal waters, throughout shelf and slope. Areas with relatively high abundances of juvenile coho salmon within the GOA include the Shelikof Strait by Kodiak Island, the north central Gulf shelf (from Resurrection Bay on the Kenai Peninsula to Ocean Cape by Yakutat Bay), and the shelf off the Alexander Archipelago (from Cross Sound in the north to Dixon Entrance in the south). Relatively high abundances of juvenile coho salmon are also found within the inside waters of Icy Strait and Upper Chatham Strait in the northern end of the Alexander Archipelago. Our study agrees with the findings of Hartt and Dell (1986) that juvenile coho can be found in northern coastal areas of the GOA as early as June, with our high abundances seen within this region. We also see juvenile coho offshore, as Dell and Hart (1986) did as soon as July, August, and September. This is an earlier offshore movement than seen in most juvenile Pacific salmon. Juvenile coho salmon may also spend their entire life in the protected waters of the Alexander Archipelago and in southern coastal waters (Hartt and Dell 1986).

Preferred habitat for marine juvenile coho salmon (Fig. 9b) within the GOA consists of all areas included within the species' distribution. This essentially includes the entire continental shelf within the GOA, beginning along the Alaska Peninsula near Mitrofania Island in the west and ending within Dixon Entrance in the southeast, and extends offshore to the U.S. EEZ boundary in the western Gulf. While the distribution of juvenile coho was relatively low within inside Southeast Alaska waters, preferred habitat includes a much larger area (i.e., Icy Strait, lower Chatham Strait, Sumner Strait, and all of Clarence Strait) which display ideal habitat conditions for juvenile coho salmon.

Immature and Maturing Coho Salmon –

EFH for mature coho salmon is the general distribution area for this life stage, located in marine waters ***to a depth of 200 m*** *off the coast of Alaska to 200 m in depth and range from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.* ***Marine mature coho salmon inhabit pelagic marine waters in the late summer, by which time the mature fish migrate out of marine waters.***

Bottom depth (P = 0.174) is the only habitat variable of the three tested with which mature coho salmon are weakly associated. Mature coho salmon are distributed in proportion to available temperatures and salinities (Table 4). Similar to juvenile coho, these fish prefer warmer temperatures (8.2° – 14.9°C).

Off the west coast of Alaska, mature coho salmon (Fig. 10a) are more southerly distributed (between lat. 55.3°'N and lat. 58.3°'N), as well as being closer to shore. Eighty percent of mature coho off western Alaska are east of long. 164°W. Of the species' 95% distribution range throughout Alaska waters, an area of low relative abundance along the northern arm of the Alaska Peninsula, from Unimak Pass north into Bristol Bay is the only distributional area of maturing coho salmon within the EBS. The remaining distributional areas of mature coho are all within the GOA (Fig. 10a), with a preference shown for outer coastal waters. One additional area of high abundance is found on the south side of the Aleutian Chain off Adak Island.

Preferred habitat for mature coho salmon (Fig. 10b) off western Alaska incorporates the southern distribution of this species, as well as waters farther north. From the Alaska Peninsula north to Nunivak Island, the entire continental shelf contains preferred SSS, SST, and bottom depth conditions for mature coho. From Nunivak Island north into the Chukchi Sea (approximately lat. 70.1°N), the preferred habitat is contained over the entire inner and middle shelf.

Within the GOA, the distribution of mature coho salmon (Fig. 10a) is very similar to that of juvenile coho, with fewer catches seen within the Alexander Archipelago and overall lower abundance levels. Relative abundance is consistent from nearshore waters out to the shelf break surrounding the coastal GOA belt, from Kupreanof Point on the Alaska Peninsula in the western side of the Gulf to the southern tip of the Alexander Archipelago in the eastern half. Areas with slightly higher abundance are seen in the west side of the Gulf nearshore off Cape Kaguyak on the western end of Kodiak Island, throughout the middle continental shelf off Gore Point on the southern tip of the Kenai Peninsula, along the shelf break off Resurrection Bay on the eastern side of the Kenai Peninsula, and in the nearshore waters off Cape St. Elias. In the eastern half of the GOA, mature coho salmon are distributed throughout the shelf along the entire outer coast, as well in offshore oceanic waters. Higher abundance is found near the entrance of Yakutat Bay, within Cross Sound, off Cape Ommaney on the southern end of Baranof Island, and at the entrance to Dixon Entrance. Fewer catches of mature coho salmon are seen within the Alexander Archipelago. Hartt and Dell (1986) reported catches of mature coho widely throughout offshore waters, as well as in coastal and inside waters in late spring and early summer. By mid- to late- summer, it is thought that maturing coho move northward and inshore towards spawning grounds (Hartt and Dell 1986). These results would help explain our findings of such a broad distribution throughout the shelf as well as in oceanic waters offshore. Sample timing potentially helps one determine where mature coho salmon will be distributed, in addition to the idea that some stocks of coho migrate extensively, moving offshore during their first summer, while other stocks remain in coastal oceanic areas or in inside waters during their entire marine phase of their life cycle (Hartt and Dell 1986, Quinn 2005).

Preferred habitat for mature coho salmon within the GOA (Fig. 10b) mirrors the species' distribution closely, except for areas of high density farther offshore in the GOA. This area essentially includes the entire continental shelf extending into offshore oceanic waters within the GOA, beginning along the Alaska Peninsula near Mitrofania Island in the west and ending within Dixon Entrance in the southeast. In the western half of the Gulf, the area extends on average 50-km beyond the 2,000-m isobath. This extension is considerably farther in the eastern half of the Gulf, where mature coho have a considerably larger offshore distribution. At its farthest point, this habitat extends approximately 165-km beyond the 2,000-m depth contour. Additional preferred habitat includes the shelf from Unimak Pass to Unalaska Island on the southern side of the Aleutian Chain.

Marine Juvenile Sockeye Salmon-

Marine EFH for juvenile sockeye salmon is the general distribution area for this life stage, located in all marine waters off the coast of Alaska to depths of 50 m and range from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean from midsummer until December of their first year at sea.

Of all Pacific salmon species in all life history stages, juvenile sockeye salmon show the greatest relationship to a certain range of habitat conditions, as they are strongly associated with waters having a specific bottom depth ($P = 0.01$) and salinity ($P = 0.01$). Juvenile sockeye salmon are associated proportionally with available temperatures ($P = 0.47$). In comparison to juveniles of other Pacific salmon species, sockeye salmon are found within a much smaller range of salinities (22.8 – 32.1 ppt).

Juvenile sockeye salmon are distributed (Fig. 11a) throughout waters along the entire west coast of Alaska, from the Alaska Peninsula north to Point Hope on the Lisburne Peninsula; however, relative abundance of this species is low north of Nunivak Island. Juvenile sockeye salmon are largely distributed and highly concentrated near the surface throughout shelf waters within Bristol Bay in the EBS, as far within the bay as long. 159°W, as far offshore as the shelf break at long. 168°W, and as far south as lat. 55.5°N. This distribution of juvenile sockeye salmon spreads north over the continental shelf to lat. 60°N, just north of Nunivak Island, and consists of relatively high abundance of the species. Highest relative abundance is seen throughout the middle shelf in the central region of Bristol Bay, and nearshore the Alaska Peninsula. The CPUE is especially high in these areas between July and September, as these areas are found to hold migrating juvenile sockeye from their respective Bristol Bay rivers (Hartt and Dell 1986). Sockeye salmon off western Alaska generally have the most southern distribution of all five salmon species. Ninety percent of the distribution of juvenile sockeye salmon off western Alaska is south of lat. 58.5°'N.

Preferred habitat for juvenile sockeye salmon (Fig. 11b) off the west coast of Alaska includes the entire range of the species' distribution. This area essentially includes all waters throughout the continental shelf from the Alaska Peninsula to the Chukchi Sea near lat. 70.1°N. From the Alaska Peninsula following the 500-m isobath northwest to approximately lat. 57.1°N, long. 173.49°W, juvenile sockeye salmon habitat consists of all water outwards from the coastline. From this point north past St. Matthews Island (approximately lat. 60.6°N, long. 174.7°W) preferred habitats are waters extending from the shore to the 100-m isobath. North of St. Matthews Island until approximately lat. 70.1°N in the Chukchi Sea, ideal habitat for juvenile sockeye salmon can be found in all waters between the Alaska coast and the U.S. EEZ boundary.

Distribution of juvenile sockeye salmon (Fig. 11a) within the GOA is generally contained to the continental shelf, with much smaller abundance levels than that seen within the EBS. However, these fish are distributed throughout the entire coastal belt, from Unalaska Island in the southwest to Dixon Entrance in the southeast. On the western side of the GOA, areas of highest relative abundance of juvenile sockeye salmon were found within the waters between Afognak Island and the southern tip of the Kenai

Peninsula, near the entrance of Cook Inlet by the Barren Islands. In the eastern half of the GOA, juvenile sockeye are distributed along the entire outer coast, from Cape Suckling to Dixon Entrance. This distribution consists of relatively low abundance levels, except near Icy Point and within Dixon Entrance, where relative abundance is higher. There are also two distributional areas with high abundance levels within the Alexander Archipelago. In northern Southeast Alaska waters, relatively high abundances of juvenile sockeye salmon are found within Icy Strait and upper Chatham Strait. In southern Southeast Alaska waters, lower Clarence Strait contains higher abundance levels of juvenile sockeye salmon as well. Previous studies have found juvenile sockeye salmon to enter the open ocean in late June (Hartt and Dell 1986). Our database consists of monthly surveys from May until September throughout inside and coastal Southeast Alaska waters, therefore capturing the dynamics of this distribution. By July, juvenile sockeye salmon are distributed throughout the east and northeast coasts of the GOA (Hartt and Dell 1986). By the fall they seem to be concentrated in the northern GOA before moving offshore (Quinn 2005).

In the GOA, preferred habitat for juvenile sockeye salmon (Fig. 11b) consists of the entire continental shelf and slightly beyond the 2,000-m isobath around the entire coastal belt of the Gulf, from Mitrofania Island in the southwest to Dixon Entrance in the southeast. South of the Aleutians, the shelf from Unimak Pass to Unalaska Island consists of habitat for juvenile sockeye salmon as well. The majority of inside waters within the Alexander Archipelago consist of ideal habitat for juvenile sockeye salmon as well, particularly: Icy Strait, Chatham Strait, Frederick Sound, Sumner Strait, and Clarence Strait.

Marine Immature Sockeye Salmon –

EFH for marine immature sockeye salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 m and range from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

Immature sockeye salmon are weakly associated with SST (P = 0.135), but are proportionally distributed with available SSS and bottom depths (Table 4). The range of salinities (30.9 – 32.9 ppt) that the central 95% distribution of immature sockeye salmon are found is the narrowest (Table 5) of all Pacific salmon.

By late spring, immature sockeye salmon have moved offshore, and by September and October, immature sockeye are distributed (Fig. 12a) north of the central Aleutian Islands (Hartt and Dell 1986). Immature sockeye salmon are generally distributed the farthest south of all Pacific salmon species, with 90% of the immature sockeye off western Alaska south of lat. 57°N, in addition to being the most westward, with 75% between long. 166°W and long. 170°W. In contrast to juvenile or mature sockeye salmon, immature sockeye are distributed farther from shore, particularly along the shelf break and over oceanic waters. Relatively high abundance levels are seen on both sides of Unimak Pass at the southern end of the Alaska Peninsula. In the EBS, this area of high abundance carries directly northwest along the edge of the shelf from Unimak Pass to about long. 171.3°W and then back east towards Bristol Bay near long.164°W.

Waters off western Alaska containing preferred habitat conditions for immature sockeye salmon (Fig. 12b) are smaller, area wise, in comparison to those for juvenile and mature sockeye salmon. This is likely due to the narrow range of SSS tolerance. Within the EBS, immature sockeye salmon range throughout the middle and outer continental shelf as far north as St. Lawrence Island, incorporating the species' spatial distribution. Off Bristol Bay, their habitat extends beyond the 2,000-m isobath by approximately 110-km. North of the Bering Strait until approximately lat. 70.2°N, offshore waters bounded by the U.S. EEZ on the west contain preferred habitat for immature sockeye salmon as well.

South of the Aleutian Islands, immature sockeye salmon are distributed (Fig. 12a) from Unimak Pass to Adak Island, along the shelf break out to the U.S. EEZ boundary. Relatively high abundance can be found over the shelf off Unalaska Island, and farther west in offshore waters south of Adak Island.

Distribution of immature sockeye salmon (Fig. 12a) within the GOA is heavily dependent on season. Studies have shown immature sockeye salmon to be distributed well offshore in the spring, and to migrate north and west during the summer, typically not re-entering coastal waters where juvenile sockeye salmon are habiting, except south of the Aleutian Islands, where one typically doesn't find juvenile sockeye (Hartt and Dell 1986). During late spring, these fish are distributed widely throughout the entire GOA and the southern side of the Aleutian Islands, extending from nearshore waters to the U.S. EEZ boundary (Hartt and Dell 1986). By mid-summer, this species' distribution shifts northward in the Gulf, as well as being highly abundant south of the central and eastern Aleutians (Hartt and Dell 1986). By late summer and early fall, abundance of immature sockeye is high south of the Aleutian Islands, and very few fish are seen within the GOA, particularly on the eastern half (Hartt and Dell 1986). Our studies support these findings. Within the GOA, we find immature sockeye salmon to be distributed from nearshore waters to the U.S. EEZ boundary throughout the entire Gulf, from Adak Island in the southwest to Dixon Entrance in the southeast. Our data shows relative abundance is to be highest in offshore waters, and particularly south of Adak Island in the Aleutian Chain. As mentioned before, these results are all dependent on survey timing.

In the western half of the GOA, from Mitrofania Island to Cape Suckling, preferred habitat for immature sockeye salmon (Fig. 12b) consists of waters from the coast to about 80-km beyond the 2,000-m isobath. East of Cape Suckling to Yakutat Bay, "ideal" habitat conditions for immature sockeye are farther offshore, extending approximately 95-km beyond the 2,000-m isobath. South of Yakutat Bay to approximately lat. 54.9°N, this area consists of waters over the shelf, and between 50 and 90-km beyond the shelf. In accord with the lack of immature sockeye salmon distributed within inside Southeast Alaska waters, there were no waters within the Archipelago exhibiting "ideal" habitat conditions as well.

Marine Mature Sockeye Salmon-

EFH for marine mature sockeye salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 m and range from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

Mature sockeye salmon are weakly associated with bottom depth (P = 0.174) and salinity (P = 0.194). The preferred depth range (26 – 2,900 m) is one of the deepest of all Pacific salmon species in all life history stages.

In the EBS, a small distributional area of mature sockeye salmon (Fig. 13a) is found over the middle shelf along the arm of the Alaska Peninsula, just north of Port Moller heading south beyond the shelf break off Unimak Pass. This distribution overlaps calculated preferred habitat (Fig. 13b). However, almost all waters off western Alaska provide a suitable environment for mature sockeye salmon. This area essentially includes all waters throughout the continental shelf from the Alaska Peninsula to the Chukchi Sea near lat. 70.2°N. From the Alaska Peninsula following the 1,000-m isobath northwest to approximately lat. 56.7°N, long. 173.5°W, habitat consists of all water outwards from the coastline. From this point north past St. Matthews Island (approximately lat. 59.5°N, long. 173.2°W) this area extends from the shore to the 100-m isobath. North of St. Matthews Island until approximately lat. 70.2°N in the Chukchi Sea, “ideal” habitat for juvenile sockeye salmon can be found in all waters between the Alaska coast and the U.S. EEZ boundary.

Distribution of mature sockeye salmon (Fig. 13a) within the GOA is widespread and sparse, consisting of low relative abundance extending from coastal waters to the U.S. EEZ boundary. It should be noted that sample sizes of this species were very small; therefore results may not accurately portray the entire distribution range of the species. The highest relative abundance of mature sockeye salmon is found in coastal waters along the southern part of the Alexander Archipelago within the GOA (Fig.13a). This distribution begins in coastal waters off Cape Ommaney on the southern end of Baranof Island, continues south along the coastal waters of the archipelago and into Dixon Entrance near Dall Island. This distribution of fish is predominately distributed throughout the shelf, with one exception: off southern Dall Island, the distribution of mature sockeye salmon reaches considerably offshore beyond the shelf break to long. 135.8°W. These results are likely the product of surveys catching mature fish migrating to their spawning streams, while the distribution seen offshore from Dall Island captured mature sockeye salmon distributed in offshore waters during the fall and winter before their return to natal streams to spawn. The only area within the inside waters of Southeast Alaska containing a portion of the 95% mature sockeye salmon distribution is within Icy Strait. Mature sockeye salmon are distributed throughout the shelf and in offshore waters in the western half of the GOA as well. Offshore waters off Kodiak and Afognak Island, nearshore waters off the southern side of the Kenai Peninsula, and waters extending from the coast near Cape Yakataga to the U.S. EEZ boundary area all areas of higher relative abundance.

Much of the sampled coastal waters of the GOA consist of "ideal" habitat conditions for mature sockeye salmon (Fig. 13b), even while the majority of the species are distributed along the southern half of the Alexander Archipelago. Mature sockeye salmon range throughout coastal marine waters from Mitrofania Island off the Alaska Peninsula to Dixon Entrance in the southeast and extend their range beyond continental shelf waters from the southern tip of Kodiak Island to Dixon Entrance. In the western half of the GOA, waters containing "ideal" habitat conditions for mature sockeye extend approximately 185-km beyond the shelf. In the east side of the GOA, habitat areas extend to the U.S. EEZ boundary. Waters over the slope from Unimak Pass south to Unalaska Island contain ideal habitat for mature sockeye as well.

Marine Juvenile Chum Salmon –

Marine EFH for juvenile chum salmon is the general distribution area for this life stage, located in all marine waters off the coast of Alaska to approximately 50 m in depth from the mean higher tide line to the 200-nmi limit of the EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

Juvenile chum salmon show a weak association with SST (P = 0.129), but have no associations with SSS or bottom depth (Table 3).

Juvenile chum salmon are thoroughly distributed (Fig. 14a) throughout the inner and middle shelf along the entire west coast of Alaska, from within Bristol Bay in the EBS, to the Chukchi Sea just past Point Hope in northern Alaska. Areas of highest relative abundance are west of Nunivak Island spreading northward over the inner shelf to the southwestern tip of St. Lawrence Island, as well as within the Bering Strait. Juvenile chum salmon off western Alaska have the most northern distribution of all juvenile Pacific salmon species, reaching lat. 70.1°N. Seventy-five percent of their distribution off western Alaska is north of lat. 55.3°'N. These results are from surveys occurring in late summer and early fall, therefore agreeing with the species distribution determined by Hartt and Dell (1986), in which only a small abundance of juvenile chum salmon were seen in the EBS in July, but an increase occurred in August.

Areas off western Alaska shown to contain preferred habitat conditions (Fig. 14b) for juvenile chum salmon include the northern distribution of this species (to approximately lat. 70.1°N), extending from shore to the 100-m isobath off Bristol Bay, and to the 50-m isobath in waters north of lat 58.5°N.

Within the GOA, juvenile chum salmon are distributed (Fig. 14a) throughout the inner and middle shelf along the Gulf coastline from Dixon Entrance to the eastern Aleutian Islands between July and September. In the southern part of their range, juvenile chum salmon leave estuaries in late June to enter the open ocean. Their abundance appears to increase in a counterclockwise fashion around the GOA coast as the summer and fall seasons progress: emergence in June into southeast waters, with catches increasing in the north central and southwest regions of the Gulf from August to October (Hartt and Dell 1986). These fish have generally moved off the continental shelf into open waters by the end of their first fall at sea (Quinn 2005). In the eastern half of the GOA, there are very few concentrations of juvenile chum salmon within the inside waters of Southeast Alaska; however, it is within these inside waters in which we find the highest relative abundance of the species. In northern Southeast Alaska waters, high abundance of juvenile chum salmon is found within Icy Strait and upper Chatham Strait. On the southern end of the Alexander Archipelago, juvenile chum salmon are found inhabiting Clarence Strait. In coastal waters in the eastern GOA, waters off Ocean Cape by Yakutat Bay and nearshore waters near the entrance to Cross Sound are areas of particular high abundance. While juvenile chum salmon appear to have a thorough distribution in the western half of the GOA, these are mostly low abundance areas. Areas of high relative abundance of juvenile chum salmon in the western half of the Gulf are over the inner and middle shelf off the Kenai Peninsula, within Montague Strait, and over the middle shelf off Cape St. Elias.

Preferred habitat for juvenile chum salmon (Fig. 14b) within the GOA essentially encompasses the same area as the species' spatial distribution. This area includes the entire coastal belt extending to the 2,000-m isobath, from Mitrofania Island off the Alaska Peninsula in the southwest to Dixon Entrance in the southeast. Within the Alexander Archipelago, additional areas are found within the inside waters of Icy Strait, Chatham Strait, and Lynn Canal in the north, and Sumner Strait, Frederick Sound, Clarence Strait, and Behm Canal in the south. One additional area for juvenile chum salmon is found over the shelf from Unimak Pass to Unalaska Island on the southern side of the Aleutian Chain.

Marine Immature Chum Salmon –

EFH for immature chum salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 m and ranging from the mean higher tide line to the 200-nmi limit of the EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

The distribution of immature chum salmon is weakly associated with bottom depth (P = 0.063), showing a preference for deeper waters (26 – 4,000- m), but is not associated with either salinity or temperature (Table 4). Immature chum salmon display one of the smallest preferred salinity ranges of all Pacific salmon species, 29.9 – 32.8 ppt, and a preference for the deepest waters (Table 5) of all salmon species in all life history stages.

Off western Alaska, immature chum salmon (Fig. 15a) are found in the northern range of surveyed waters, with distributions reaching lat. 64°N. Immature chum salmon are also found farther offshore, throughout the middle and outer shelf extending into oceanic waters. Seventy-five percent of their distribution is west of long. 166°W. The majority of immature chum salmon are distributed within a region just off Unimak Pass heading northwest along the 2,000-m isobath beyond the Pribilof Islands, and then east over the middle shelf towards Bristol Bay. This distribution continues through Unimak Pass into the southern side of the Aleutians, with a relatively high abundance along the shelf break directly off Unimak Pass to Adak Island. An extremely high abundance of immature chum salmon has been found offshore Adak Island. A second area of high relative abundance is found surrounding St. Lawrence Island directly off Norton Sound, particularly along the northern coast of the island.

As seen by the species' distribution off western Alaska (Fig. 15a), waters containing preferred habitat for immature chum salmon (Fig. 15b) are farther offshore as well. From Bristol Bay north to Cape Newenham, this area consists of waters over the middle and outer shelf, extending beyond the 2,000-m isobath. North of Cape Newenham to Point Hope on the Lisburne Peninsula in the Chukchi Sea, immature chum salmon are found throughout the innershelf, but not the nearshore area.

Following what was seen in the EBS, immature chum salmon within the GOA (Fig.15a) are distributed widely offshore throughout the outer shelf and over oceanic waters as far offshore as the U.S. EEZ boundary. Throughout the coastal belt, immature chum salmon are distributed nearshore as well, but with smaller abundance levels. This distribution is consistent from the southern side of Adak Island within the Aleutian Chain around the Gulf coast to Dixon Entrance in the southeast. Areas of particularly high abundance are in offshore waters south of Adak Island, off the southeastern side of the Kenai Peninsula, and throughout the entire central GOA throughout oceanic waters. Seventy-five percent of the distribution of immature chum salmon in the GOA is found west of long. 148.6°W. In the eastern half of the GOA, the amount of immature chum salmon in offshore waters is lower than in the western Gulf, yet immature chum salmon are thoroughly distributed over the shelf down the entire coast. These areas all display lower abundance levels in comparison to the distribution in the western half of the GOA.

The distribution of immature chum salmon (Fig. 15b) within the GOA includes the entire coastal belt, extending beyond the 2,000-m isobath, from Mitrofania Island off the Alaska Peninsula in the southwest, to Dixon Entrance in the southeast. This region includes nearshore to oceanic waters, except south of Cape Ommaney on Baranof Island, where immature chum salmon are found throughout the outer shelf and oceanic waters only. Farther west, a small area containing preferred habitat conditions is found within Unimak Pass, heading south of the Aleutians throughout the entire shelf from to the western edge of Unalaska Island. Following what has been seen as an offshore preference of habitat, immature chum salmon are found only within Icy Strait and upper Chatham Strait in the inside waters of the Alexander Archipelago.

Marine Mature Chum Salmon –

EFH for mature chum salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 m and ranging from the mean higher tide line to the 200-nmi limit of the EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

Mature chum salmon are distributed proportionally to available SST, SSS, and depth conditions (Table 4). Mature chum salmon can be found within a small range of salinity conditions (24.8 – 32.5 ppt), as well as one of the broadest and deepest ranges of water (26 – 3,606-m). This is the smallest range of salinities and broadest range of depths, including the deepest waters, that mature Pacific salmon are found.

Mature chum salmon off western Alaska have two major distributional areas (Fig. 16a): southern and northern. The southern distribution inhabits waters nearshore along the arm of the Alaska Peninsula, from just north of Port Moller south to Unimak Pass, and farther offshore following the shelf break past the Pribilof Islands. The southern distribution of mature chum salmon off western Alaska consists of low relative abundance. In the north, mature chum salmon are distributed around St. Lawrence Island directly off Norton Sound, with relatively high abundances on the northern side of the island.

Areas containing preferred habitat for mature chum salmon (Fig. 16b) off western Alaska encompass the two northern and southern distributions of mature chum as well as in waters throughout the inner and middle shelf in between. From the Alaska Peninsula following the 2,000-m isobath northwest to approximately lat. 56.5°N, long. 173.2°W, this habitat consists of all water outwards from the coastline. North from this point until St. Matthews Island, habitat includes those waters from shore extending to the 100-m isobath. North of St. Matthews Island until approximately lat. 70.1°N in the Chukchi Sea, ideal habitat for mature chum salmon can be found in all waters between the Alaska coast and the U.S. EEZ boundary.

Mature chum salmon within the GOA display a distribution (Fig. 16a) similar in part to both juvenile and immature chum salmon species' ranges. As seen with immature chum salmon, mature chum salmon are primarily found in outer coastal and offshore oceanic waters. Similar to the distribution of juvenile chum salmon, mature chum salmon are distributed throughout the entire GOA. The highest relative abundance of mature chum salmon is seen along the shelf break and over oceanic waters throughout the entire Gulf, but primarily from Kodiak Island to Yakutat Bay. In the eastern half of the Gulf, the only distribution seen in inside waters is within Icy Strait and upper Chatham Strait in the northern part of the Alexander Archipelago, and these areas consist of relatively low abundances

Preferred habitat for mature chum salmon within the GOA (Fig. 16b) includes almost all waters within the Gulf, both nearshore and offshore, from Mitrofania Island off the Alaska Peninsula extending around the Gulf to Dixon Entrance, including the inside waters of Southeast Alaska. The exception to this is an area found in the central Gulf, between long. 147.8°W and long 141.6°W, and lat. 59.1°N and the U.S. EEZ boundary. In the western half of the Gulf, Unimak Pass and waters over the shelf down the Aleutian Chain to Unalaska Island are found to contain mature chum habitat as well. The majority of waters within the Alexander Archipelago are also considered preferred habitat, including the following: Clarence Strait, Sumner Strait, Frederick Sound, Icy Strait, Cross Sound, and Chatham Strait.

Marine Juvenile Chinook Salmon –

Marine EFH for juvenile Chinook salmon is the general distribution area for this life stage, located in all marine waters off the coast of Alaska from the mean higher tide line to the 200-nmi limit of the EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. ***Marine juvenile Chinook salmon are at this life stage from April until annulus formation in January or February, during their first winter at sea.***

Marine juvenile Chinook salmon are proportionally associated with available SSS, SST, and bottom depth conditions (Table 4).While not significantly associated with either of the following habitat variables, the central 95% of the sampled juvenile Chinook salmon distribution is found within shallower waters (18 – 447 m) and cooler surface temperatures (5.1° – 14.7°C). This temperature range is broader, as well as colder, than temperatures (Table 5) where juvenile salmon of all the remaining species are found.

In the EBS off western Alaska, juvenile Chinook salmon (Fig. 17a) are found closer to shore, with 90% of their distribution east of long. 169°W. Juvenile Chinook are found throughout the inner shelf from within Bristol Bay to the Bering Strait, yet the majority of this distribution consists of low levels of abundance. There are two areas of noticeably higher abundance: off Cape Constantine within Bristol Bay spreading northwest along the coast past Cape Newenham into the southern entrance of Kuskokwim Bay, and farther north near the southern edge of St. Lawrence Island moving into Norton Sound and up the coast of the Seward Peninsula to the edge of the Bering Strait. Chinook salmon will often spend most of, if not all of, their marine life in coastal waters, generally north of their river of origin or close to their natal river (Quinn 2005).

Preferred habitat for juvenile Chinook salmon off western Alaska (Fig. 17b) essentially includes the entire inner and middle shelf, including all areas of the species' distribution. Waters include all of Bristol Bay down the arm of the Alaska Peninsula to Unimak Pass. At Unimak Pass, this region follows the 150-m isobath northwest to just beyond the Pribilof Islands. Beyond the Pribilofs (lat. 56.8°N, long. 173.3°W), the area extends northeast to the 50-m isobath, following this contour until St. Matthews Island, in which the area containing EFH extends to the U. S. EEZ boundary (lat. 63.1°N, long. 174.3°W). North of this point, all waters contained between the west coast of Alaska and the U.S. EEZ boundary, from St. Lawrence Island north through the Bering Strait past Cape Lisburne into the Chukchi Sea (70.1°N), contain preferred habitat conditions for juvenile Chinook salmon as well.

In the GOA, juvenile Chinook salmon (Fig. 17a) occur progressively along the coast of the GOA to the northwest and southwest in mid-summer to early fall, with abundance declining in the northern areas in September and October, and a late season presence within the inside waters of Southeast Alaska (Hartt and Dell 1986). These fish will often spend the majority if not entirety of their marine life in coastal waters (Quinn 2005). The majority of the juvenile Chinook salmon are distributed within the inside waters of the Alexander Archipelago in the eastern Gulf. In northern Southeast Alaska waters, the Taku Inlet and Upper Chatham Strait are areas with smaller relative abundances of juvenile Chinook salmon. Relative abundance of juvenile Chinook salmon increases within Icy Strait. On the southern end of the Alexander Archipelago, the relative abundance of juveniles is high from Cape Decision into Sumner Strait, as well as off Cape Ommaney on the southern end of Baranof Island, and within Frederick Sound. On the west side of the GOA, distributions containing relatively small abundance of juvenile Chinook salmon are found throughout inner-shelf waters off Cape Douglas and Resurrection Bay, as well as throughout the outer shelf off the southern end of Montague Island.

While the majority of the distribution of juvenile Chinook salmon is within inside Southeast Alaska waters, the entire coastal belt of the GOA, from the coast extending beyond the shelf break, is considered to contain "ideal" habitat conditions for juvenile Chinook salmon (Fig. 17b). This region begins along the Alaska Peninsula at Krupeanof Point, continuing around the entire Gulf to Dixon Entrance at the most southern point of Southeast Alaska. Preferred habitat areas are off the Alaska Peninsula, southwest of Kodiak Island, and encompass those waters beyond the 2,000-m depth contour, extending approximately 210-km beyond this isobath. In the eastern half of the Gulf, EFH from Yakutat Bay to just beyond Cross Sound extend approximately 160-km beyond the 2,000-m depth contour. The remaining waters for juvenile Chinook salmon generally extend approximately 50-km beyond the 2,000-m isobath. Following the species distribution closely, the majority of inside waters within the Alexander Archipelago display ideal habitat characteristics for juvenile Chinook salmon. These areas include Icy Strait, Chatham Strait, Taku Inlet, and Stephen's Passage in the north. In the south, Sumner Strait, Fredrick Sound, Behm Canal, and Clarence Strait are all preferred habitat for juvenile Chinook salmon.

Marine Immature Chinook Salmon –

EFH for marine immature Chinook salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska and ranging from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

Immature Chinook salmon were weakly associated with temperature (P = 0.055) but not with SSS or bottom depth (Table 4). Immature Chinook salmon display a preference for warmer temperatures (6.5° – 15.5°C) than seen in juvenile and mature Chinook salmon, however, these conditions are still cooler than temperatures in which immature fish of the other Pacific salmon are found (Table 5). Depth conditions (Table 5) are deeper than those in which juvenile Chinook are found.

Immature Chinook salmon are distributed (Fig. 18a) broadly throughout the continental shelf and over the slope off western Alaska from Bristol Bay south along the Alaska Peninsula past Unimak Pass, offshore past the Pribilof Islands to long. 173°W, and northward through the Bering Strait. These fish are distributed farther offshore than Chinook salmon juveniles, and also migrate farther offshore than stocks within the GOA (Hartt and Dell 1986).While this distribution is rather expansive, these areas have low relative abundance for the species.

The distribution of immature Chinook salmon off western Alaska is broad and the calculated preferred habitat (Fig. 18b) incorporates this distribution well. All of Bristol Bay waters, down to Unimak Pass, are considered preferred habitat for immature Chinook salmon. This area extends offshore from Unimak Pass, following the 1,000-m isobath until approximately lat. 57.1°N, when potential immature Chinook EFH moves closer to shore, following the 100-m isobath until cutting to the U.S. EEZ boundary at lat. 60.4°N, long. 174.3°W. This region follows the distribution of immature Chinook salmon to the northern coast of St. Lawrence Island, and continues farther north beyond the species distribution range into the Chukchi Sea near lat. 70.1°N.

The remaining distribution range of immature Chinook salmon (Fig. 18a) is found throughout the shelf within the GOA, particularly south of Adak Island, off the southeastern tip of the Kenai Peninsula, and within Icy Strait and upper Chatham Strait in northern Southeast Alaska waters. While juvenile Chinook salmon are primarily distributed within the Alexander Archipelago, immature Chinook salmon within the GOA are distributed throughout the Gulf coast, but primarily on the west side of the GOA and the southern side of the Aleutian Islands.

Preferred habitat for immature Chinook salmon (Fig. 18b) within the GOA mimics the species' distribution closely, generally extending just beyond the outer continental shelf in areas in which the species is distributed. One small area of preferred habitat exists throughout the shelf in the stretch of water from Unimak Pass to Unalaska Island. Farther north and east, just beyond Kupreanof Point along the Alaska Peninsula, begins an area containing preferred habitat conditions for immature Chinook salmon. This area continues around the entire coast, stopping short of Dixon Entrance near lat. 54.9°N, long. 134.1°W, and, includes waters extending from the nearshore from Kupreanof Point to Cross Sound. Immature Chinook salmon habitat then moves farther offshore, spanning waters between the 150-m isobath and upwards of 50-km beyond the 2,000-m isobath near Kanz Bay off Chichagof Island heading south to lat. 53.5°N, long. 134.1°W. Inside Southeast Alaska waters are confined strictly to areas within the species distribution as: Icy Point and upper Chatham Strait in the north, and lower Clarence Strait to the south.

Compared with juvenile Chinook salmon, immature Chinook salmon were distributed farther offshore over the shelf in the Bering Sea and were more extensively distributed throughout the GOA.

Marine Mature Chinook Salmon –

EFH for marine mature Chinook salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska and ranging from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. ***Marine mature Chinook salmon inhabit pelagic marine waters from January to September, by which time the mature fish migrate out of marine waters.***

Mature Chinook salmon have a weak association with bottom depth ($P = 0.128$), but are proportionally distributed with available salinities and temperatures (Table 4). In comparison to Chinook salmon in the juvenile and immature life history stages, mature

Chinook are found in deeper waters (66 – 2755 m), colder temperatures (4.2° – 13.9°C), and within a similar range of salinities (20.8 – 32.5 ppt). Seventy-five percent of mature Chinook salmon is found in salinities greater than 30.4 ppt. The preferred tolerance range for temperature (Table 5) is the broadest and coldest for all species of salmon in all maturity stages.

Ninety-five percent of the spatial distribution of mature Chinook salmon (Fig. 19a) is entirely within the GOA, with the highest abundances found along the outer coast and inside waters of the Alexander Archipelago. Seventy-five percent of their distribution is south of lat. 55.4°N. Areas of relatively high abundance are found near the entrance to Sumner Strait and the inside waters of Stikine Strait and upper Chatham Strait. Mature Chinook salmon are seen as far offshore as long. 135.1°W off the southern end of the Alexander Archipelago. Once again, these results are strongly influenced by the timing of the surveys used in this study. The high relative abundance of mature Chinook found within inside Southeast Alaska waters are likely from surveys carried out in the summer months of June, July, and August when mature salmon are returning to spawning streams. The offshore distribution off the southern end of the Archipelago was observed during winter sampling, when mature fish are more likely to be offshore in oceanic habitats.

Although none of the 95% of the spatial distribution of the species' range is outside of the GOA, all waters throughout the continental shelf off western Alaska, from Unimak Pass north into the Chukchi Sea (lat. 70.2°N), is considered to contain desirable habitat conditions for mature Chinook salmon (Fig. 19b). While the majority of the spatial distribution of mature Chinook salmon (Fig. 19a) is in the eastern half of the GOA, almost all the waters within the Gulf are considered to contain “ideal” habitat conditions for mature Chinook salmon. Nearshore to considerably offshore waters from Kupreanof Point on the Alaska Peninsula around the Gulf coast to Dixon Entrance in the southeast are all considered to be preferred habitat. One area of oceanic waters within the central Gulf which does not meet these criteria is located from approximately long. 147.7°W to long. 141.5°W, and lat. 56.32°N to lat. 58.7°N.

CONCLUSIONS

The role of habitat association plays a key role in the designation of EFH for Pacific salmon in the marine environment, and subsequently re-defines areas of EFH for more effective management. Our methodology helps validate and refine current EFH designations for salmon and helps to identify patterns of habitat preference. Frequency distributions of survey catch data allowed a comprehensive analysis of the distribution of the CPUE of Pacific salmon and its relationship with SSS, SST, and bottom depth. After we identified areas of important habitat relative to high fish abundance, the re-defined EFH was smaller in area by an average of 71.3% (Table 3).

Identifying environmental influences on salmon distribution seems logical, as water is the medium surrounding fish, and salmon move in response to temperature, salinity, dissolved oxygen, pH, and other attributes of their immediate environment (Quinn 2005). Therefore, our proposed methodology attempted to incorporate these factors into EFH designation. However, our results suggest that bottom depth, temperature, and salinity alone do not dictate the distribution of Pacific salmon in marine waters. If water is too warm or saline, these factors alone do not provide directional cues for salmon to move to a more favorable environment (Burgner 1984). These results may also be a reflection of the broad range of environmental conditions that salmon are able to occupy, and that other factors not included within this data set may have a stronger influence on the distribution of the relative abundance of Pacific salmon within the U.S. EEZ off Alaska. In particular, SST and SSS may not be a consistent indication of temperatures and salinities at depths inhabited by salmon. Archival tag data and vertical distribution studies of salmon in the marine environment (Machidori 1966; Taylor 1969; Godfrey et al. 1975; Orsi et al. 1987; Ogura 1994) have shown that salmon habitat selection has a vertical component as well, and that vertical distribution of salmon differs significantly by species and age-group (Orsi and Wertheimer 1995). Future work looking at vertical distribution data in combination with SST and SSS data would likely give further explanation to habitat selection of salmon. Studies by Orsi and Wertheimer (1995) showed that preferred water temperature differed by species and undoubtedly influenced their vertical distribution. In addition, salmon EFH at Level 1 has historically been designated to include all waters within a defined geographic boundary (entire EEZ). Inclusion of vertical habitat data may allow for more specific designations of EFH and subsequent management action. For example, a specified depth domain could be designated as Chinook salmon EFH in the central Gulf because it is known that the vertical distribution of Chinook salmon is between depths of 20 – 110 m (Major et al. 1978). An area could then be conserved from any adverse effects from fishing activities (gears) within those depths. However, the area could remain open to other gear types that would not have any adverse effect on fishing that would occur at depths other than those occupied by Chinook salmon.

EFH is to be described with the most recent information and best data available. Levels of information (Levels 1-4) detail how information should be used to make each description. For EFH species within Alaska, including Pacific salmon, information does not exist or is limited to describe EFH only as Level 1 General Distribution. While site-specific research can delineate EFH at a much greater detail, broadly ranging species, such as salmon, challenge data to define EFH at higher levels throughout the entire stocks' range. A problem with relying on methods meeting Level 2 EFH requirements (habitat-related densities) is that the spatial distribution of salmon in marine waters is likely the result of numerous factors in the ocean environment, and oceanographic conditions can vary considerably. Level 2 EFH allows for a certain degree of uncertainty to exist; however, the key is the relationship to habitat value. Simply, we cannot estimate habitat value as uncertainty; seasonal habitat utilization, and annual variances must be accounted for within its EFH description. While our dataset covers multiple years of sampling throughout a wide geographic range, the spatial scales of physical processes and associated temporal changes in the ocean environment make it very difficult to conduct a detailed analysis of the environmental factors that control the spatial distribution of salmon. Often times, several factors can be confounded, or may mask other variables at play. For example, temperature and salinity are conditions of the water column which may mask the influence of oxygen concentration or prey distribution

(Perry and Smith 1994). Water depth may also serve as a pretense for increased fish production as a result of high chlorophyll *a* concentrations (Chl) (Ware and Thomson 2005). Juvenile Chinook and coho residing in coastal waters along the Washington and Oregon coast are believed to have spatial distributions influenced by water depth (Brodeur et al. 2004; Beamish et al. 2005; Bi et al. 2007) and Chl (Brodeur et al. 2004; Bi et al. 2007). The distribution of Chl is often characterized by higher levels of nutrient enrichment in shallower waters close to the coastline, which attracts small pelagic fishes due to the higher concentration of food associated with these productive waters (Bi et al. 2008; Cieciel et al. 2009). After investigating whether it was the shallow depth attracting juvenile salmon, or the high prey abundance attracted to increased Chl within the shallow waters over the shelf, it was concluded that the primary reason why juvenile salmon were found only in nearshore shallow shelf waters, was prey abundance (Pearcy and Fisher 1990; Bi et al. 2008; Cieciel et al. 2009). Although our results show that salmon distributions may not be related directly to temperature, depth, or salinity, the relationships explored between salmon distribution and these three variables may serve as reasonable first conjectures for other factors at play.

Newly described EFH in our study consistently incorporated much larger areas than those areas containing the highest relative abundance of the species. This may be an issue with annual and seasonal SST and SSS changes, and exposes a potential problem with using the Perry and Smith (1994) methodology for defining EFH. While we were able to identify the “preferred” habitat conditions (temperature, salinity, and depth), and were able to map areas where these variables all correspond together, SST and SSS conditions can change drastically in an area by season and year. Recent climate records for the Bering Sea alone indicate 2000, 2001, and 2006 as being cold years, and 2002 – 2005 as being warmer years (Farley et al. 2009). Annual comparisons were carried out between these warm and cool years in the EBS, and habitat associations were not consistent. This led investigators to believe that any associations found between juvenile salmon and their habitats was likely a result of salmon migration patterns instead of an association with a particular habitat characteristic (Farley et al. 2005; Cieciel et al. 2009). Using a similar habitat-abundance analysis, Bi et al. (2008) noted varying sizes of favorable habitat on a year to year basis for juvenile Chinook and coho salmon off the coasts of Washington and Oregon. Relying on fluctuating environmental variables to describe habitat essential for a fish's survival may not be effective or reliable. Thus, any future work should compare habitat associations between the two regions (EBS/Chukchi Sea and the GOA), among years, and address seasonality. Alternative methods of defining EFH due to relative high abundance may be worth exploring (i.e. habitat suitability index (HSI) modeling as a means to estimate the spatial distributions of species in relation to habitat across environmental gradients (Rubec et al. 1998), mathematical optimization through simulated annealing (Cook and Auster 2005), principal components analysis (PCA) of the presence or absence of species across some environmental gradient to determine biologically relevant environmental zones (Rubec et al. 1998), and gradient maps derived from spatial components fit with catch distribution data (Lanz et al. 2009)).

Related to the problem of variable environmental conditions is the lack of fall and winter data within this study (Table 1). Oceanographic conditions are much different in the winter season, and not incorporating these data excludes a large part of the salmon habitat picture. More data from the fall and winter seasons and an increase in offshore sampling would give a more thorough picture of preferred habitat conditions for Pacific salmon within the marine environment, specifically for immature and mature salmon. Very little is known about the movements of immature salmon at sea, and especially their behavior and ecology in winter (Quinn 2005). Inclusion of winter data would also provide a better understanding of seasonal marine salmon movement patterns and marine survival. It is important to note that this study is likely just the beginning of what is to be a topic further analyzed, and the resulting database will only benefit from having more data added in the future. If this fall and winter data were available and could be combined with our existing data set, then perhaps a more comprehensive seasonal analysis could be done to better define salmon EFH in the U.S. EEZ off Alaska.

There are several potential datasets that could be examined to further describe salmon EFH, for example: data from the commercial trawl fisheries in Alaska, the coast wide coded wire tag (CWT; RMIS; http://www.rmpc.org/, Received 9 June 2010) database of AFSC, decade's worth of Japanese fisheries and foreign survey data, data from the Alaska Department of Fish and Game (ADFG) Mark, Tag, and Age Laboratory (http://tagotoweb.adfg.state.ak.us/, Received 9 June 2010), and other International North Pacific Anadromous Fish Commission (INPAFC) report volumes could be mined for data, like what we accomplished with the Hartt and Dell (1986) volume on juvenile salmon. For example, Takagi et al. (1981), has extensive seasonal data on pink salmon tagging and migration in the North Pacific Ocean. The commercial trawl fisheries data will be of particular interest, as Chinook and chum salmon occur as bycatch in these pelagic/mid water and benthic trawl fisheries both in the GOA and BS. Particularly for Chinook salmon, this is a prime data set for future consideration in describing EFH definitions in terms of the spatial and temporal occurrence of this species. In addition, the commercial trawl fisheries data will provide crucial data gathered during times of the year not surveyed with research cruises.

Expanding the geographical coverage in our existing dataset with other sources would help fill several gaps.While our study includes a data set of wide geographical coverage, there still remain areas that have been surveyed more than others, areas that have not been surveyed at all, and areas that have been surveyed but the data wasn't accessible for this study. These include waters north of the Aleutians and within the Bering Sea west of 170˚W, waters within the international "donut hole" in the Bering Sea, inside Cook Inlet, and the Arctic (Chukchi and Beaufort Seas), to name a few. The use of kriging within ArcView GIS helped overcome this problem when defining species spatial distribution, however, we are only able to use our proposed methodology to re-define essential habitat in waters that have been surveyed. The exploration of additional data sources in the future may help fill the geographical gaps of the current dataset.

Ecosystem-based fisheries management methods imply that there is extensive knowledge of the physical factors controlling Pacific salmon distribution and abundances. Although significant associations between habitat and salmon distribution were not found, and there are likely many other factors influencing the distribution of Pacific salmon, this study helped provide a general, workable concept of the contribution of three physical factors (temperature, salinity, and bottom depth) to the distribution of Pacific salmon. Updated spatial distributions of each of the five Pacific salmon species in each life history stage were determined and mapped. These distributions, along with environmental variables, were used to calculate, re-designate, and map EFH. Smaller EFH areas for all Pacific salmon species by each life history stage within the Alaska EEZ can be accomplished, therefore providing for more effective and informed management. This has been the first time that salmon data sets from multiple surveys, agencies, and years have been accumulated and formatted for Pacific salmon distribution and habitat analysis. Not only will the resulting database of this project be of invaluable use for future research, a much greater understanding of Pacific salmon in the marine environment has been gained. It is necessary to better understand salmon habitat-related densities and the value of this habitat (i.e., EFH Level 2) before exploring mechanisms that might control their growth and survival, which is the next step in defining EFH within Level 3 (NMFS 2005).

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TABLES AND FIGURES

Table 1. -- Summarization of effort by data set used for spatial distribution and habitat analysis.

Data set	Source	Years conducted	Season of survey	Survey method	Total effort (km^2) (area trawled or swept)	Total number of hauls/sets
OCC	NMFS, AFSC	1999 - 2007	Late summer – early fall	Surface trawl	260 km^2	1157
SECM	NMFS, AFSC	1997 - 2009	Summer – Early Fall: May – October	Surface trawl	35.6 km^2	1333
DFOC	DFOC	1995 - 2009	Year round: Feb., March, June, July, August, Sept., Oct., Nov., Dec.	Surface trawl	140.2 km^2	953
NMFS_GLOBEC	NMFS, AFSC	2000 - 2004	July and August; November and October in 2004	Surface trawl	32.8 km^2	709
NMFS_Highseas	NMFS, AFSC	1997 - 1999	Summer: May, July, August	Surface trawl	65.1 km^2	147
UAF_GLOBEC	UAF & GLOBEC	1999, 2001 - 2004	Summer and Fall: July – October	Surface trawl	12.3 km^2	145
Hartt and Dell	University of Washington, NMFS, INPFC	1964 - 1968	Spring – Fall: April - October	Purse Seine	211 km^2	836

Table 2. -- Definitions of quantities associated with equations in the text.

n_h	=	number of hauls or sets in stratum *h* ($h = 1, \ldots, L$)
n	=	$\sum_{h=1}^{L} n_h$, total number of hauls
W_h	=	N_h / N , proportion of the survey area in stratum *h*
y_{hi}	=	number of fish of a particular species caught in set *i* ($i = 1, \ldots, n_h$) and stratum h
$\bar{y}_h$	=	estimated mean abundance of a particular species of fish in stratum *h*
$\bar{y}_{st}$	=	$\sum_{h=1}^{L} W_h \bar{y}_h$, estimated stratified mean abundance for a particular species of fish
x_{hi}	=	measurement for a hydrographic variable in set *i* of stratum *h*

Table 3. -- Existing, refined, and percentage decrease in calculated size of EFH for all five Pacific salmon species in each life history stage. Calculations are in square kilometers.

		Area in square kilometers (km^2)		
Species	Life history stage	Existing EFH description	Refined EFH description	Percentage decrease (-) in EFH area as compared to existing EFH description
Pink salmon	Juvenile	3,974,737.90	1,161,794	**-70.8**
Pink salmon	Mature	3,974,737.90	1,165,337	**-70.7**
Coho salmon	Juvenile	3,974,737.90	1,090,060	**-72.6**
Coho salmon	Mature	3,974,737.90	1,188,599	**-70.1**
Sockeye salmon	Juvenile	3,974,737.90	1,142,809	**-71.2**
Sockeye salmon	Immature	3,974,737.90	891,083	**-77.6**
Sockeye salmon	Mature	3,974,737.90	1,267,260	**-68.1**
Chum salmon	Juvenile	3,974,737.90	1,088,141	**-72.6**
Chum salmon	Immature	3,974,737.90	1,037,309	**-73.9**
Chum salmon	Mature	3,974,737.90	1,276,365	**-67.9**
Chinook salmon	Juvenile	3,974,737.90	1,100,137	**-72.3**
Chinook salmon	Immature	3,974,737.90	1,143,035	**-71.2**
Chinook salmon	Mature	3,974,737.90	1,291,852	**-67.5**

Table 4. -- Test results for statistical differences in the catch-weighted cumulative frequency distribution compared with the un-weighted cumulative frequency distributions of bottom depth, temperature, and salinity. Tabled *D* values are the Monte Carlo re sampled test statistics. Bold entries represent a significant association between species and habitat variable.

		Pink salmon		Coho salmon		Sockeye salmon			Chum salmon		Chinook salmon	
Maturity state	Habitat variable	D	D	D	P	D	P	D	D	P	D	P
Juvenile	Depth	0.046	0.98	0.082	0.124	**0.155**	0.014	0.075	0.073	0.639	0.075	0.642
Immature		------		------		0.334	0.986	0.065	0.303	0.063	0.065	0.237
Mature		0.056	0.758	0.099	0.174	0.157	0.174	0.156	0.088	0.701	0.156	0.128
Juvenile	Temperature	0.071	0.573	0.067	0.383	0.087	0.465	0.062	0.099	0.129	0.062	0.975
Immature		------		------		0.388	0.135	0.083	0.242	0.633	0.083	0.055
Mature		0.067	0.655	0.067	0.606	0.105	0.673	0.076	0.104	0.916	0.076	0.878
Juvenile	Salinity	0.078	0.366	0.069	0.31	**0.146**	0.009	0.066	0.064	0.822	0.066	0.82
Immature		------		------		0.356	0.411	0.038	0.241	0.6	0.038	0.82
Mature		**0.147**	0.014	0.079	0.381	0.147	0.194	0.084	0.077	0.884	0.084	0.76

Table 5. -- Ranges of depth (m), temperature (°C), and salinity (ppt) for Pacific Salmon by species and maturity stage within the U.S. EEZ off Alaska in which 95% of the respective spatial distribution is found. * represents a significant association between species and habitat variable.

Maturity State		Preference Range Depth (m)	Temperature (°C)	Salinity (ppt)
	Pink			
Juvenile		(25 – 600)	(6.9 – 15)	(20.7 – 32.2)
Mature		(35 – 2900)	(7.4 – 14.8)	(22.3 – 32.5)*
	Coho			
Juvenile		(24 – 500)	(8.8 – 14.9)	(20 – 32.2)
Immature		----------------------	-------------------------------	-------------------------
Mature		(24 – 1400)	(8.2 – 14.9)	(22.1 – 32.4)
	Sockeye			
Juvenile		(36 – 462)*	(7.3 – 14.6)	(22.8 – 32.1)*
Immature		(42 – 3207)	(8.3– 13.6)	(30.9 – 32.9)
Mature		(26 – 2897)	(7.4 – 14.6)	(24 – 32.5)
	Chum			
Juvenile		(23 – 470)	(6.9 – 15)	(20.2 – 32)
Immature		(26 – 4000)	(6.9 – 14.6)	(29.9 – 32.8)
Mature		(26 – 3606)	(7.3 – 15.3)	(24.8 – 32.5)
	Chinook			
Juvenile		(18 – 447)	(5.1 – 14.7)	(18.3 – 32.2)
Immature		(26 – 968)	(6.5 – 15.5)	(20.1 – 32.3)
Mature		(66 – 2755)	(4.2 – 13.9)	(20.8 – 32.5)

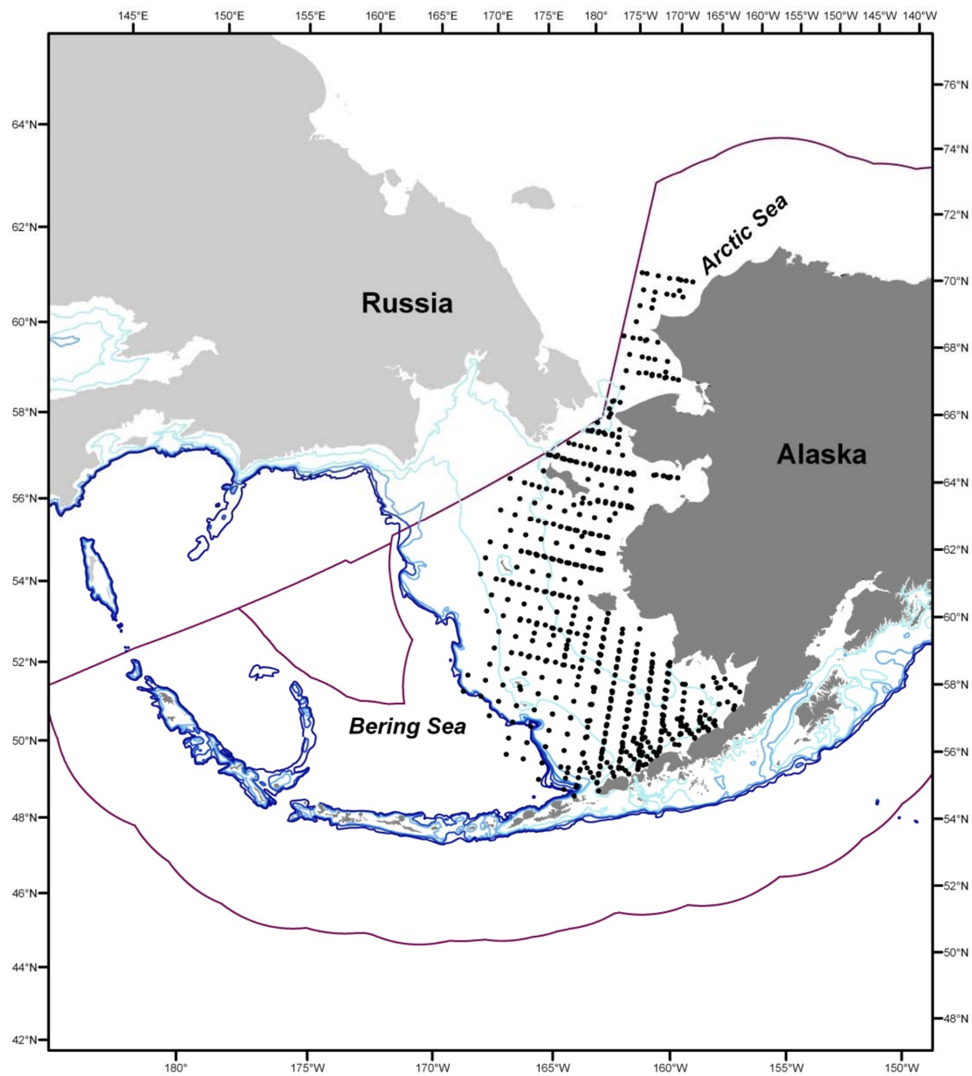

Figure 1. -- Stations sampled during BASIS surveys (1999 – 2007) off western Alaska. Black dots represent individual stations; the smooth line is the U.S. EEZ boundary, and depth contours are 50, 100, 200, 400, and 600 m.

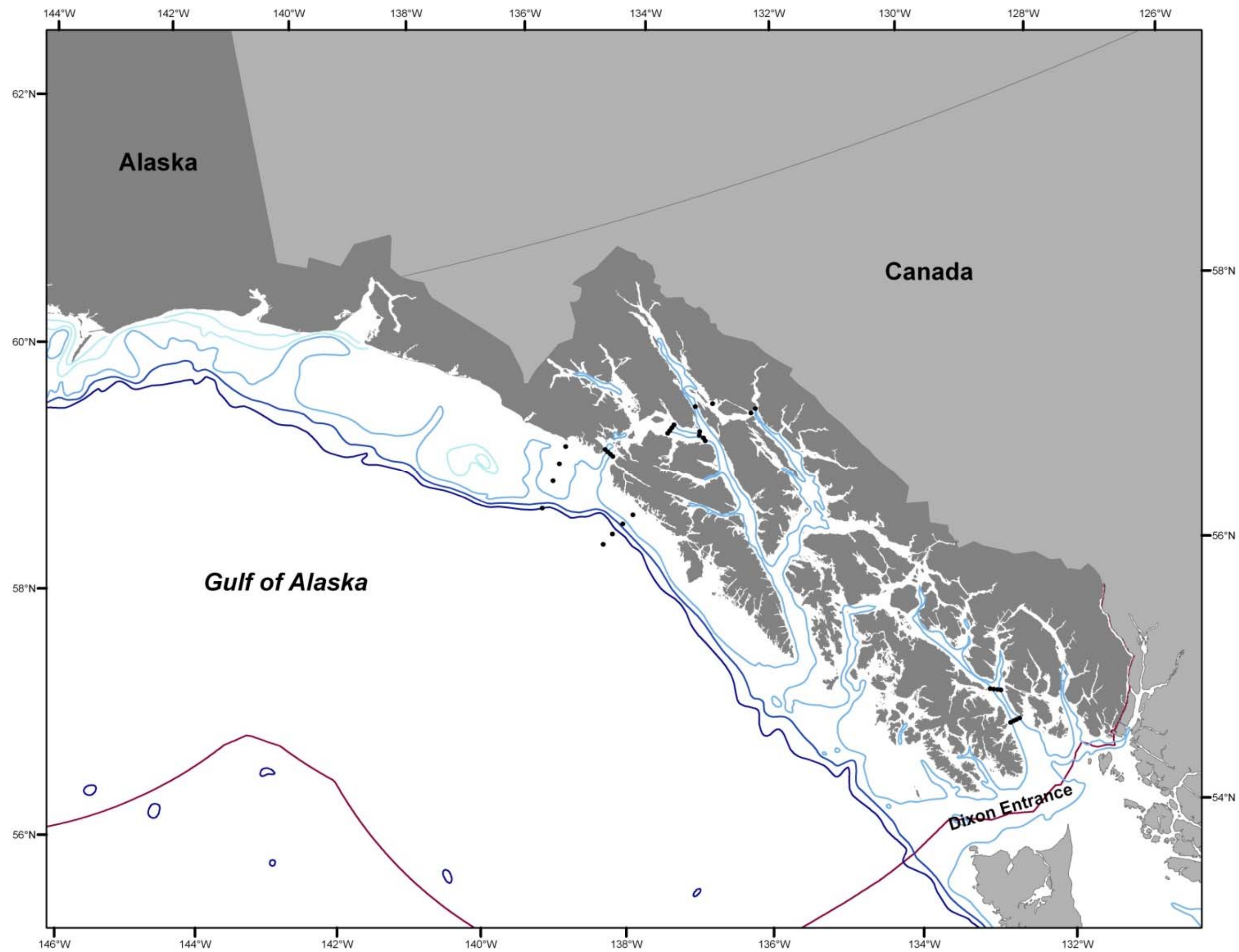

Figure 2. -- Stations sampled during the SECM surveys (1997 – 2009) within and outside the Alexander Archipelago. Black dots represent individual stations; the smooth line is the EEZ boundary, and depth contours are 50, 100, 200, 400, and 600 m.

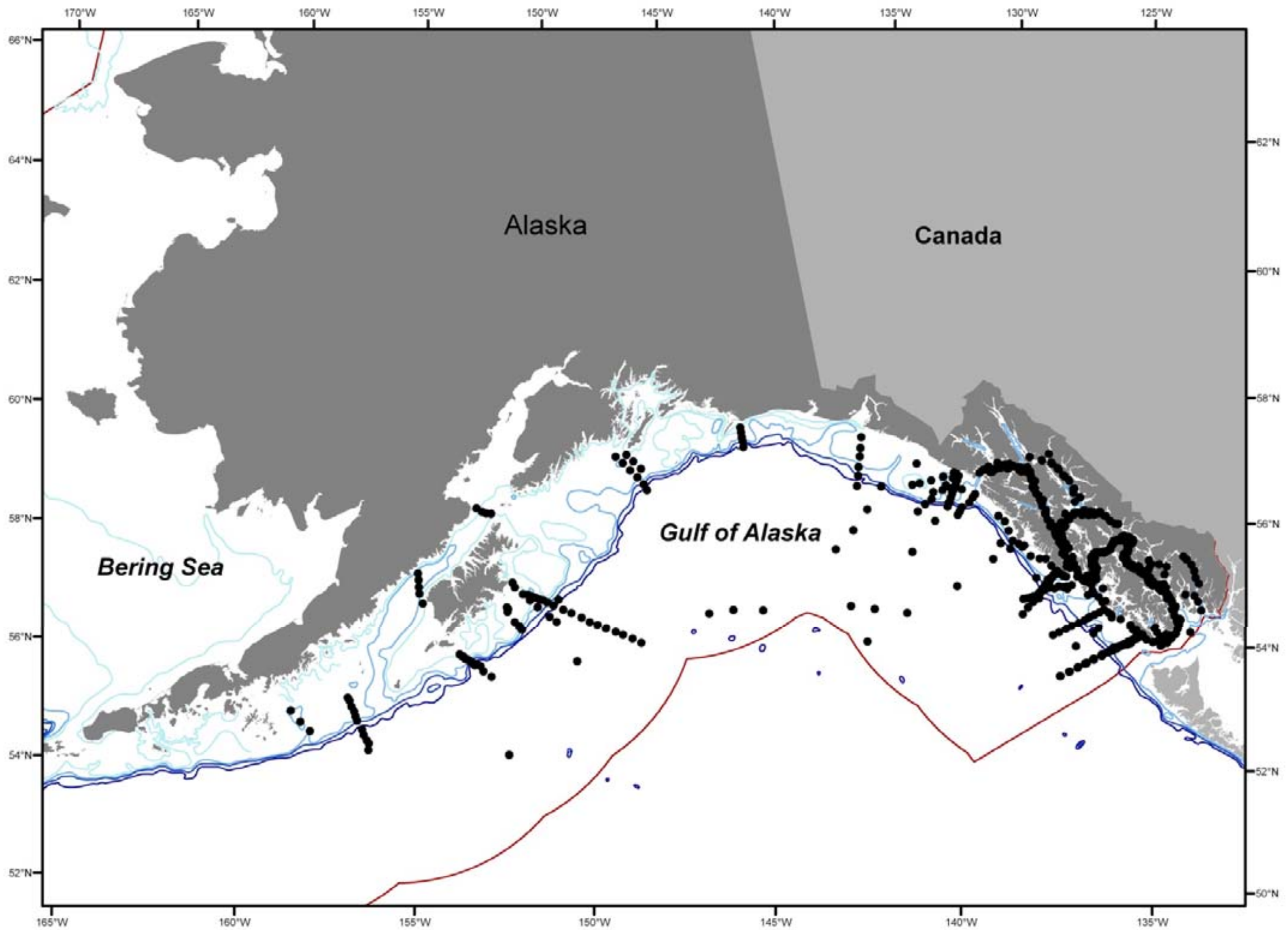

Figure 3. -- Stations sampled by the Canada Department of Oceans and Fisheries (1995 – 2009) within the GOA. Black dots represent individual stations; the smooth line is the EEZ boundary, and depth contours are 50, 100, 200, 400, and 600 m.

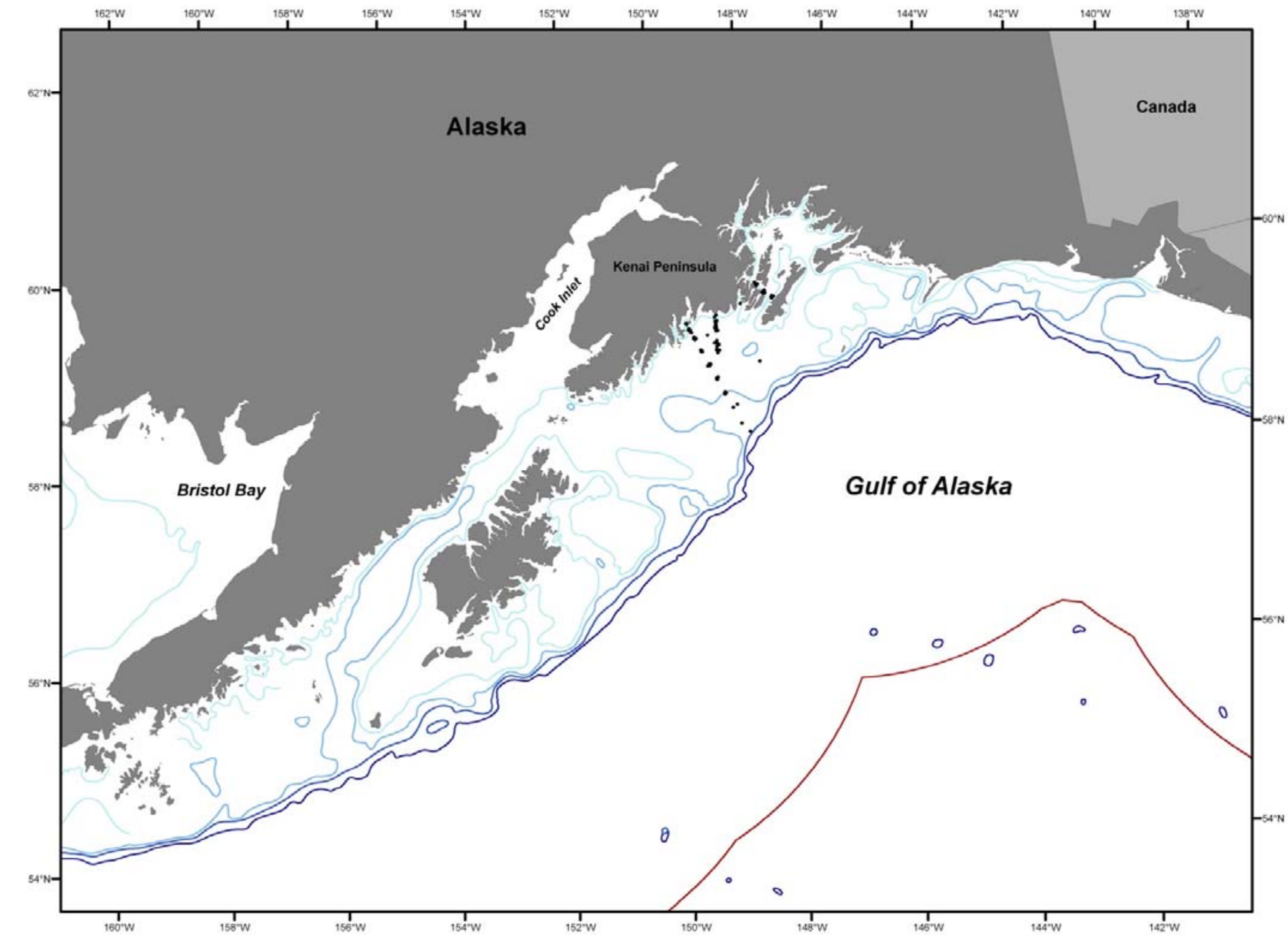

Figure 4. -- Stations sampled through the Coastal Gulf of Alaska GLOBEC/UAF surveys (2001 – 2004). Black dots represent individual stations; the smooth line is the EEZ boundary, and depth contours are 50, 100, 200, 400, and 600 m.

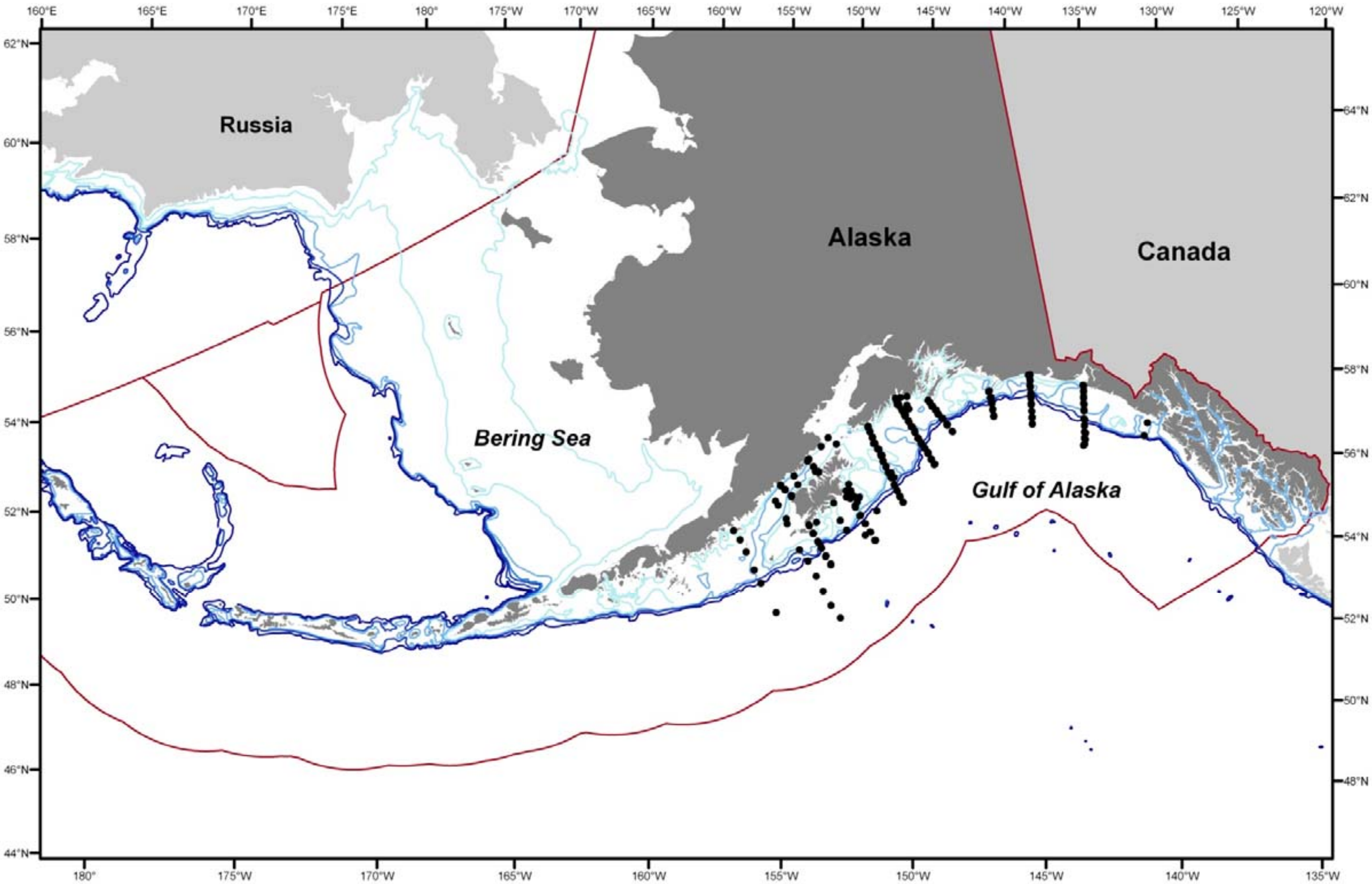

Figure 5. -- Stations sampled through the NMFS/GLOBEC Gulf of Alaska coastal salmon surveys (2001 – 2004). Black dots represent individual stations; the smooth line is the EEZ boundary, and depth contours are 50, 100, 200, 400, and 600 m.

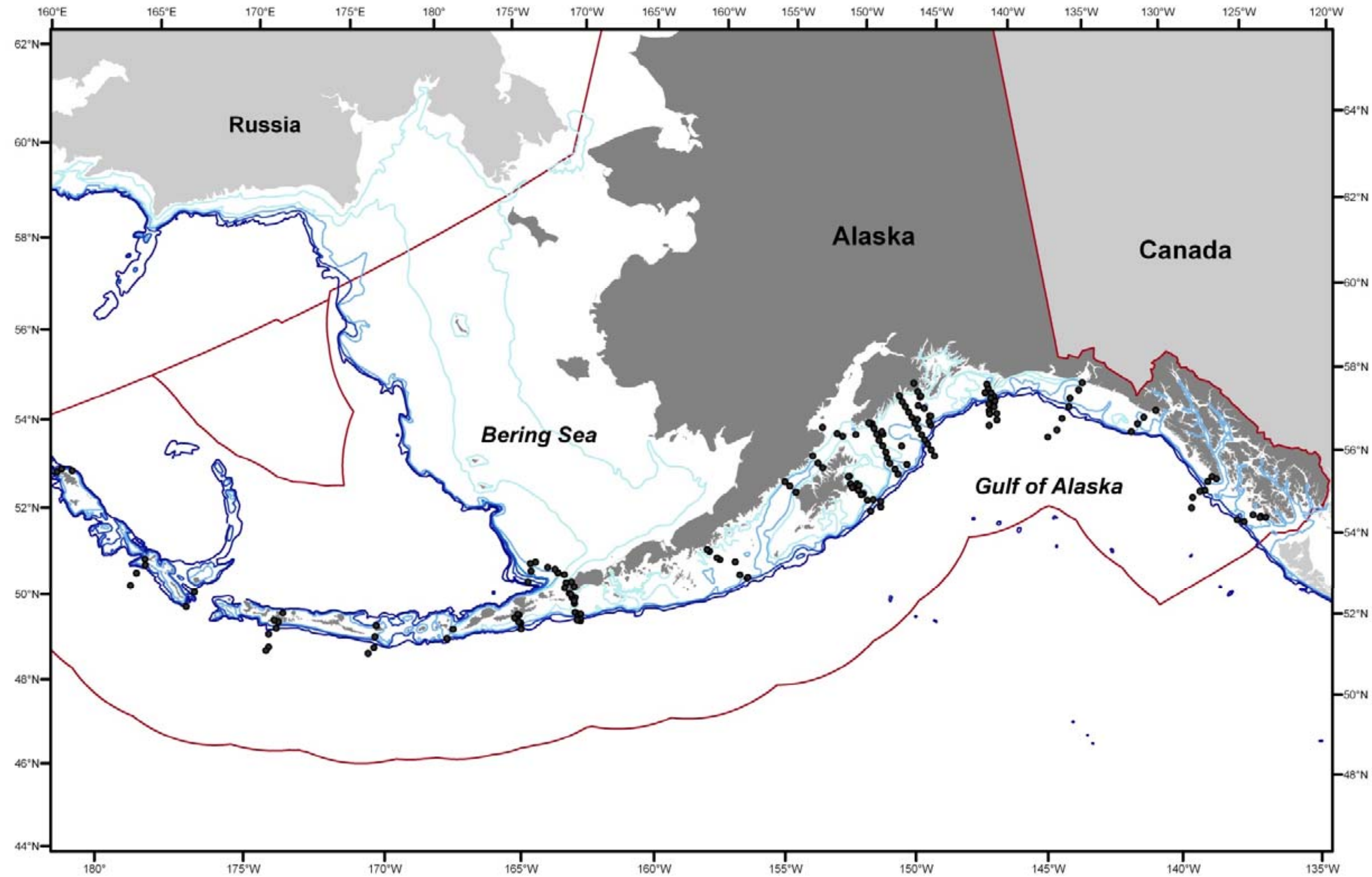

Figure 6. -- Stations sampled during the NMFS highseas and coastal surveys (1997 – 1998 and 2000). Black dots represent individual stations; the smooth line is the EEZ boundary, and depth contours are 50, 100, 200, 400, and 600 m.

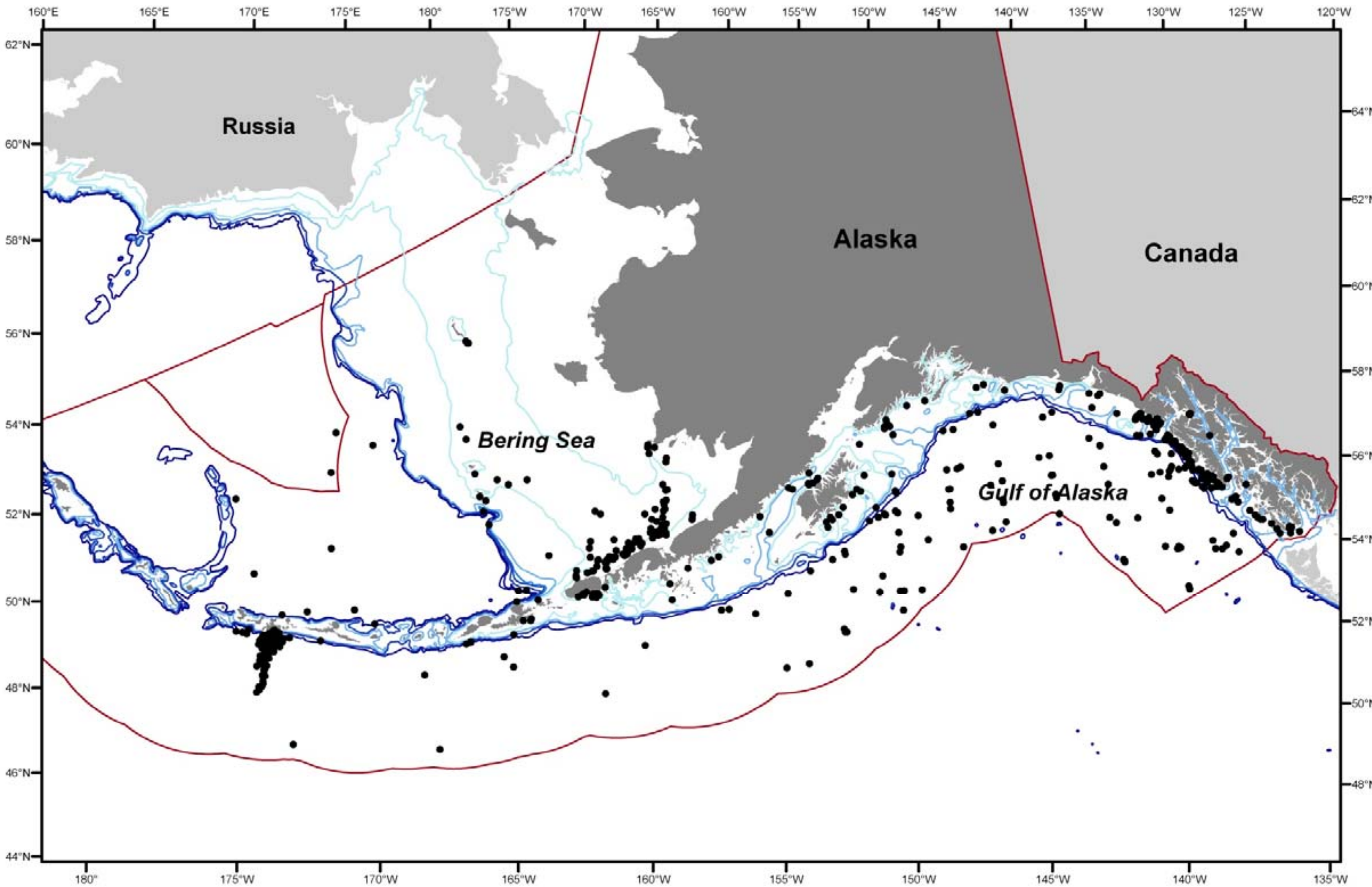

Figure 7. -- Stations sampled by Hartt and Dell (1964 - 1968). Black dots represent individual stations; the smooth line is the EEZ boundary, and depth contours are 50, 100, 200, 400, and 600 m.

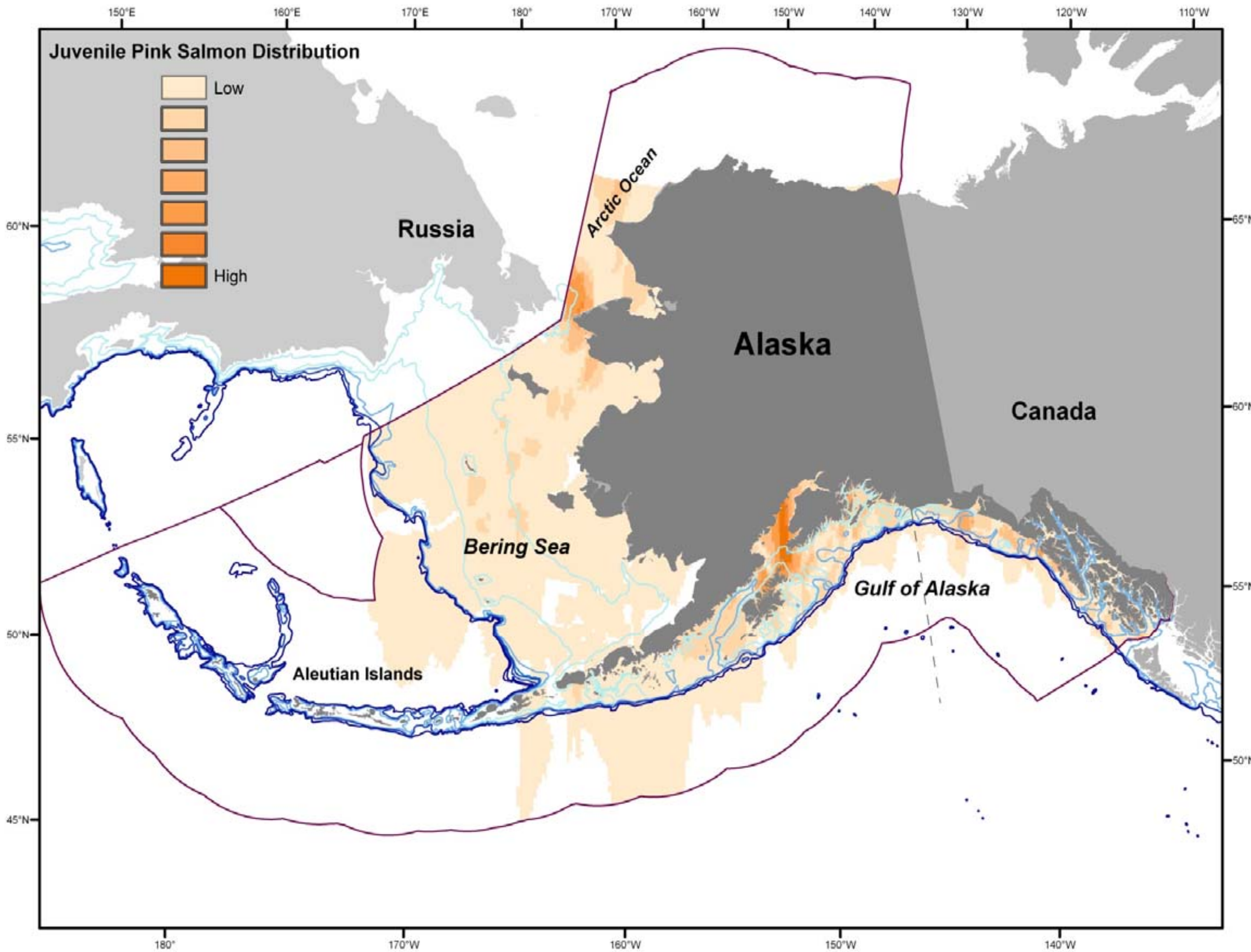

Figure 7a. -- 95% of the spatial distribution of marine juvenile pink salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West GOA Alaska Department of Fish and Game (ADFG) management areas, depth contours are 50, 100, 200, 400, and 600 m.

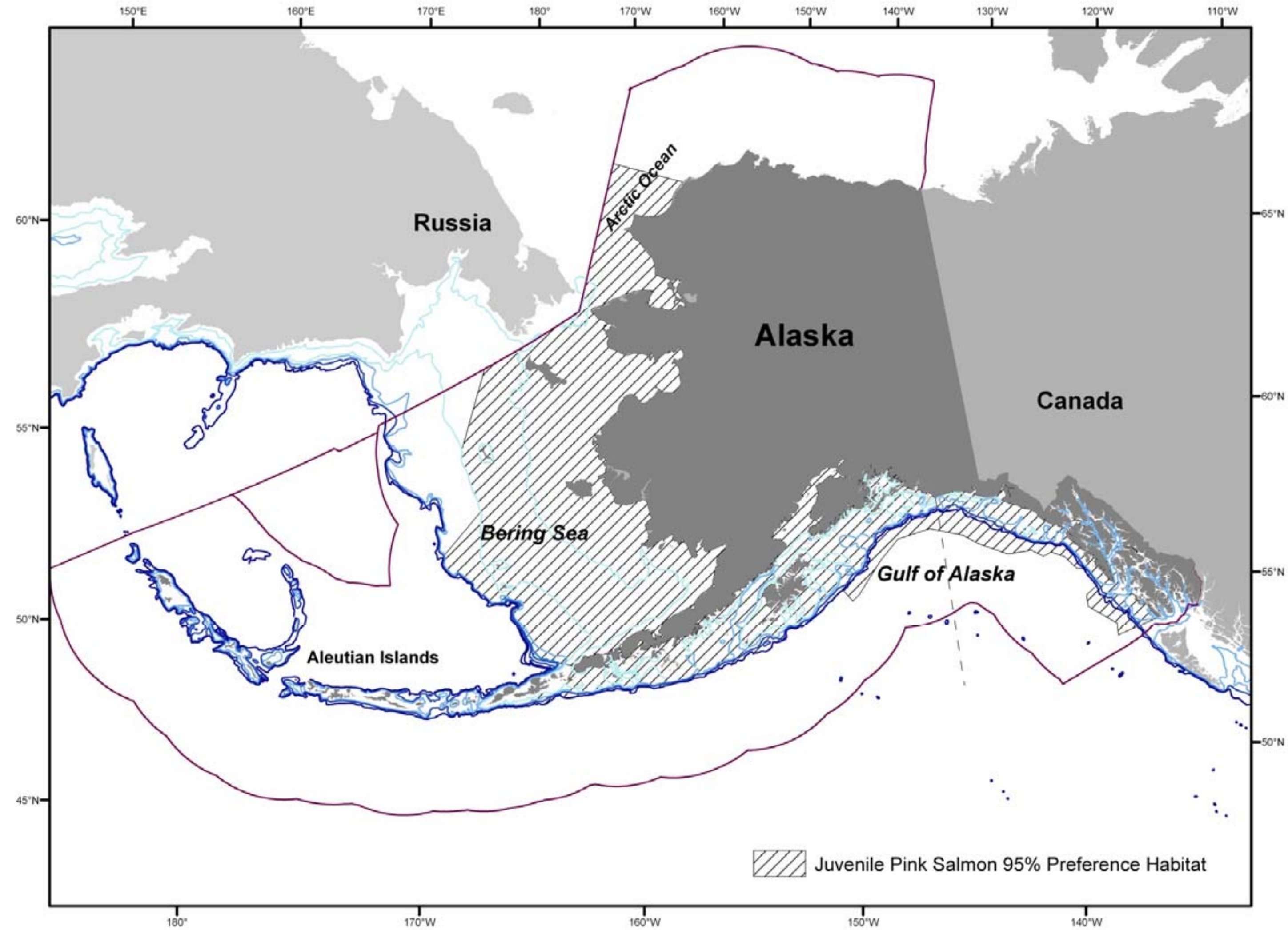

Figure 7b. -- Marine Juvenile Pink Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

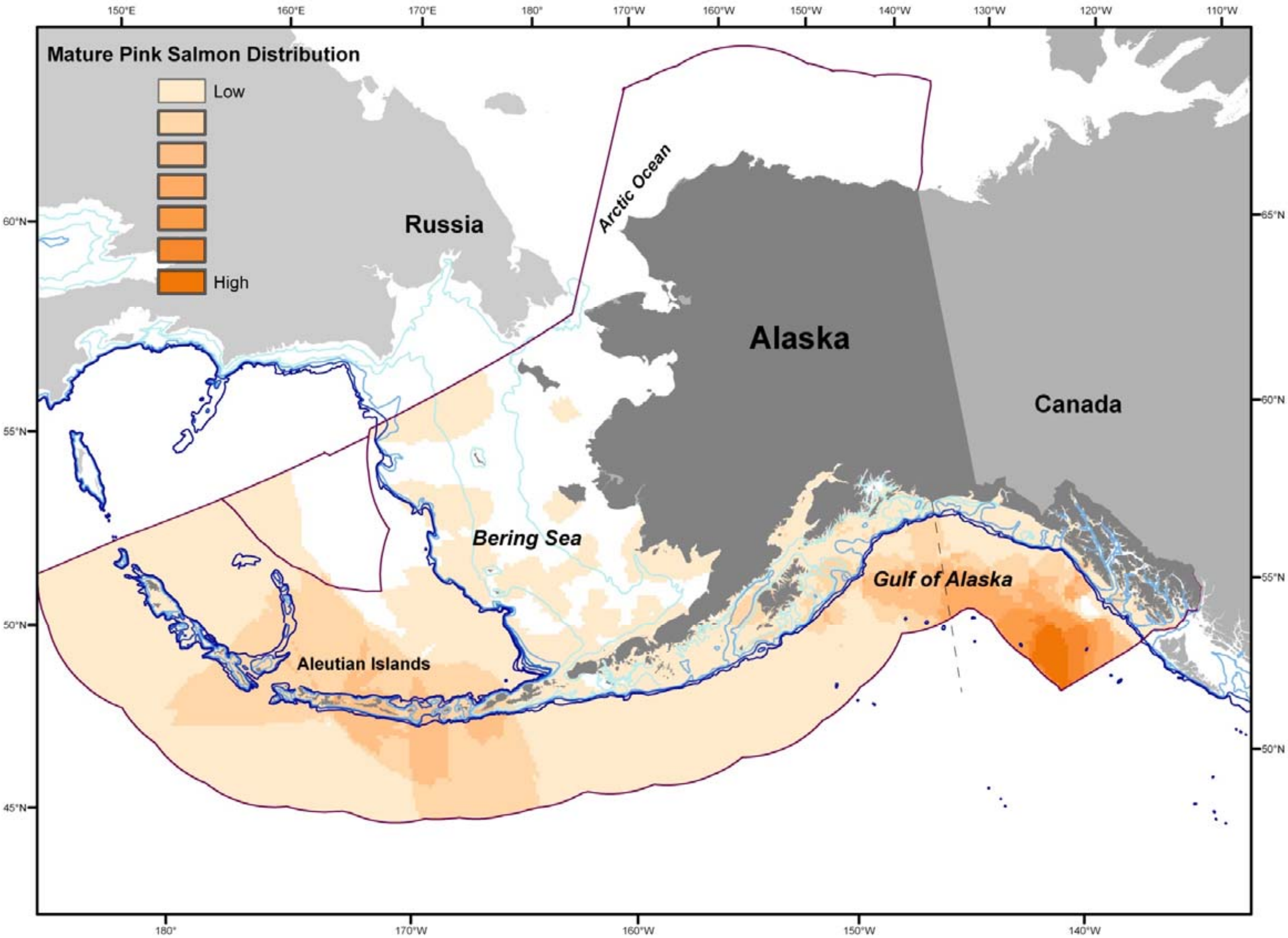

Figure 8a. -- 95% of the spatial distribution of marine mature pink salmon range. Smooth line represents the EEZ boundary;dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

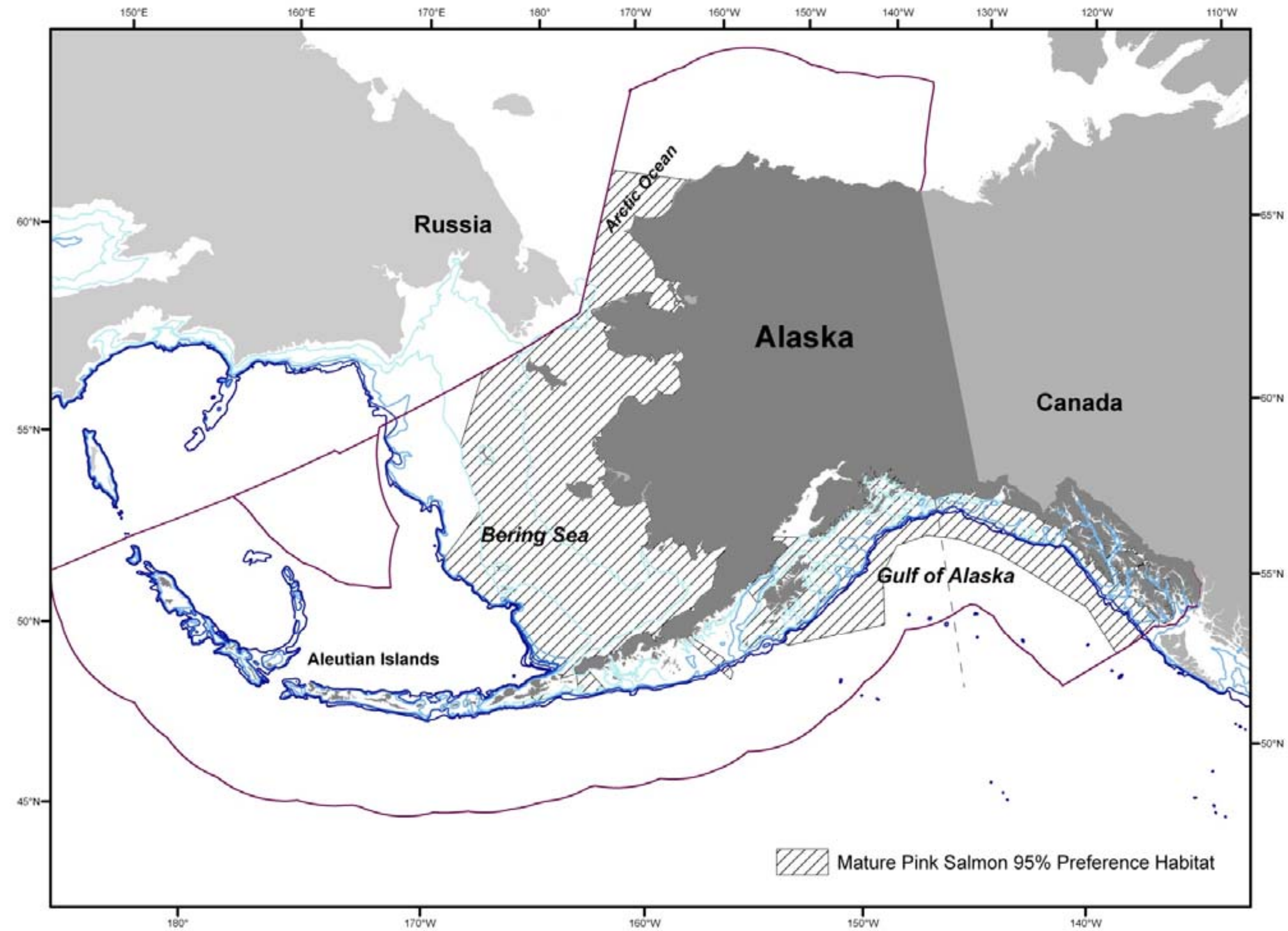

Figure 8b. -- Marine Mature Pink Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

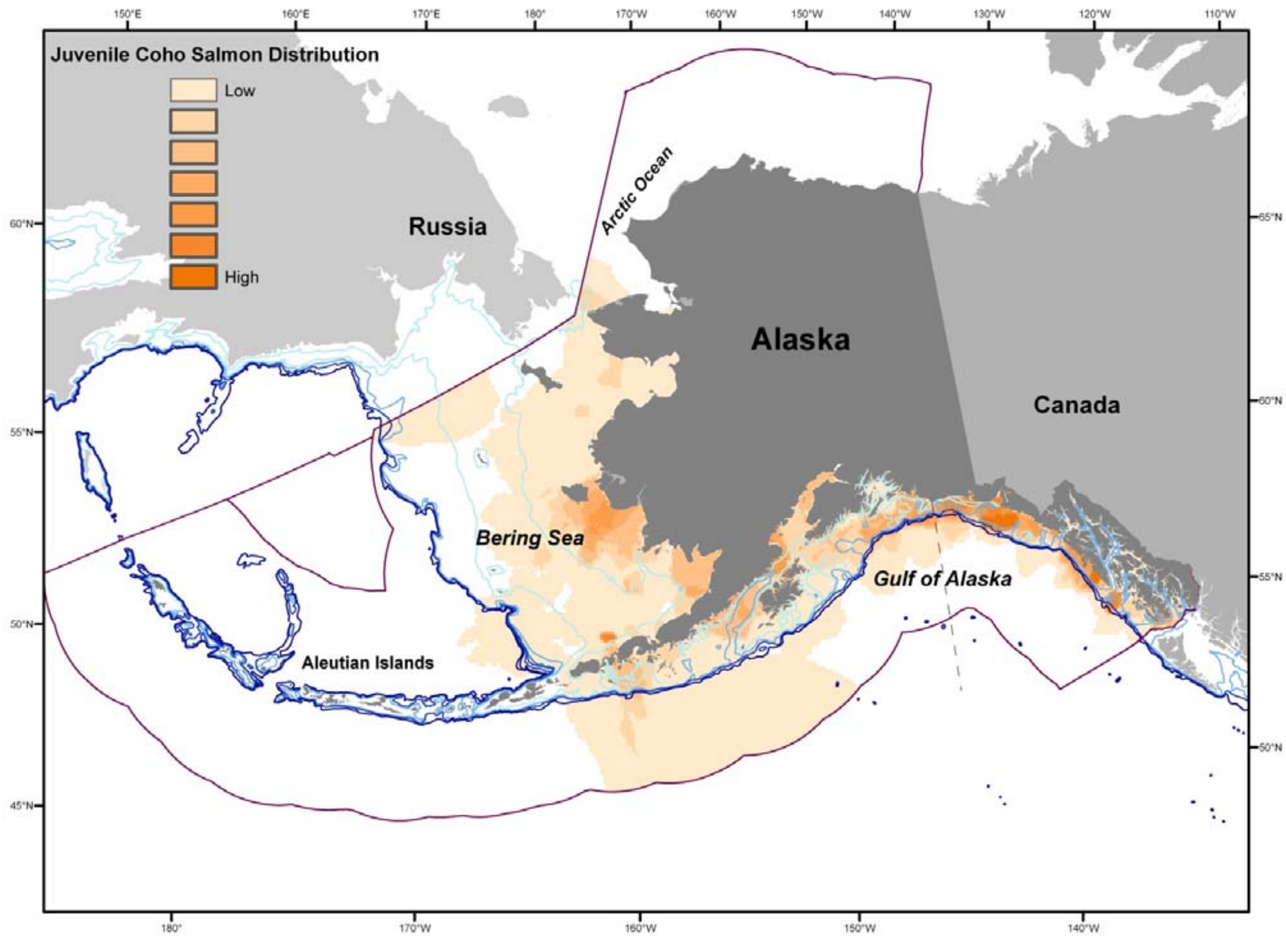

Figure 9a. -- 95% of the spatial distribution of marine juvenile coho salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

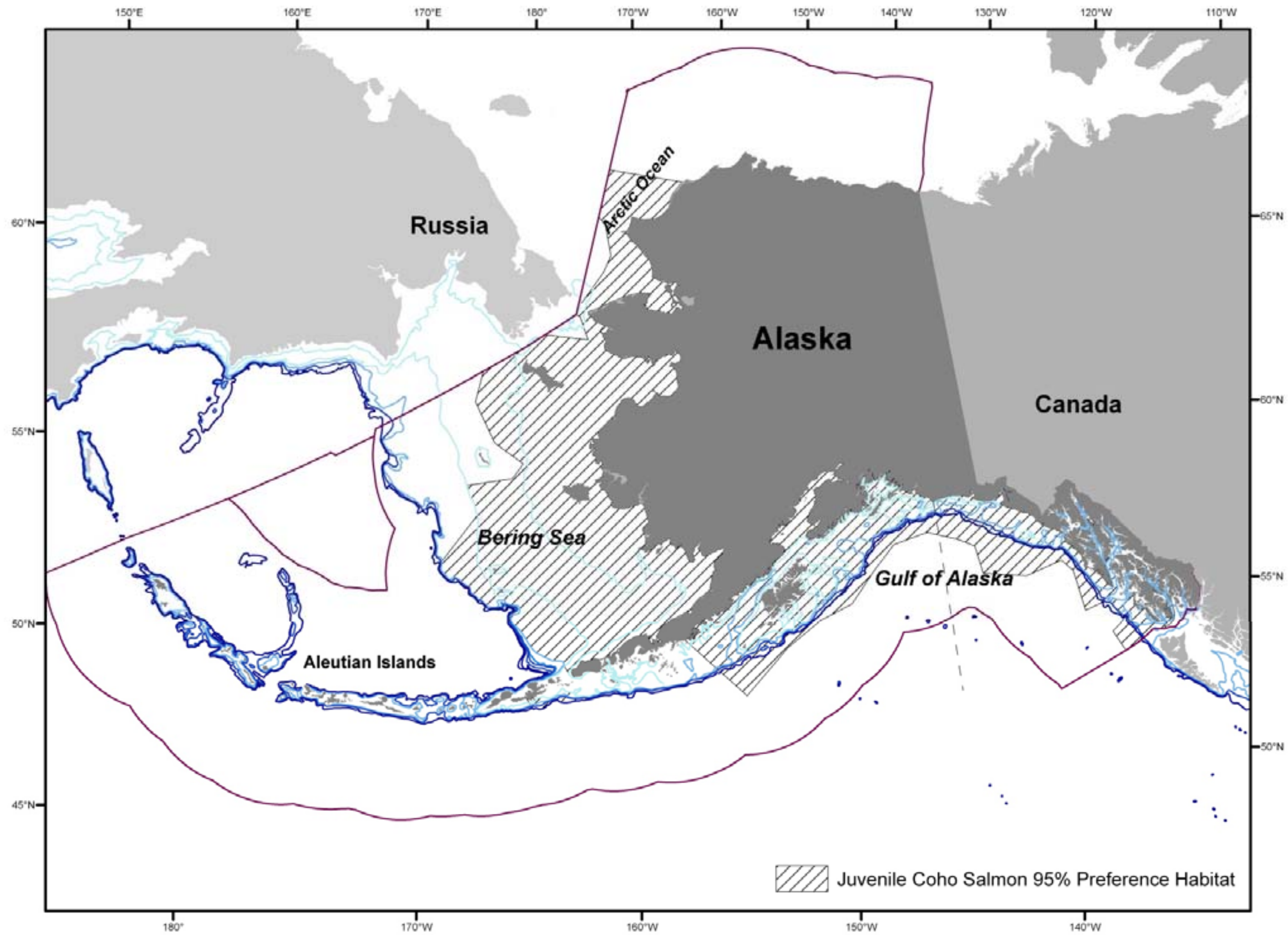

Figure 9b. -- Marine Juvenile Coho Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

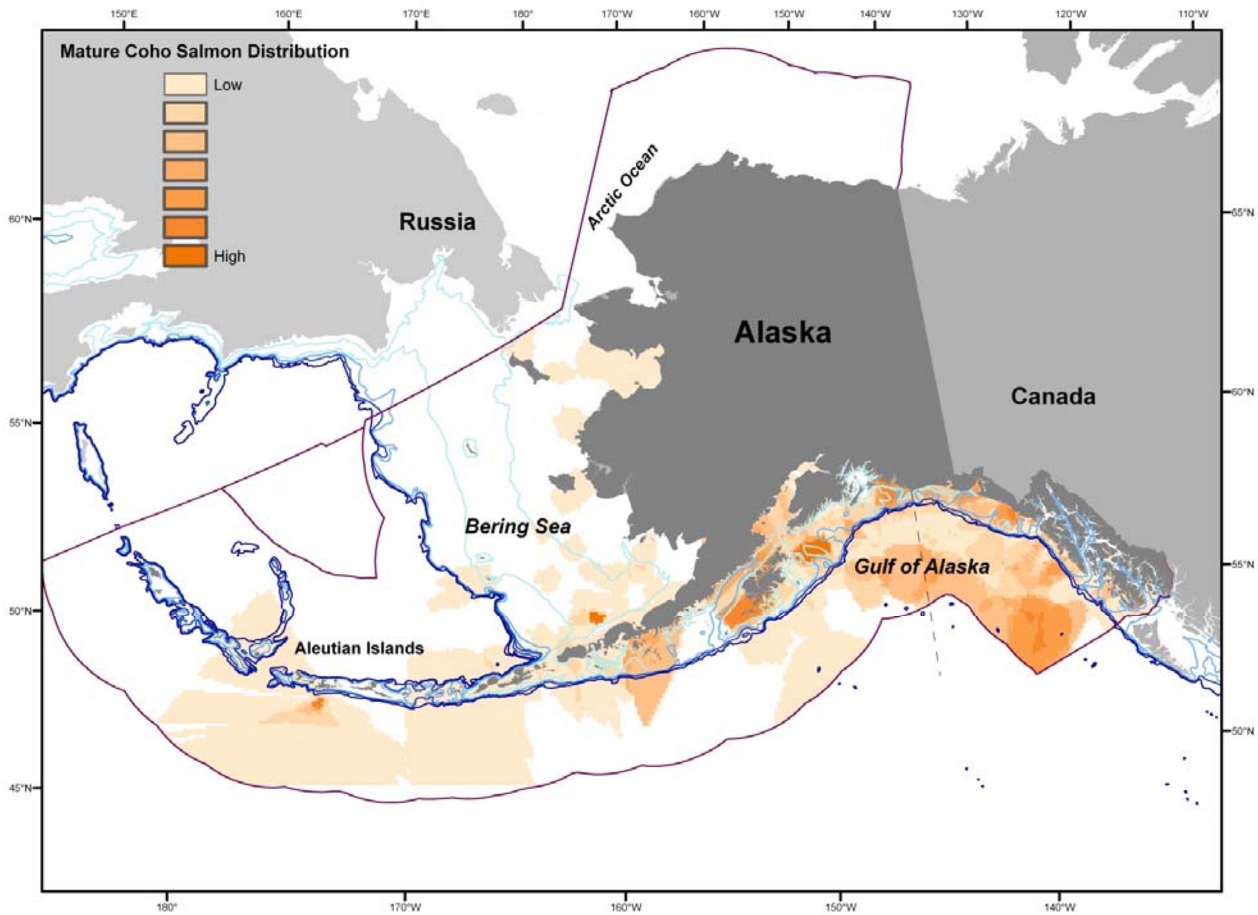

Figure 10a. -- 95% of the spatial distribution of marine mature coho salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

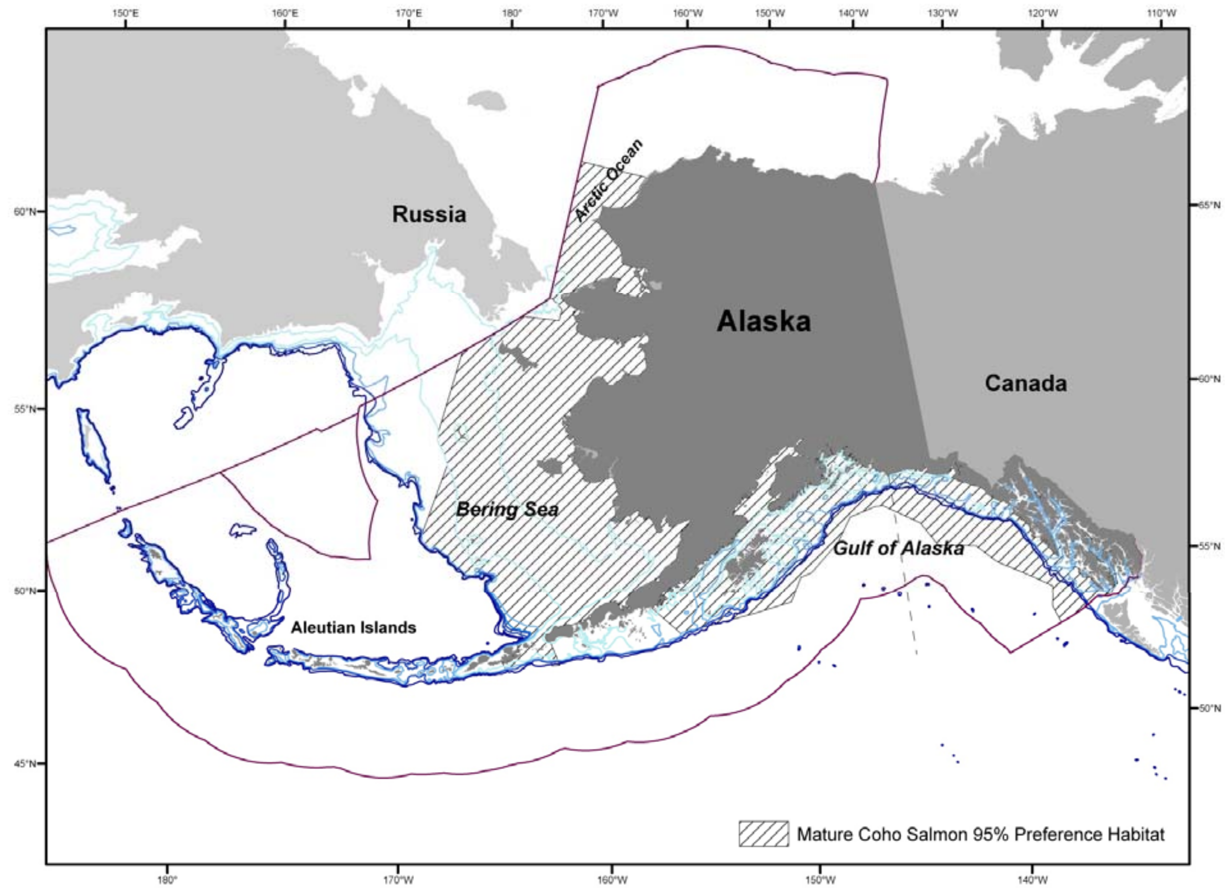

Figure 10b. -- Marine Mature Coho Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

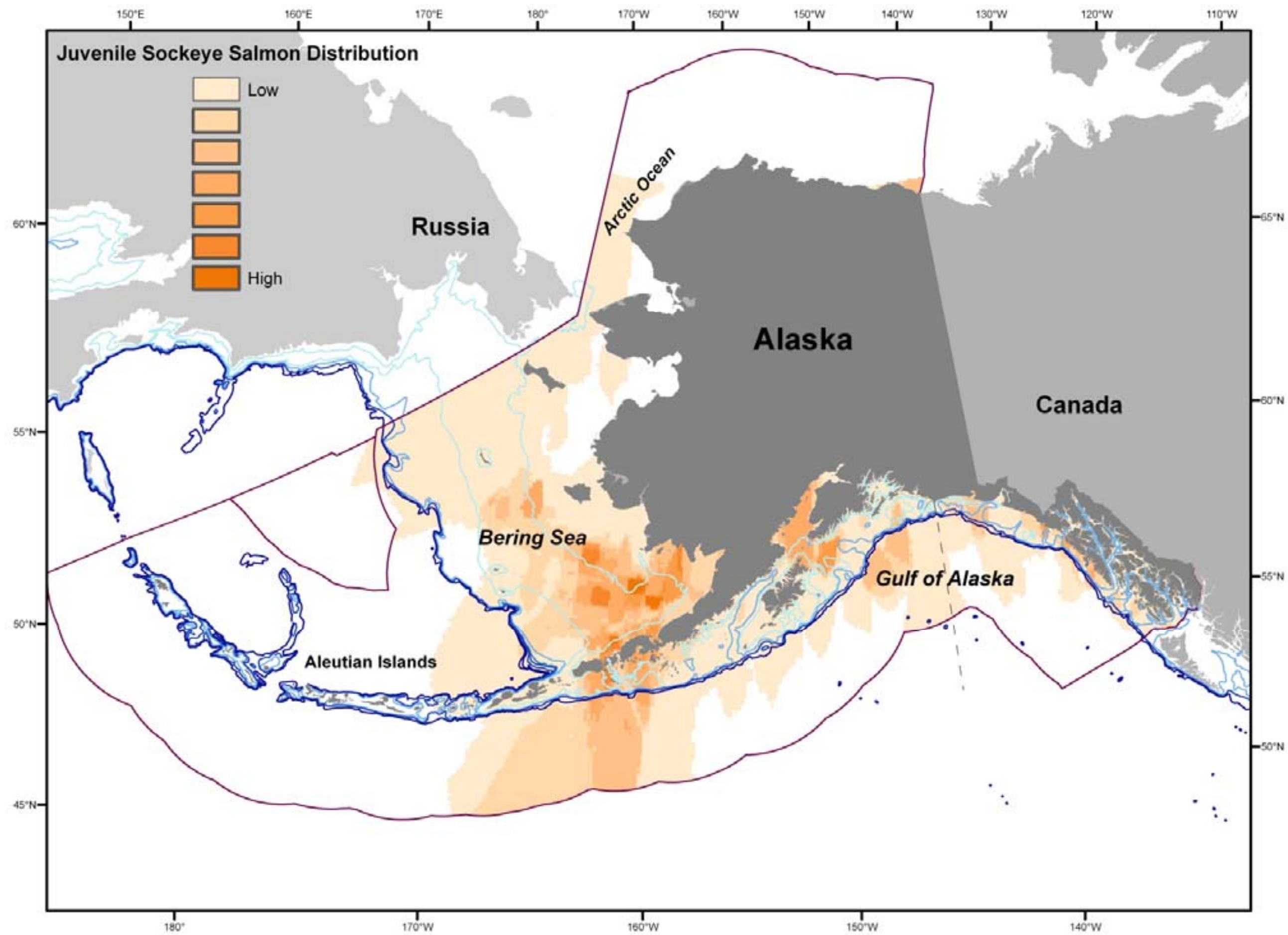

Figure 11a. -- 95% of the spatial distribution of marine juvenile sockeye salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

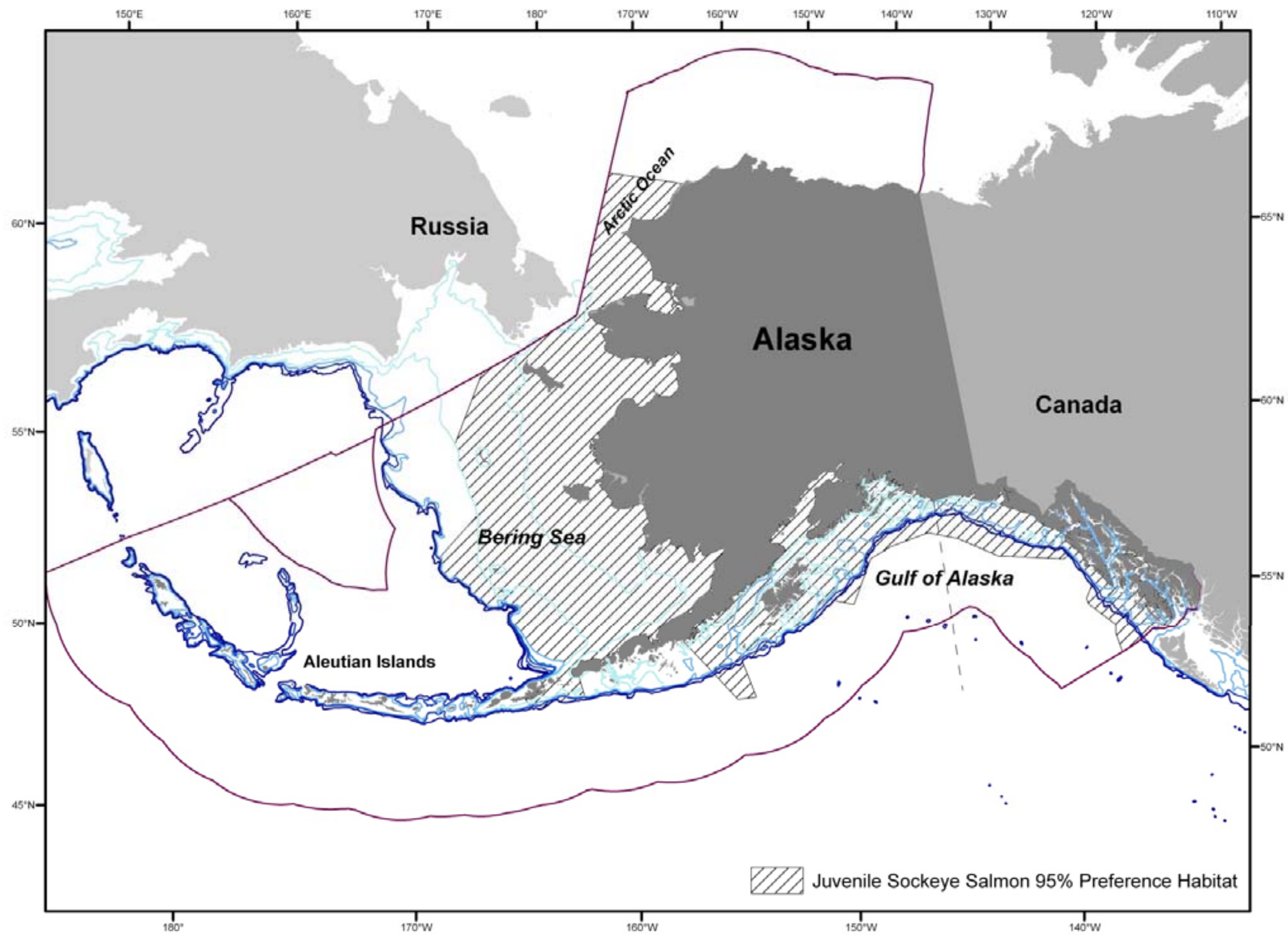

Figure 11b. -- Marine Juvenile Sockeye Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

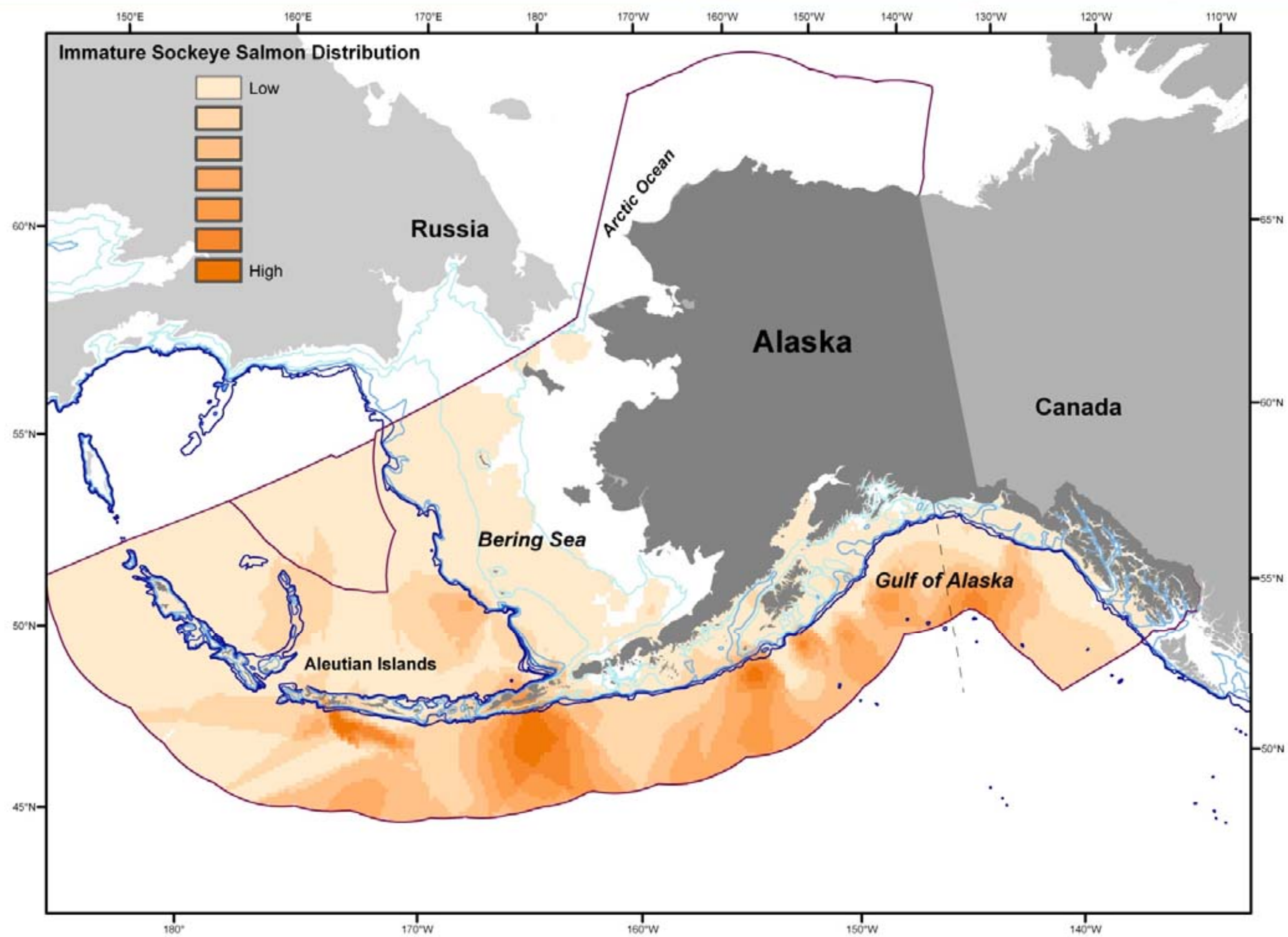

Figure 12a. -- 95% of the spatial distribution of marine immature sockeye salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

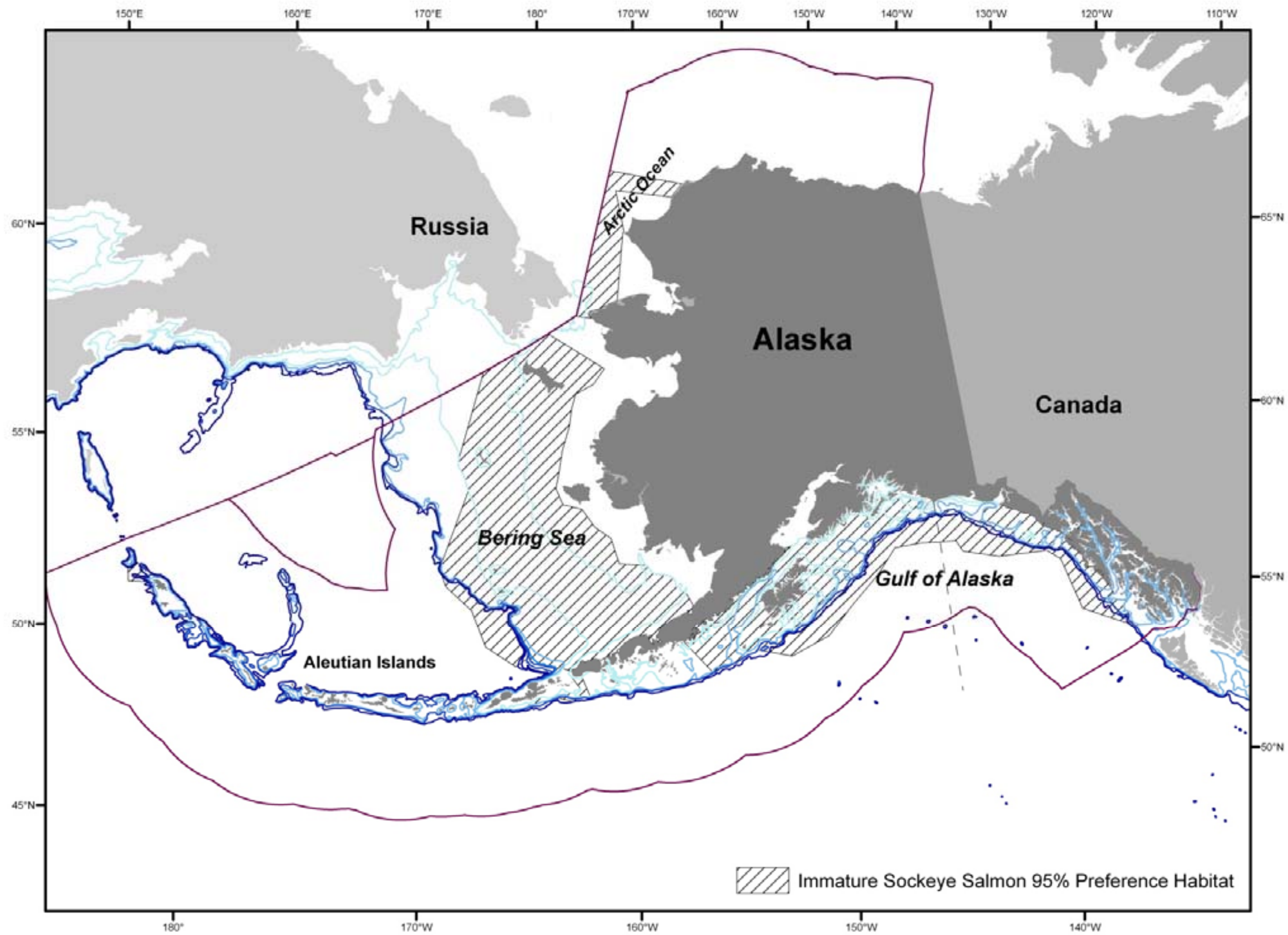

Figure 12b. -- Marine Immature Sockeye Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

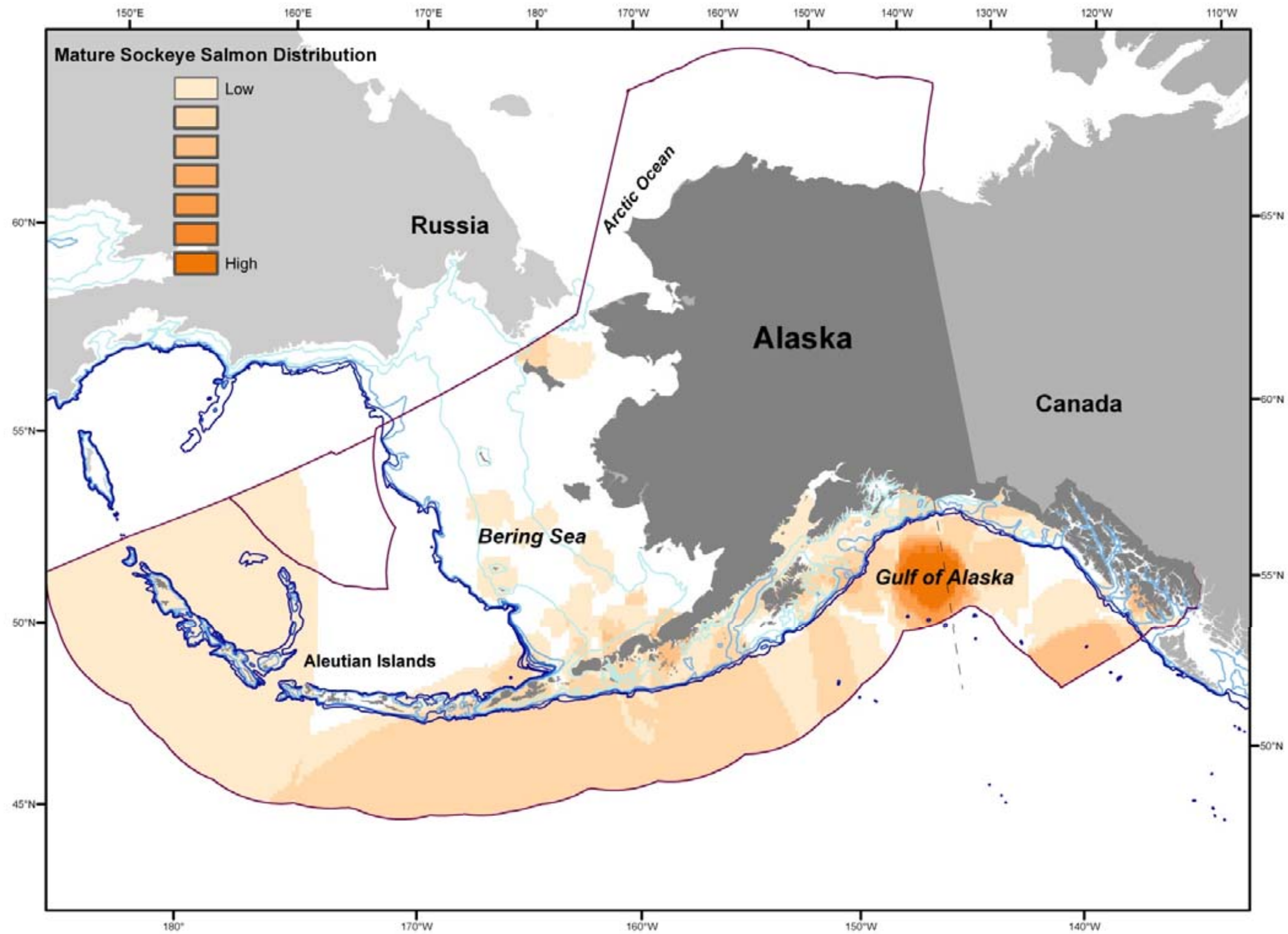

Figure 13a. -- 95% of the spatial distribution of marine mature sockeye salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

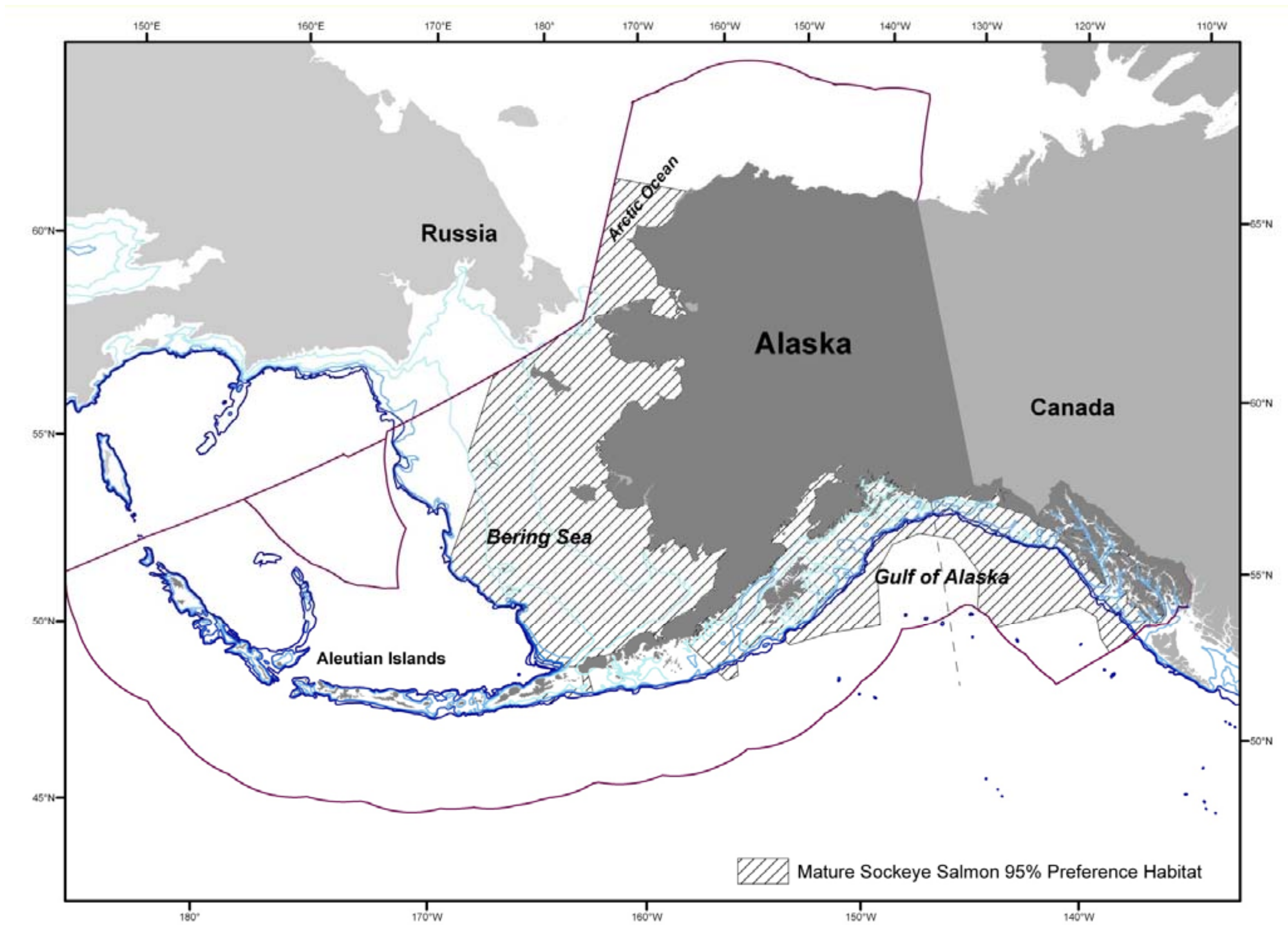

Figure 13b. -- Marine Mature Sockeye Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

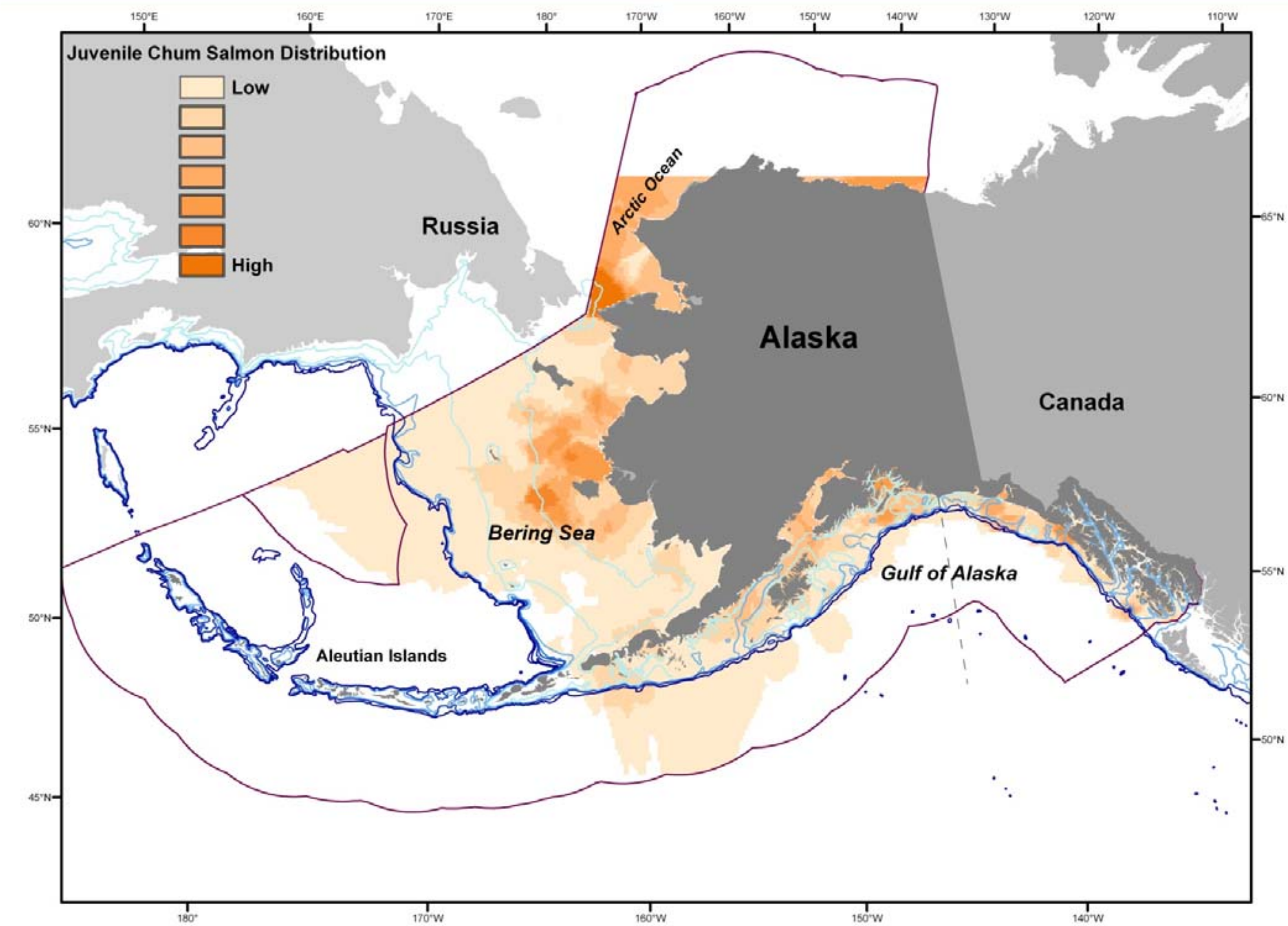

Figure 14a. -- 95% of the spatial distribution of marine juvenile chum salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

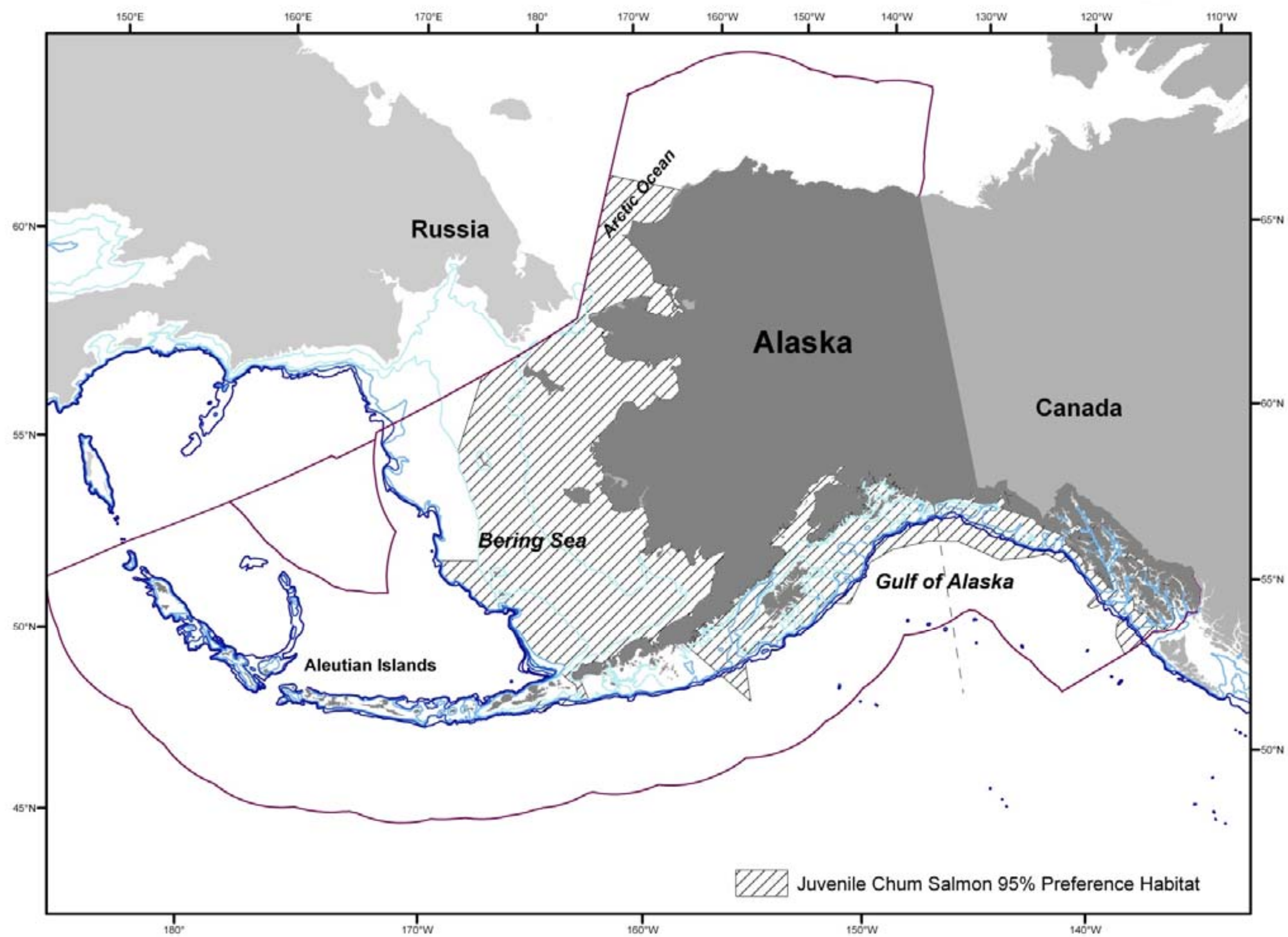

Figure 14b. – Marine Juvenile Chum Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

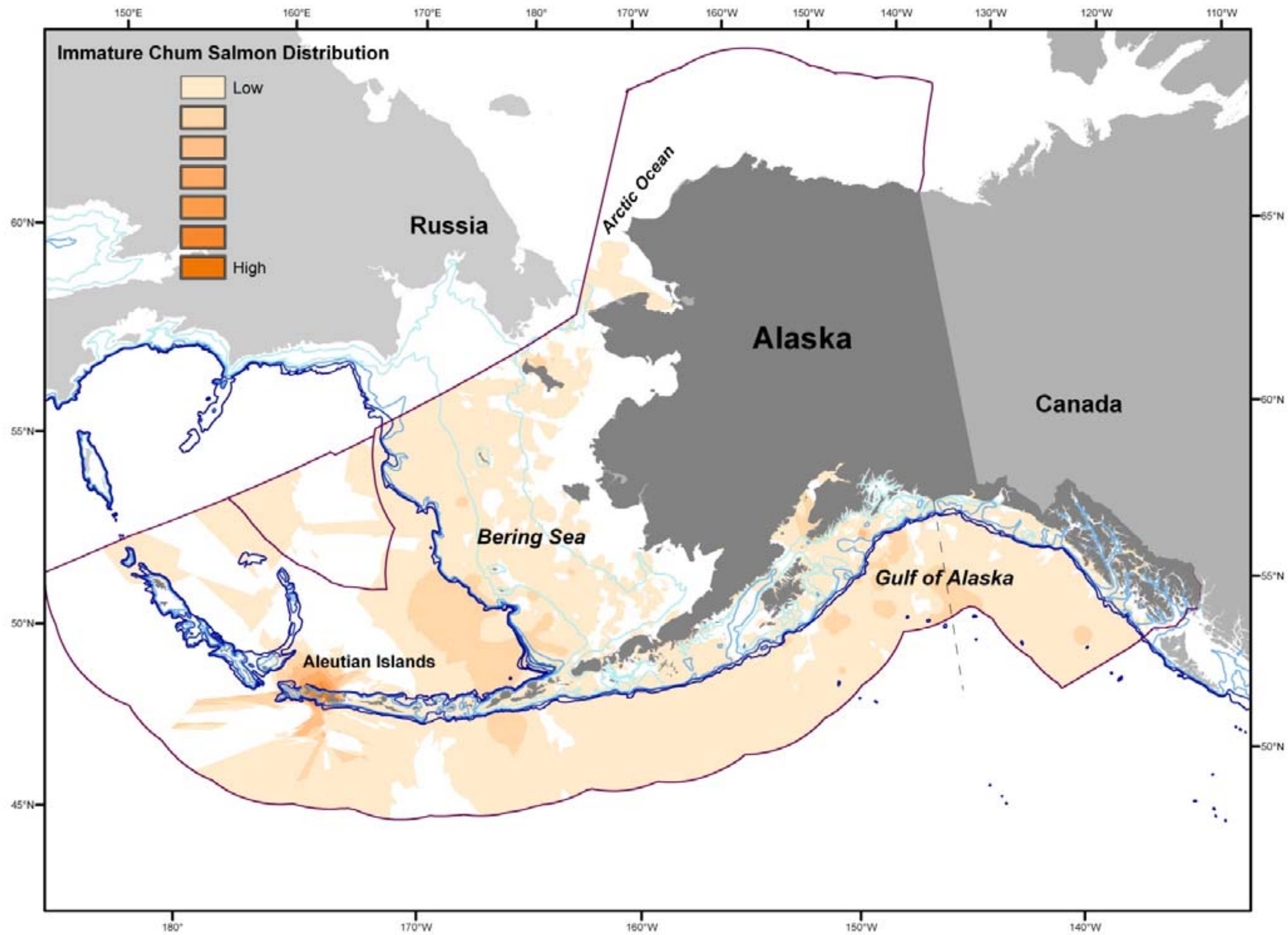

Figure 15a. -- 95% of the spatial distribution of marine immature chum salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

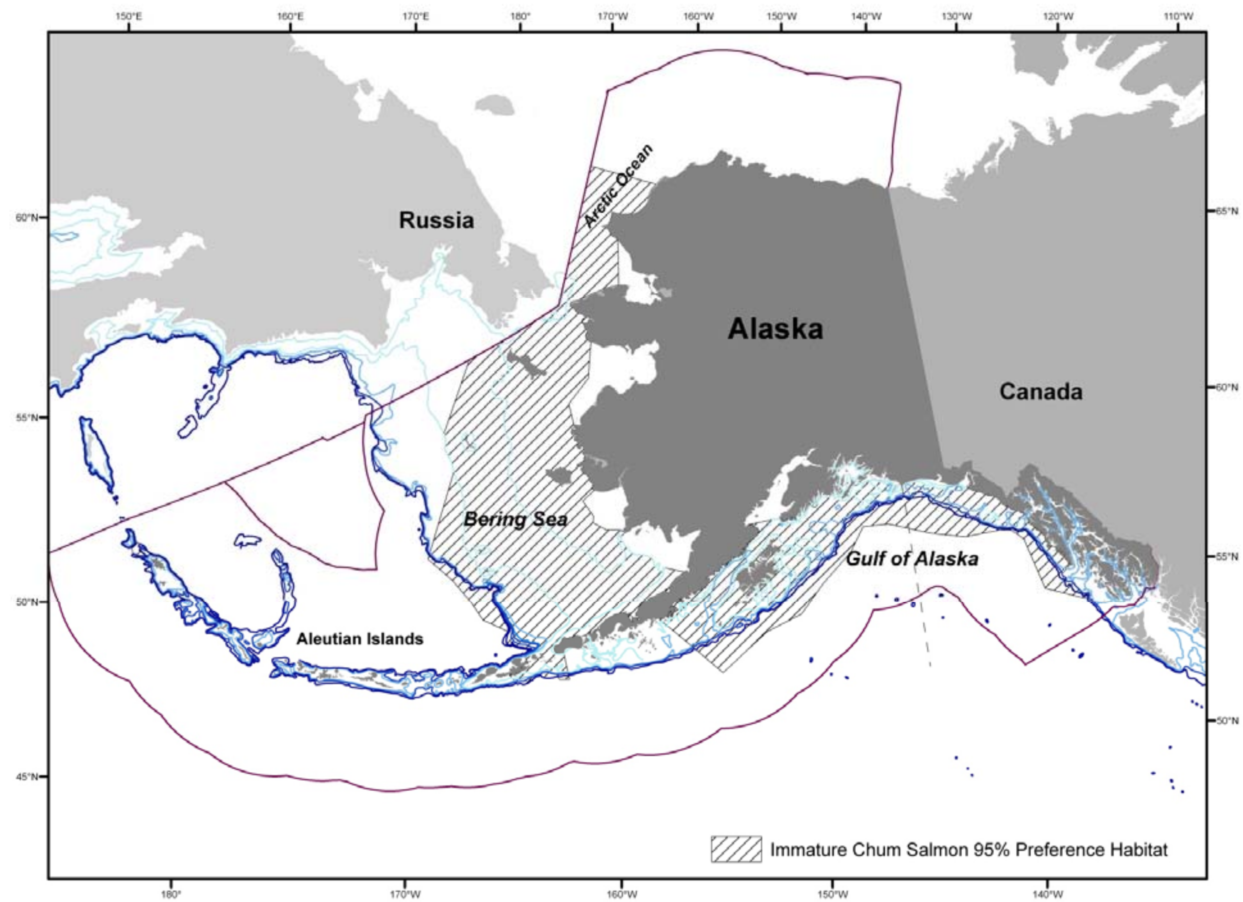

Figure 15b. -- Marine Immature Chum Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

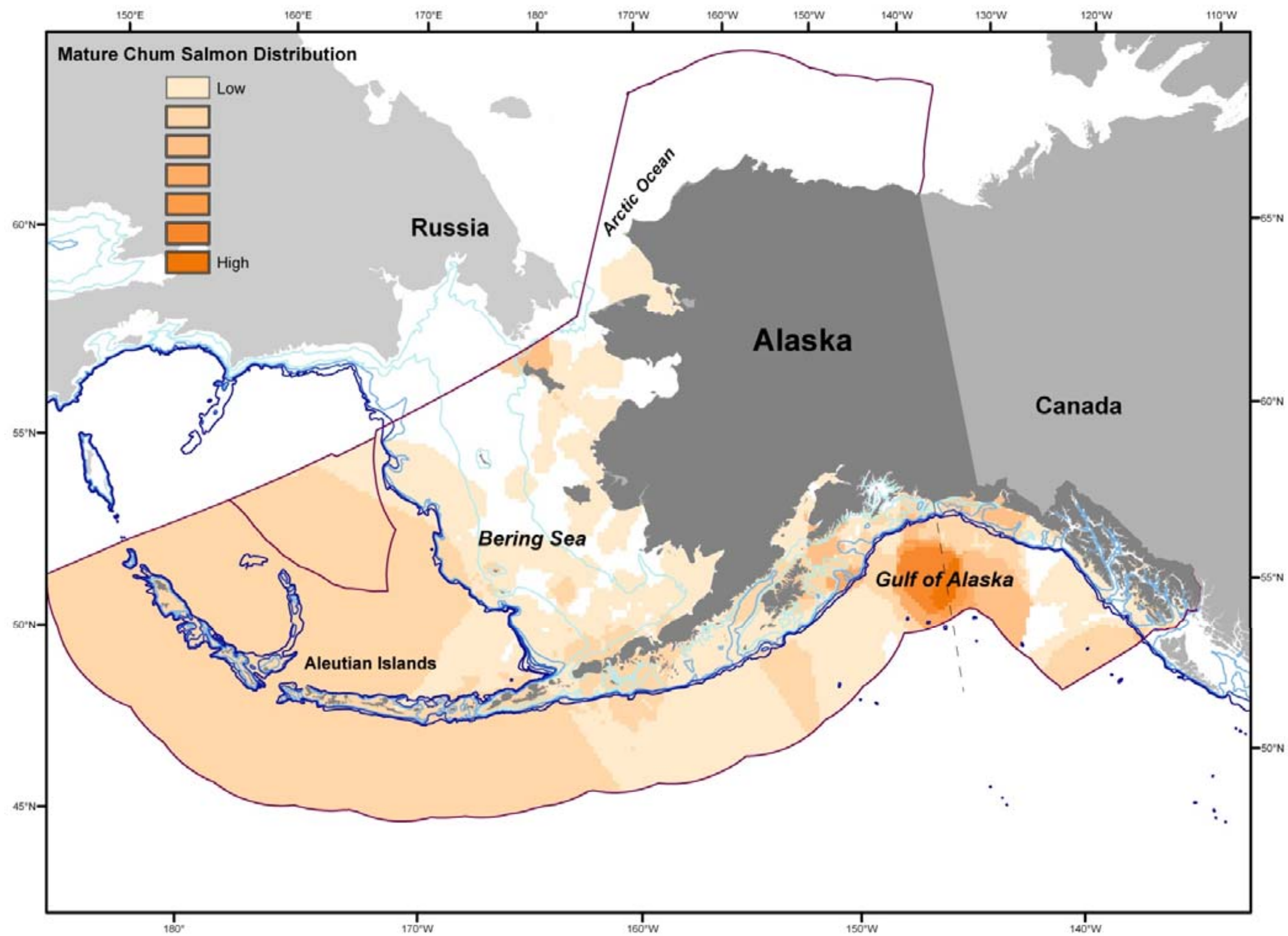

Figure 16a. -- 95% of the spatial distribution of marine mature chum salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

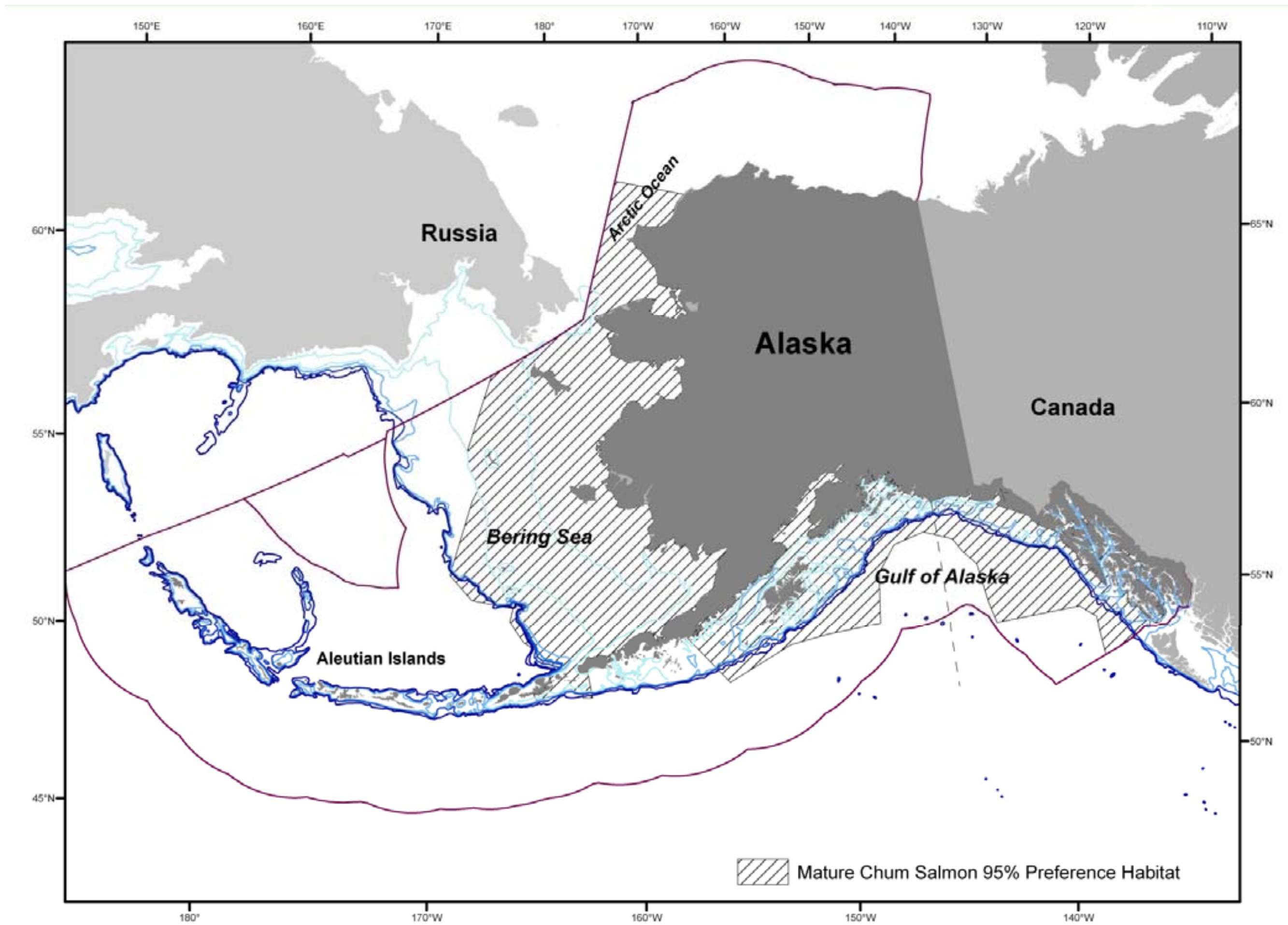

Figure 16b. -- Marine Mature Chum Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

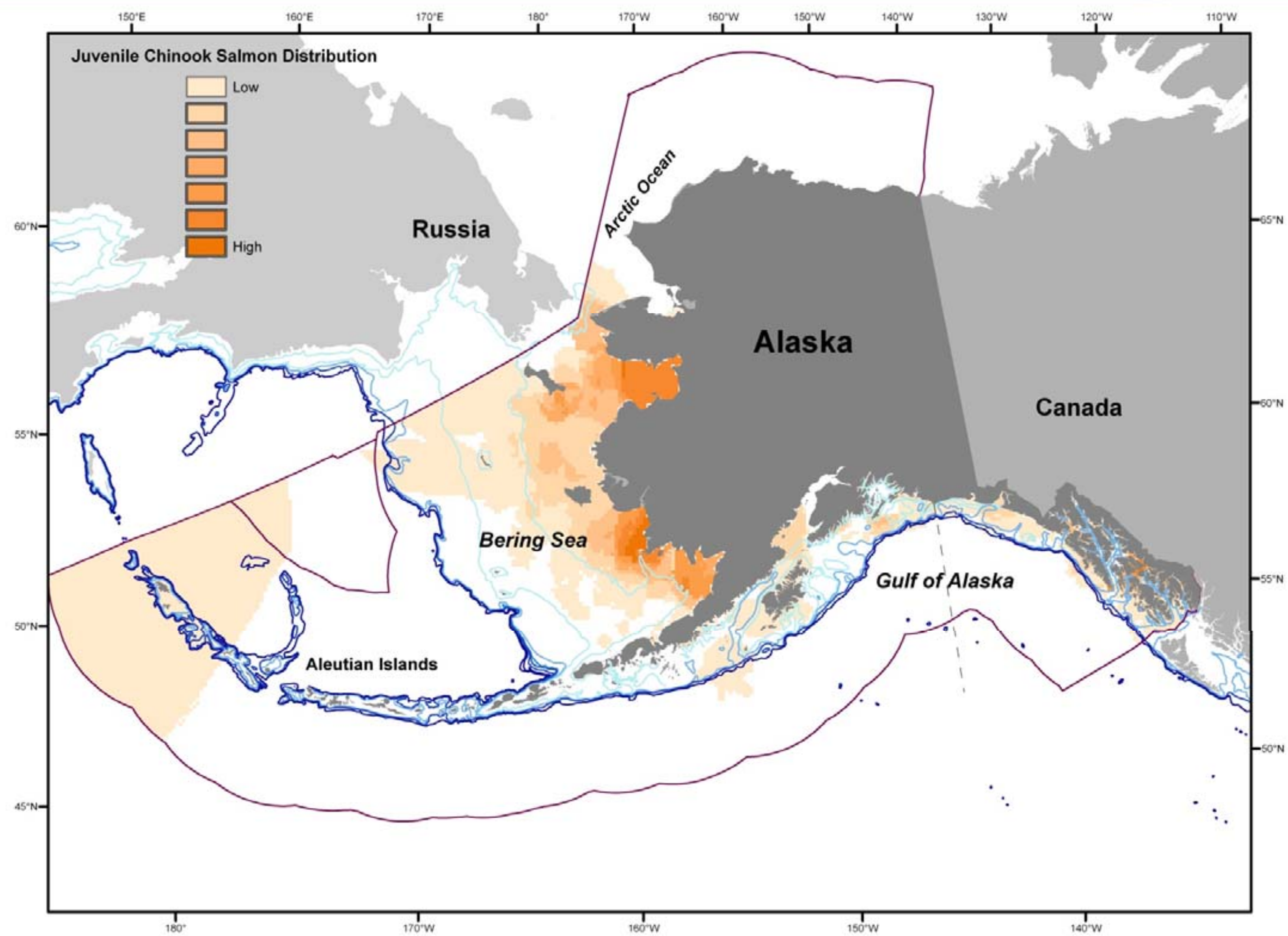

Figure 17a. -- 95% of the spatial distribution of marine juvenile Chinook salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

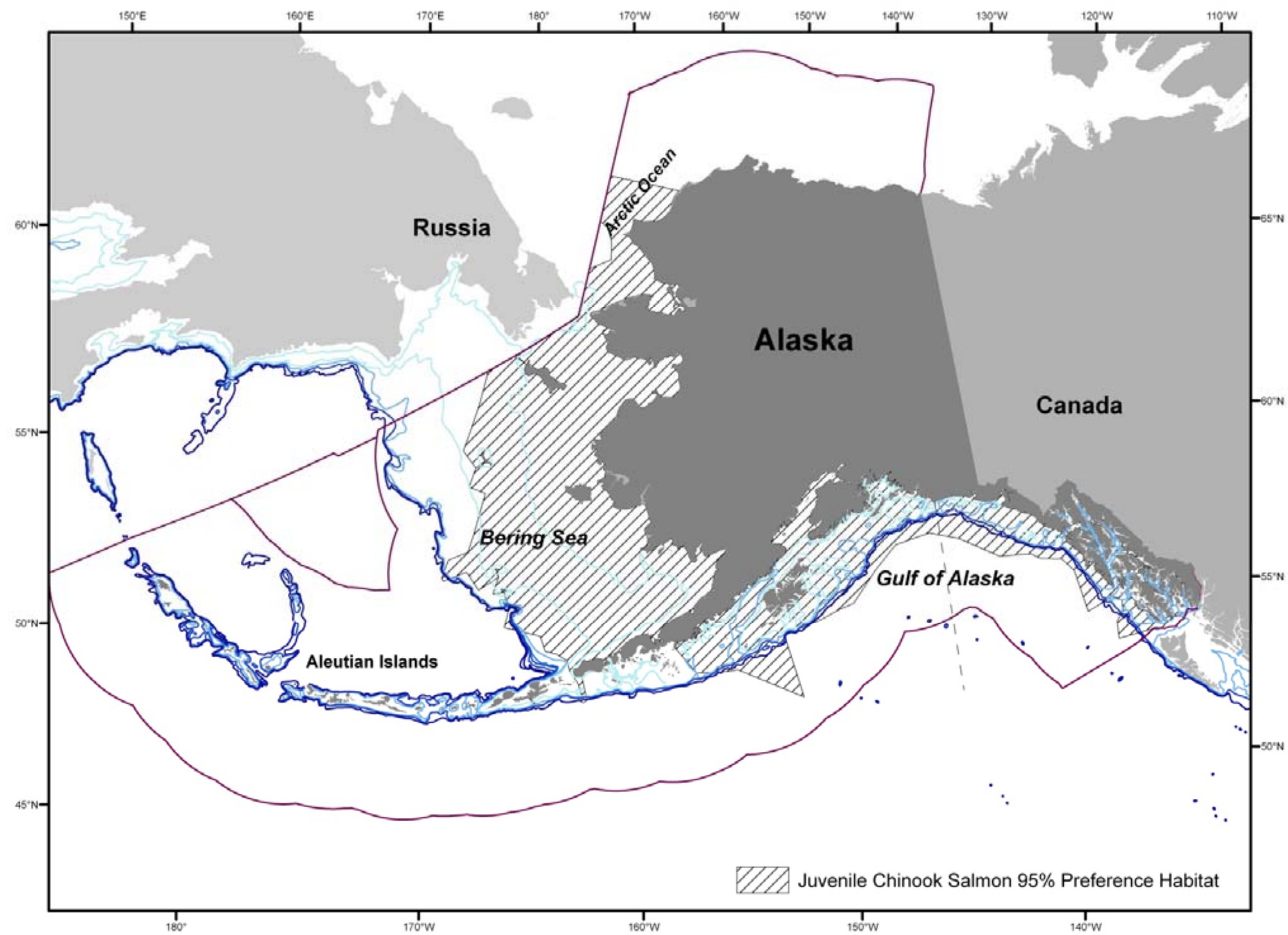

Figure 17b. -- Marine Juvenile Chinook Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH,smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

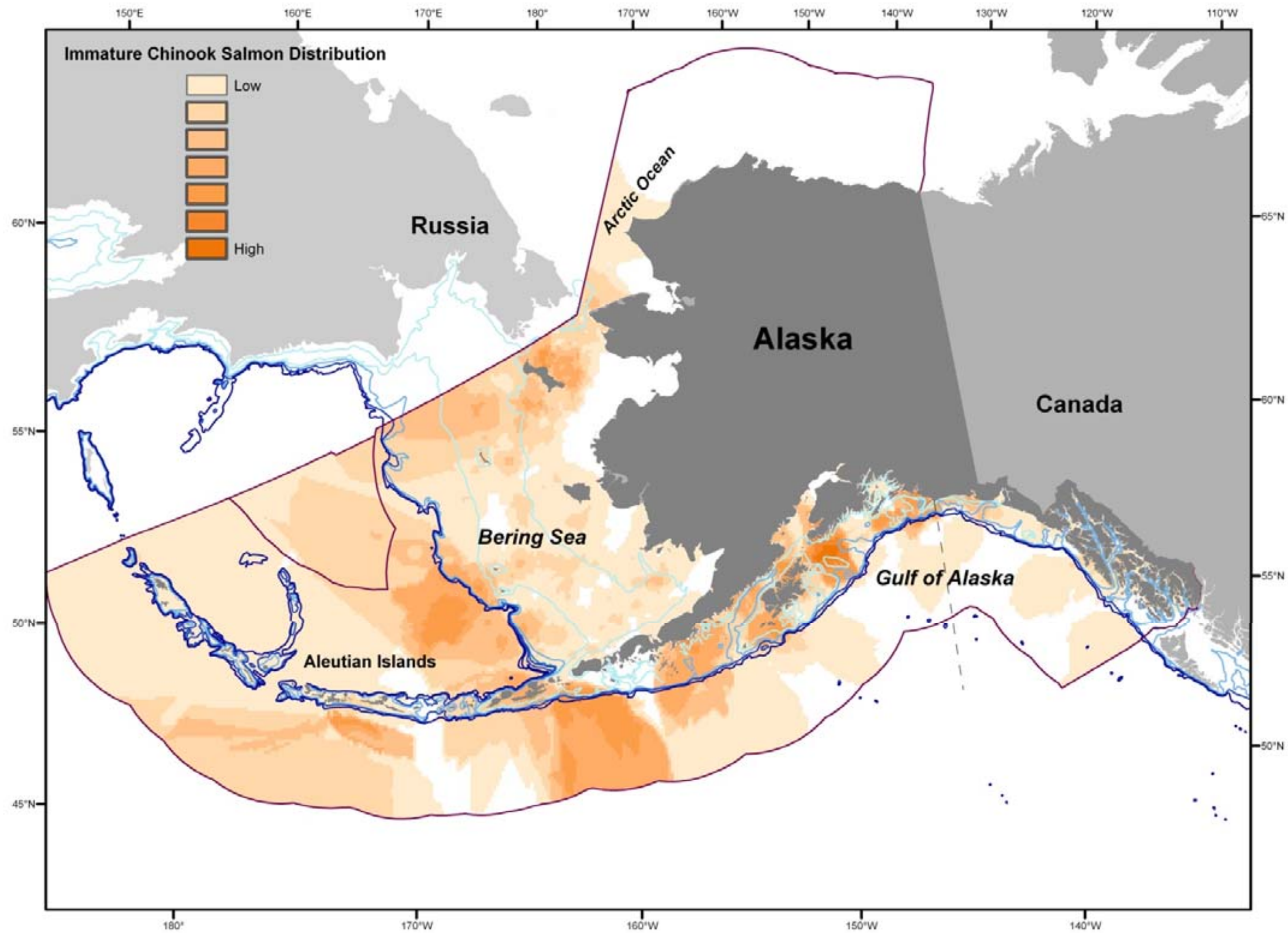

Figure 18a. -- 95% of the spatial distribution of marine immature Chinook salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

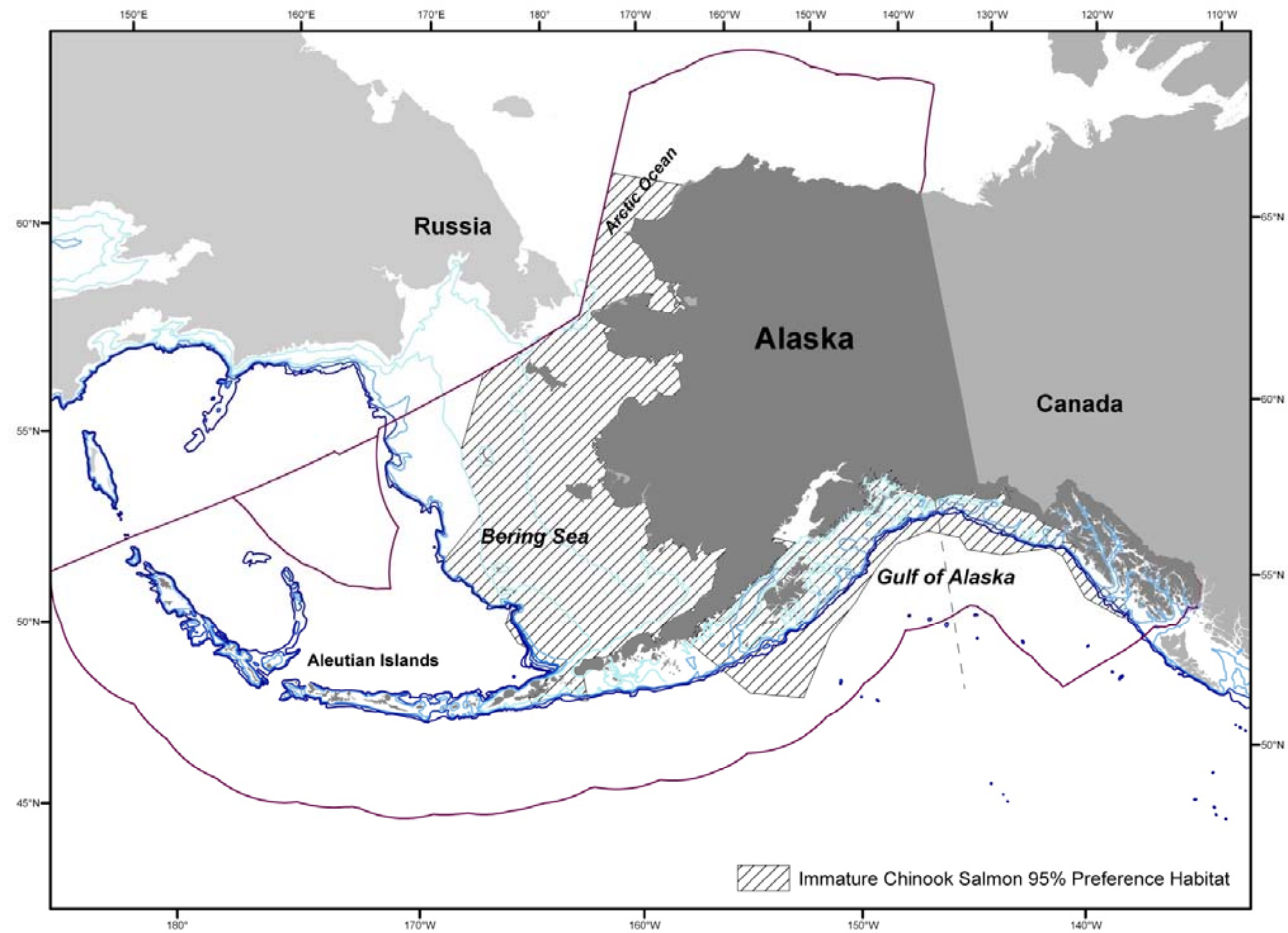

Figure 18b. -- Marine Immature Chinook Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH,smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

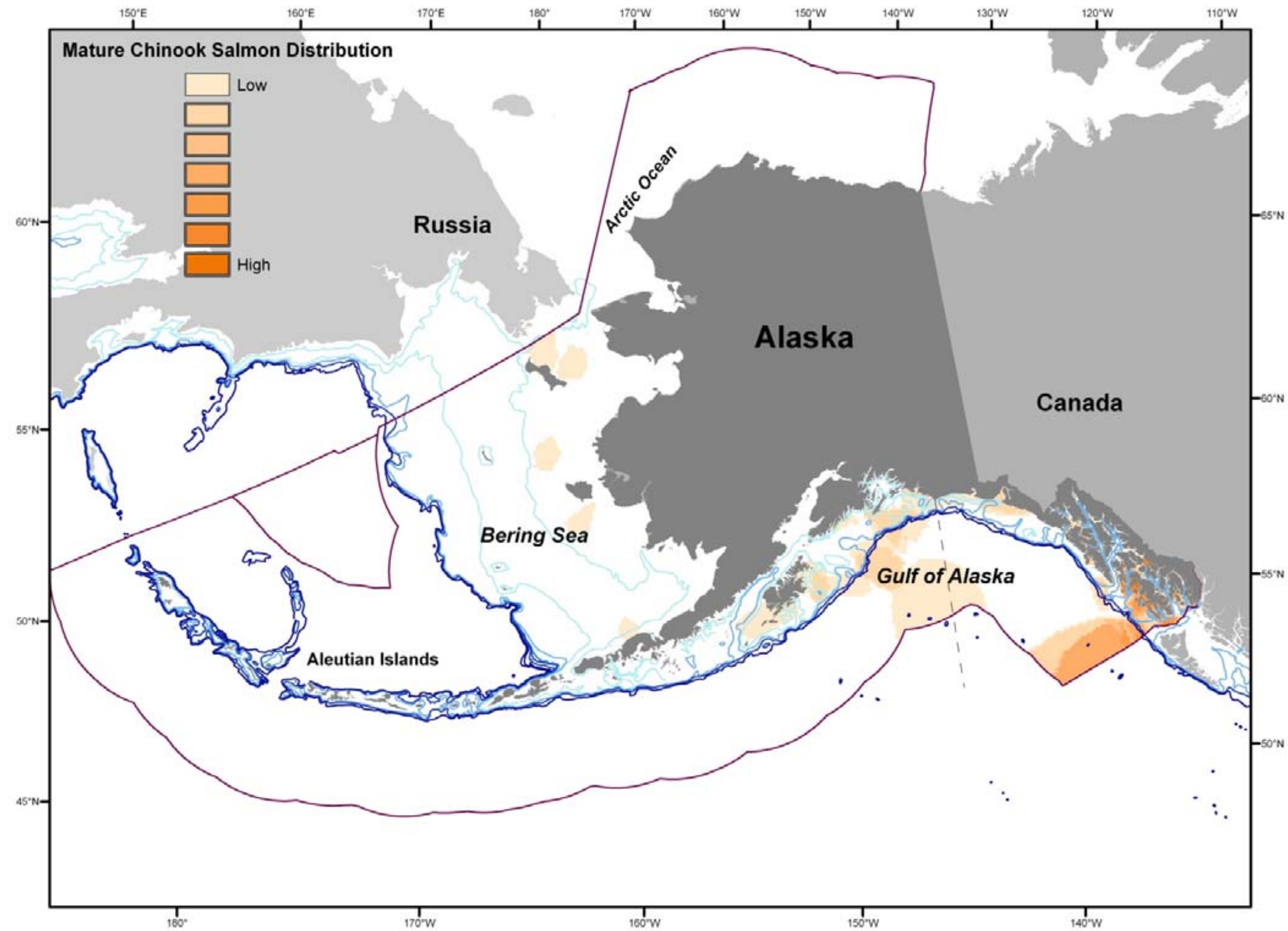

Figure 19a.-- 95% of the spatial distribution of marine mature Chinook salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

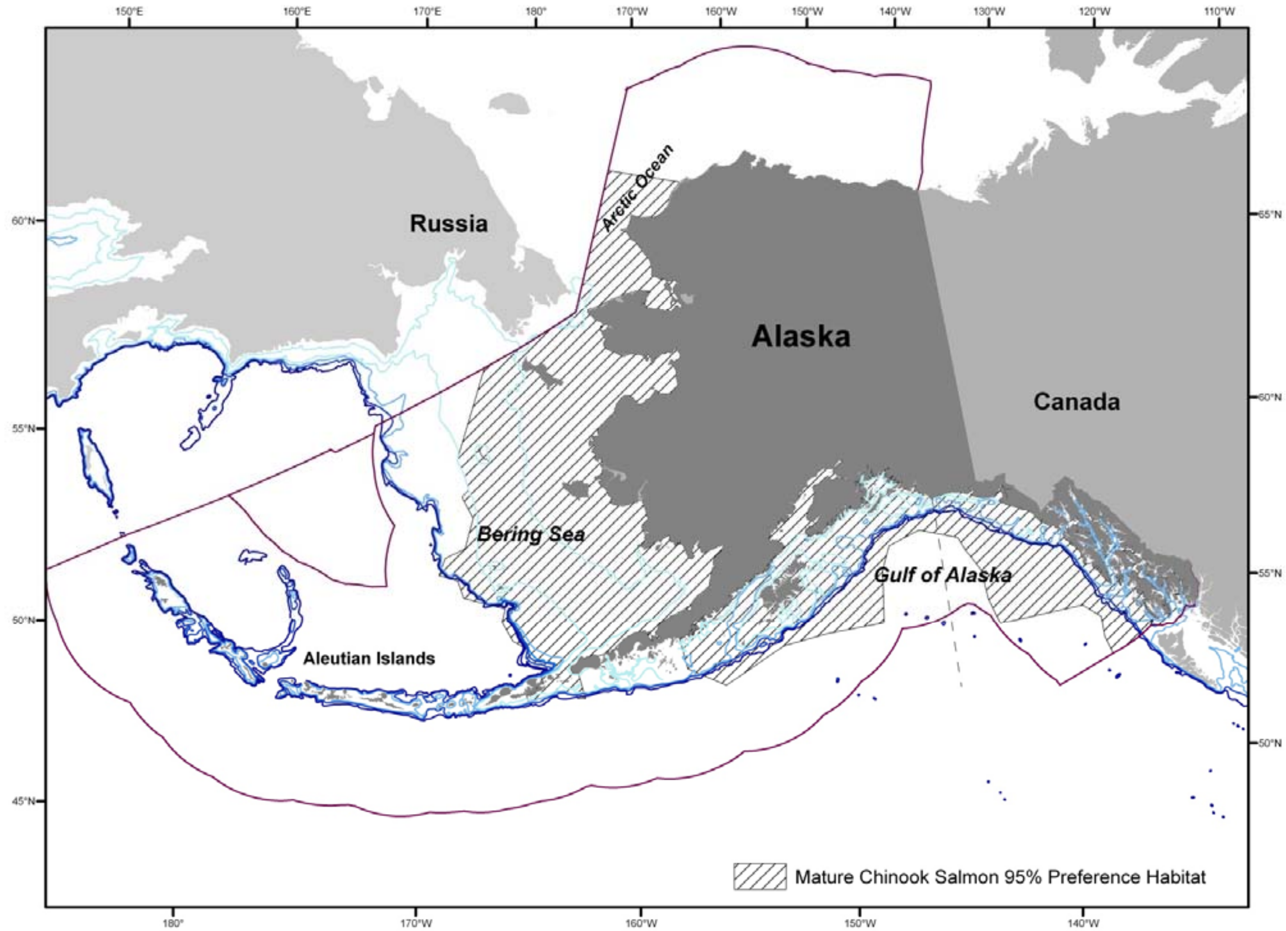

Figure19b. -- Marine Mature Chinook Salmon - Refined EFH Map Description. Dashed sections represent refined areas of EFH, smooth line represents boundary of the existing EFH Map Description for Marine Salmon (entire EEZ), dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, and depth contours are 50, 100, 200, 400, and 600 m.

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