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ABSTRACT

In southwestern Bristol Bay, the North Aleutian Basin has been identified as a potential lease area for oil and gas exploration. In preparation of an upcoming field project to learn more about the salmon distribution, season use, and migration pathways in the lease area the Alaska Fisheries Science Center, Ted Stevens Marine Research Institute undertook a review of existing information on salmon in the area. Bristol Bay has some of the largest salmon returns in the world which play an important role for the subsistence communities and for the economic health of the region. Between 1988 and 2008 in Bristol Bay, commercial fisheries harvested an average of over 26 million salmon. Salmon research efforts were instigated in the 1930's to better understand this important resource. Seaward-bound juveniles as well as returning adults are abundant in the North Aleutian Basin lease area from May to September. Migratory routes for both juveniles and maturing fish traverse the North Aleutian Basin, Bristol Bay and the eastern Bering Sea. Bycatch data collected by the National Marine Fisheries Service (NMFS) observer program shows that immature salmon occupy the area at all seasons of the year.

CONTENTS

INTRODUCTION

The Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE), Environmental Studies Program (ESP) was established and funded by the U.S. Congress to support the offshore oil and gas leasing program of the U.S. Department of the Interior in pursuit of national energy policies. Administered originally in 1973 by the Bureau of Land Management, the consistent mandate of the ESP has been to establish the information needed for assessment and management of potential impacts from oil and gas development on the Outer Continental Shelf (OCS) and coastal environments. The OCS refers to 1.7 billion acres of Federal jurisdiction lands submerged under the ocean seaward of State boundaries, generally beginning three statute miles off the coastline (for most states) and extending for 200 miles. The Alaska OCS Region alone contains approximately one billion acres. The Alaska ESP has primary focus on upcoming developments, possible lease sales, exploration activities and existing leases in the Beaufort Sea, Chukchi Sea, and North Aleutian Basin Planning Areas. The focus of this document is on the North Aleutian Basin (NAB), or southwestern Bristol Bay (Figure 1).

It would be difficult to identify an area in the Bering Sea, or possibly anywhere in the world that has greater fisheries use issues than the North Aleutian planning area. Bristol Bay includes eight major river systems that collectively support the largest commercial sockeye salmon fishery in the world. The Kvichak River is home to the single largest salmon run and the Nushagak River hosts a robust king salmon run, providing subsistence and commercial income to the peoples of western Alaska. Annual commercial catches average nearly 24 million sockeye salmon, 69,000 chinook, 971,000 chum, 133,000 coho, and 593,000 pinks. On average, individuals in Bristol Bay communities harvest 315 pounds per person, as their main source of food.

Local residents, highly dependent on salmon for both economic and subsistence livelihoods, are concerned about oilspill and other impacts on salmon in the lease area. A review of fishery resources within the eastern Bering Sea suggested that salmon were found in the North Aleutian Basin waters from May through at least October as seaward-migrating juveniles or returning adults; immature salmon were believed to be present in the area year round (Thorsteinson and Thorsteinson 1984). The goal of this report is to examine relevant data sources, both past and present, and existing literature to update what is known about juvenile, immature and maturing salmon distribution and migration pathways within the NAB region and to create spatial and temporal GIS layers of these known distributions for interim use in NEPA evaluations.

METHODS

A review of existing literature and relevant data products was performed and key data on salmon presence and absence were identified; see Table 1 for list of data sources. Other relevant data products come from commercial fishery catch records from the Alaska Department of Fish and Game, Area M fishery and from salmon bycatch records collected by the Alaska Fishery Science Center, Observer Program during the Bering Sea walleye Pollock fishery. Gear types included: pelagic trawls, gill nets, seines, circular tow nets, and surface trawls.

The largest data sets for salmon presence and absence in the NAB come from summer and fall surveys conducted by scientists at the Alaska Fisheries Science Center, U.S. Bering-Aleutian Salmon International Survey (U.S. BASIS) project (1999 to 2009) and from salmon bycatch records available in the NORPAC database. For U.S. BASIS data, all salmon were combined and sorted by maturity stage into three groups: juvenile, immature, and mature. Salmon catch data were selected from all stations south of 60 degrees latitude north; this area will be referred to as the southern eastern Bering Sea (SEBS). Because U.S. BASIS data included data on salmon catches from July to October; we chose to group summer and fall seasons together as the U.S BASIS data come from a continuous cruise that overlaps these seasons (Appendix I).

For salmon bycatch data, salmon were separated into two groups: Chinook and other salmon (other salmon is predominantly composed of chum). Catches occurred from 1988 to 2006 for chinook and from 1989 to 2006 for other salmon. Salmon captured as bycatch are not sorted by maturity; given the gear type and seasons we will consider the majority of these salmon as immature. We confined our data query to catch locations that occurred in the Bering Sea less than 175 degrees longitude west and less than 60 degrees latitude north.

Salmon catch data were grouped by season into the following categories: winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and fall (September, October, and November). Splitting these data by season provided a greater understanding of the seasonal presence and absence of salmon in the NAB lease area and the surrounding areas.

RESULTS and DISCUSSION

The biology of Pacific salmon, as it pertains to Bristol Bay and North Aleutian Basin area, can be divided into three phases that include the juvenile, immature, and maturing life history stages. All of the five common Pacific salmon species in western Alaska are anadromous, in that they spend parts of their life history in freshwater and marine environments. However, each species spend differing amounts of time in each environment. For example, pink and chum salmon proceed immediately to sea after emergence from spawning beds, whereas chinook, coho, and sockeye salmon may spend up to 1 or more years in freshwater after emergence before heading out to sea. The timing of the seaward migration of salmon smolt is generally from May through August, peaking sometime during June. However, the peak seaward migration is species and stock specific and varies according to annual differences in spring ice break-up and the distance salmon fry must travel to get to the ocean from a particular spawning or rearing area within a lake or river. Once in the ocean, western Alaska salmon have extensive ocean migration pathways spanning the North Pacific Ocean (Myers et al. 2007). Pink and coho salmon spend only one year in the ocean before returning to natal streams to spawn. Chinook, chum, and sockeye salmon typically spend two or more years in the ocean before returning to spawn as adults, although there are some instances where these salmon return after one year at sea.

Juvenile Salmon

Nearly all the information on western Alaska juvenile salmon life history stage comes from research efforts conducted in the eastern Bering Sea from the 1930s to present (Farley et al. 2005; Hartt and Dell 1986; Isakson et al. 1986; Ogi 1973; Paulus 1973; Straty 1981; Straty et al. 1974; Straty and Jaenicke 1980). Much of the previous research (through the 1970s) was summarized in Thorsteinson and Thorsteinson (1984) to provide an overview of the potential impacts of oil and gas development on fish resources within the North Aleutian Basin/ Bristol Bay region. Their summary on western Alaska salmon suggested that both seaward-bound juveniles and returning adults are abundant in the NAB region from May to September. While juvenile sockeye, chinook, coho, pink, and chum salmon were collected during the surveys, the data were only sufficient to describe the migratory pathway for juvenile sockeye salmon (Straty 1974). The survey results indicated that the migratory pathway for juvenile sockeye salmon was near the coast, where the migratory band extended approximately 60 km from the shore (Figure 2). The absence of juvenile chinook salmon during later survey periods supported the hypothesis that juvenile chinook salmon migrated out of the Bristol Bay region more quickly than other juvenile salmon species.

Research surveys conducted in the mid 1980s to determine the offshore distribution and migration corridors for juvenile sockeye salmon largely confirmed the results found by Straty (1974) and summarized in Thorsteinson and Thorsteinson (1984) in that the migratory corridor for juvenile sockeye salmon was nearshore along the Alaska Peninsula (Isakson et al. 1986). However, the hypothesis that juvenile sockeye salmon progressively move offshore with increasing size was not strongly supported by their data. These results were likely influenced by the survey design, because the sampled transects did not extend as far offshore as those sampled during previous surveys. In addition, sockeye salmon smolt marking experiments performed by Straty (1974) during 1967 to 1970 were summarized in Isakson et al. (1986). The mean migration rate estimated for pooled stocks by year and for pooled years by stock indicate a grand mean of approximately 9.6 km/day, which they report is very close to one body length per second for juvenile Bristol Bay sockeye salmon of average length. The authors emphasized the pressing need for research to define the roles and consequences of biotic and abiotic variables in modifying salmon migrations.

Beginning in 2000, scientists from the National Marine Fisheries Service conducted research along the eastern Bering Sea shelf with a goal of determining mechanisms affecting marine survival of western Alaska juvenile salmon. The research named U.S. Bering-Aleutian Salmon International Survey (U.S. BASIS) was conducted in collaboration with member nations of the North Pacific Anadromous Fish Commission (NPAFC[1]). The portion of the surveys that focused on juvenile salmon in the southeastern Bering Sea occurred during mid August to early September and sampled stations within Bristol Bay and offshore along the eastern Bering Sea shelf (Figure 3). Juvenile salmon were collected using a mid-water rope trawl that was rigged to fish the top 15 m of the water column (see Farley et al. 2005 for details). The mid-water rope trawl was 198 m long, had hexagonal mesh in wings and body, and had a 1.2-cm mesh liner in the codend. The rope trawl was towed at 3.5 to 5 knots, and had a typical spread of 50 m horizontally and 12 m vertically.

The research provided information on distribution (Figure 4), migration pathways (Figure 5), and size of juvenile western Alaska salmon (Farley et al. 2005). Upon leaving freshwater lake systems around Bristol Bay, juvenile sockeye salmon migrate west along the northern and southern sides of Bristol Bay, moving offshore and away from their freshwater rearing habitats as they grow. Juvenile chum and coho salmon migrate westward along the northern end of the southeastern Bering Sea region (south of latitude 60˚N) upon entering the eastern Bering Sea from the Kuskokwim River, gradually

[1] North Pacific Anadromous Fish Commission. 2001. Plan for NPAFC Bering-Aleutian Salmon International Survey (BASIS) 2002 – 2006. NPAFC Doc. 579, Rev. 2. 27 p.

moving offshore (southwest) as they grow. Juvenile chinook salmon from the Kuskokwim River also appear to migrate westward along the northern end of the southeastern Bering Sea region; however, the decreasing size with distance from the northern shoreline suggests the presence of other stocks farther offshore.

Juvenile chum and chinook salmon from the Yukon River migrate southwesterly. The presence of 2 coded wire tagged juvenile Whitehorse Rapids Salmon Hatchery chinook salmon caught within Norton Sound also suggests that some juvenile chinook salmon from the Yukon River migrate north into Norton Sound. A general southwesterly migration pathway along the northeastern Bering Sea shelf appears plausible, with either the presence of separate stocks of juvenile pink salmon from western Alaska or a mixture of western Alaska stocks nearshore and Russian stocks (southeasterly migration) offshore.

For Bristol Bay sockeye salmon, the results indicated two different migration pathways. The first migration pathway was west in an area defined from the Alaska Peninsula and extending offshore to 57°N, while the second migration pathway was farther offshore along the northern and southern sides of Bristol Bay (Farley et al. 2007a; Farley et al. 2005). In general, these recent studies indicated that fish were large, had higher marine-stage survival rates, and were in better condition when their migration pathway was farther offshore. In addition, growth rate potential in the offshore regions was higher than nearshore regions suggesting that juvenile sockeye salmon that distribute and migrate farther offshore would find themselves in areas of higher growth rate potential. Size selective mortality, particularly on smaller juvenile sockeye salmon, appears to be an important factor impacting their early marine survival (Farley et al. 2007a; Farley et al. 2007b).

Juvenile coho and chinook salmon were distributed nearshore, but not found in the deeper, offshore waters. One possible explanation for the absence of juvenile coho and chinook salmon within the deeper, offshore waters is that their vertical distribution increases as bottom depth increases, potentially making them unavailable to the surface trawl. Although we do not have data on the actual vertical distribution of juvenile salmon in our survey, we can infer some general patterns from other surveys. Juvenile coho and chinook salmon can occur in water depths down to 50-m, but juvenile coho salmon maintain their highest densities in the upper 15-m of the water column (Beamish et al. 2000); whereas juvenile chinook salmon are distributed deeper, but are still present in the upper 15-m of the water column (Orsi and Wertheimer 1995). Therefore, the absence of juvenile coho and chinook salmon in deeper, offshore waters of our survey does not necessarily indicate a bias in our sampling gear but rather that they appear to prefer the nearshore, shallow locations.

Comparisons between the earlier and more recent research on juvenile salmon indicate that the migratory pathways for juvenile salmon depend upon the prevailing environmental conditions during spring and summer within the eastern Bering Sea. In general, juvenile sockeye and pink salmon are found offshore in deeper water during August through September, whereas juvenile chinook and coho salmon are still present in nearshore locations. The past and present data sets indicate that all five juvenile salmon species are distributed in the eastern Bering Sea shelf, near or within the NAB region from May through October (Figure 4; Table 1). These juvenile fish are likely present on the shelf beyond October.

Immature Salmon

Most of the information on immature salmon distribution in the Bristol Bay and North Aleutian Basin areas comes from research surveys and observer data collected on board fishing vessels during the Bering Sea walleye Pollock commercial fishery. Immature salmon (ocean age #.1) were also captured during the April through October surveys (Hartt and Dell 1986). All of the salmon species were caught in the eastern Bering Sea, along the Alaska Peninsula during the survey periods with the exception of coho salmon during April to June and pink salmon during September to October, although sampling did not occur in all areas during the later time period.

Salmon mature at different stages depending on species. Pink and coho salmon mature at age #.1 and thus can be expected to be moving toward spawning grounds during their second summer or fall at sea. The other salmon species are considered immature, meaning that a majority of them will remain in the ocean for 1 or more years before maturing and thus are considered to be migrating into and out of the eastern Bering Sea area.

Salmon bycatch data are considered to be predominantly immature salmon. These salmon are split into two groups: chinook and other salmon species. It is critical that the bycatch data are interpreted correctly. These data show where fisheries occur and where these fisheries capture salmon as bycatch. These data do not show all the areas that salmon are present; they only show areas that have been fished. Salmon bycatch (not including chinook) occurs in the lease area every season of the year (Figure 6). Similarly, chinook bycatch occurs in the lease area every season of the year (Figure 7). Figures 6 & 7 display uneven distributional patterns for most seasons and have large voids where salmon were not caught; some of these surrounding areas probably were not fished and do have immature salmon present. The bycatch data provides key information on immature salmon distribution during the winter and spring periods when weather conditions are prohibitive to research sampling.

Maturing Salmon

The time of the spawning migration for all five Pacific salmon species returning to their natal rivers in the eastern Bering Sea was summarized by Thorsteinson and Thorsteinson (1984). Their summary included results of research efforts from the 1960s to 1970s to determine migratory pathways of maturing salmon returning to western Alaska. These summaries suggest that maturing sockeye, chum, and pink salmon are widely distributed throughout the eastern Bering Sea, but are heavily concentrated in bands north and south of the Pribilof Islands (Figures 8 - 10). The southern band traverses Bristol Bay and includes stocks of salmon migrating to the north side of the Alaska Peninsula, Bristol Bay, and Kuskokwim River (Straty 1981). The homeward migratory band of chinook salmon is a little further offshore than sockeye, pink, and chum salmon, whereas the migratory band of coho salmon is nearshore along the Alaska Peninsula (Straty 1981)(Figures 11, 12). Recent data from a test fishery near Port Moller (Flynn et al. 2003) supported the earlier migratory model for these salmon developed by Straty (1981).

Commercial catch records collected from fisheries along the northern Alaska Peninsula and Bristol Bay were also provided in the report. The results suggested that maturing salmon are most abundant in the NAB region from mid-May to early September. Maturing chinook salmon arrive first, followed by sockeye, chum, pink, fall chum, and coho salmon. Mean salmon catch between 1977 and 1981 for the major salmon districts was 1.7 million salmon for the Alaska Peninsula and 23 million salmon for Bristol Bay from 1977 to 1981. For Bristol Bay, the largest average catch was sockeye salmon (17,230,369) followed by pink (3,901,557), chum (1,313,866), coho (227,911), and chinook (171,719) salmon (Thorsteinson and Thorsteinson 1984).

More recent data indicate that between 1988 and 2008 in Bristol Bay, commercial fisheries harvested an average of over 26 million salmon; the largest average catch was sockeye salmon (24,953,708) followed by chum (957,138), pink (230,944), coho (97,606), and chinook (65,939) respectively (Jones et al. 2009). Although smaller in scale, the North Alaska Peninsula region contains fisheries that are directly inshore from the North Aleutian Basin Lease Area. Between 1998 and 2007 in the North Alaska Peninsula, commercial fisheries harvested an average of over 2 million salmon; the largest catch was sockeye salmon (2,021,408) followed by chum (84,787), coho (64,190), pink (34,136), and chinook (6,237) respectively (Murphy and Hartill 2009). The commercial data also suggest similar run timing through the North Aleutian Basin (June through September) area to that found in the past, with chinook salmon moving through first followed by sockeye, pink, chum, and coho salmon (Table 2).

CONCLUSIONS

It is evident from reviewing the available literature and data sets that salmon are present in the NAB and surrounding areas all seasons of the year. The U.S. BASIS data illustrate the broad distributions of all maturity stages of salmon that extend across the breadth of the southeastern Bering Sea during the summer and fall months (Figure 4). These data support previous studies that demonstrated the migratory routes of both juvenile (Figure 5) and maturing salmon; many of these migratory routes pass through or very near to the NAB. The NMFS observer data provides key insights into the winter and spring use of the NAB and surrounding areas and clearly show that immature chinook and other salmon (mostly chum) are commonly found within the NAB at all seasons.

ACKNOWLEDGEMENTS

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Table 1. – Months where southeastern Bering Sea catch data and information exists for juvenile, immature, and maturing sockeye, chum, pink, coho, and chinook salmon. (Source: Ogi 1973; Straty 1974; Straty 1981; Isakson 1986; Hartt and Dell 1986; U.S. BASIS; and NMFS Observer Program).

LHS	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I/Mat	Sockeye					X	X	X	X	X			
	Chum	X	X	X	X	X	X	X	X	X	X	X	X
	Pink						X	X	X				
	Chinook	X	X	X	X	X	X	X	X	X	X	X	X
	Coho						X	X	X	X			
Juv	Sockeye					X	X	X	X	X			
	Chum						X	X	X	X	X		
	Pink						X	X	X	X	X		
	Chinook						X	X	X	X			
	Coho						X	X	X	X	X		

Table 2. – Fisheries on salmon migrating through the North Aleutian Shelf including the total catch (millions), periods fish were taken, and peak week for 2008. (Source: Murphy and Hartill 2009; Jones et al. 2009; Whitmore et al. 2008).

	North Peninsula	Bristol Bay	Kuskokwim
Chinook			
Total Catch	0.002	0.024	0.028
Fishing Period	6/7 – 9/5	6/9 – 8/21	6/15 – 9/8
Peak Weak	6/28 – 7/14	6/28 – 7/9	6/15 – 7/5
Sockeye			
Total Catch	2.004	27.686	0.044
Fishing Period	6/7 – 9/12	6/9 – 8/28	6/15 – 9/6
Peak Weak	6/28 – 7/11	6/30 – 7/10	7/5 – 7/9
Chum			
Total Catch	0.177	1.290	0.046
Fishing Period	6/28 – 9/12	6/9 – 8/21	6/15 – 9/8
Peak Weak	7/19 – 7/25	6/26 – 7/20	6/30 – 7/14
Pink			
Total Catch	0.021	0.276	0.00
Fishing Period	6/21 – 8/29	6/18 – 8/20	
Peak Weak	7/19 – 8/1	7/20 – 8/2	
Coho			
Total Catch	0.125	0.114	0.516
Fishing Period	7/5 – 9/12	7/4 – 9/5	7/6 – 9/8
Peak Weak	8/9 – 8/22	7/29 – 8/16	8/23 – 8/30

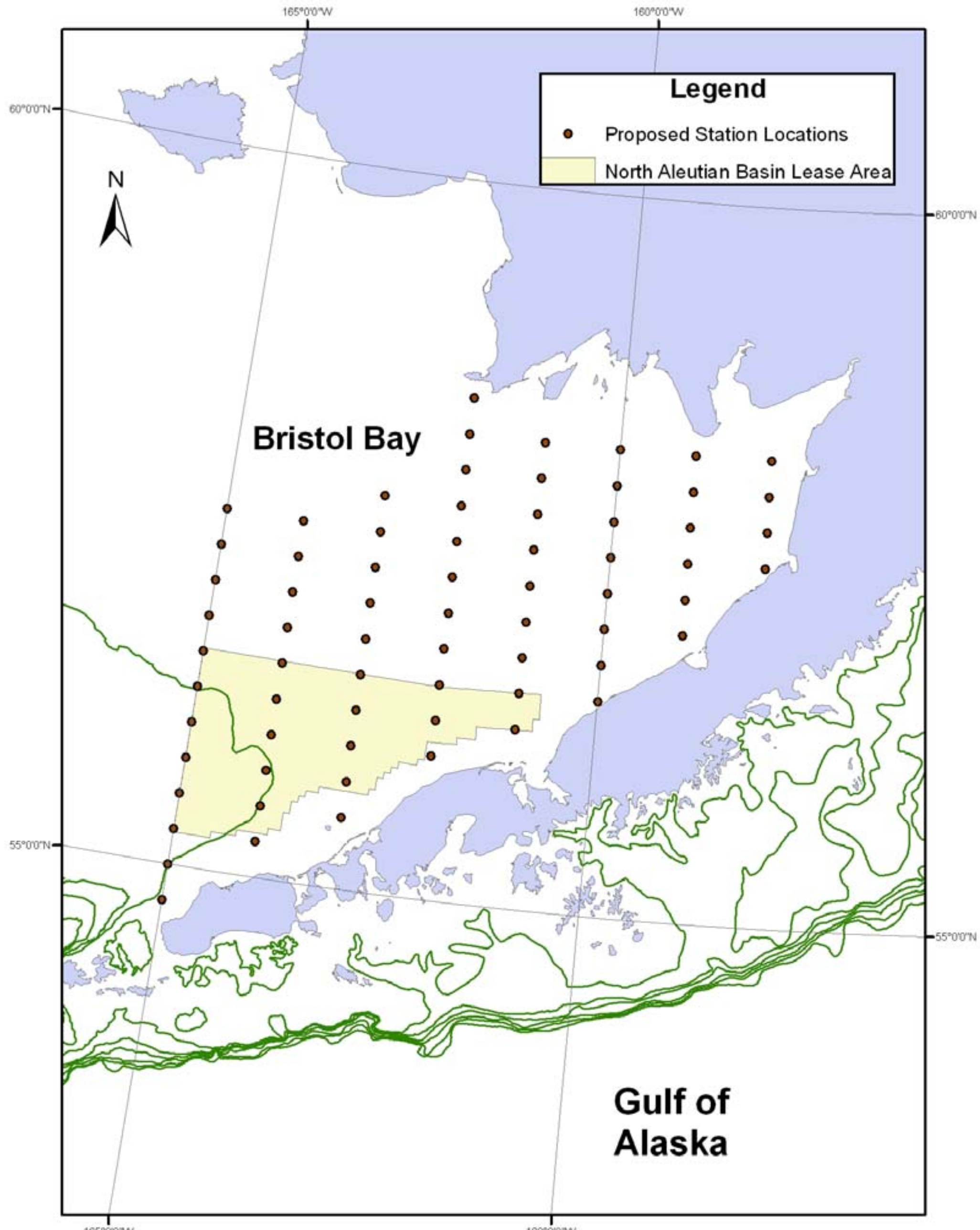

Figure 1. – Map of Bristol Bay, showing the North Aleutian Basin Lease Area (yellow) and survey stations to be sampled during May and July 2010 by the Alaska Fisheries Science Center.

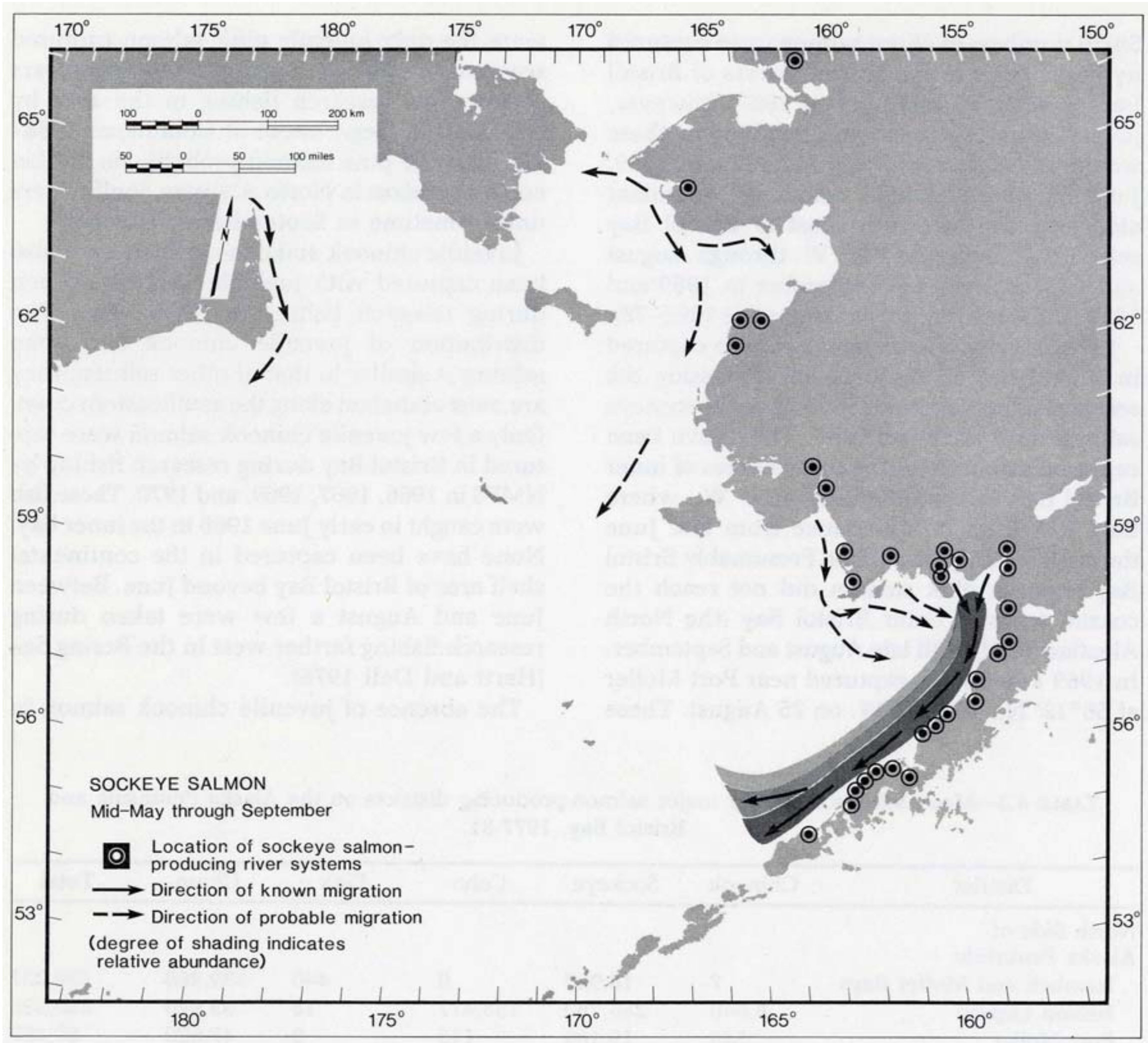

Figure 2. – Distribution of juvenile sockeye salmon during seaward migration, mid-May through September (Straty 1981).

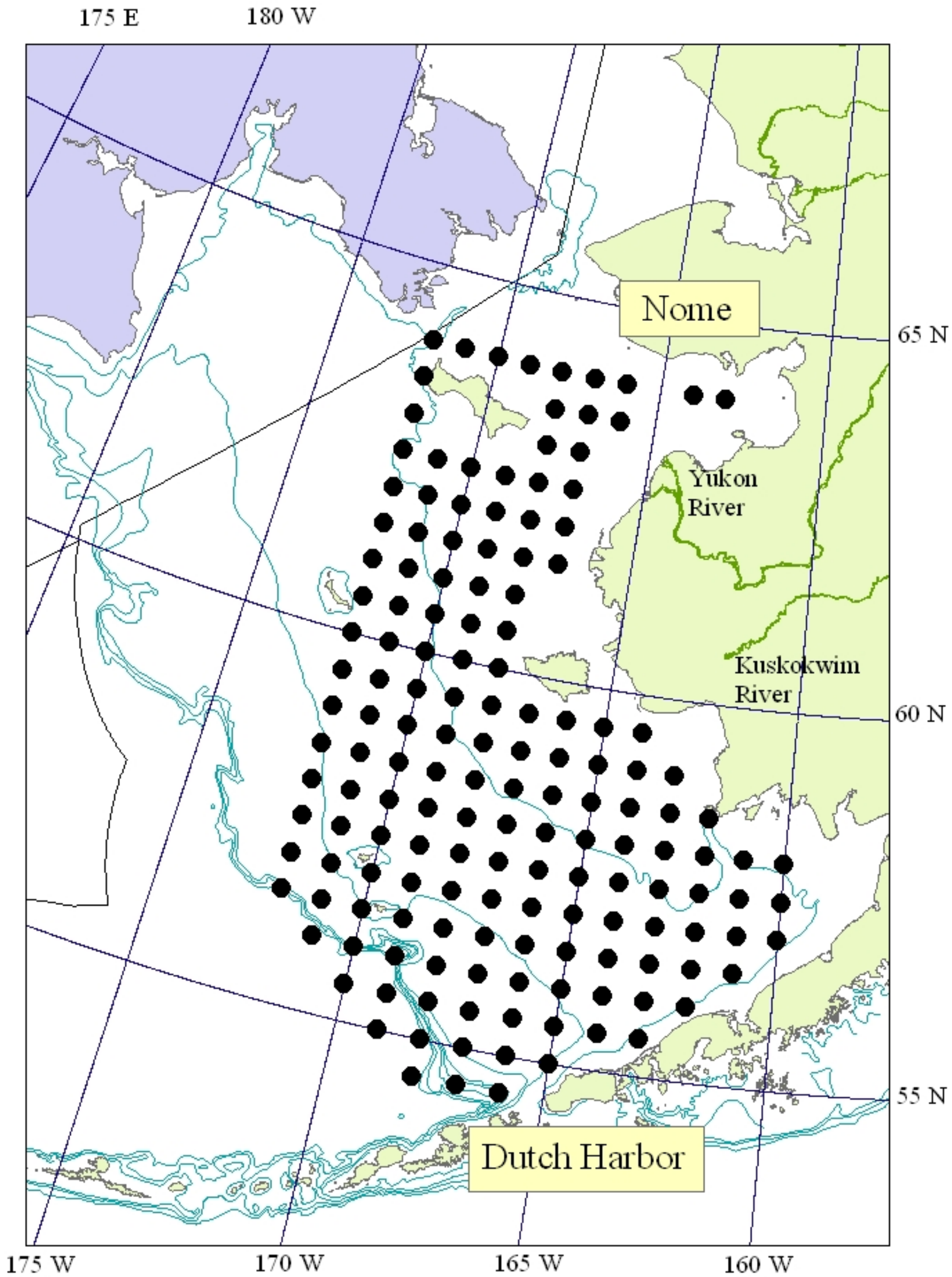

Figure 3. – Typical surface trawl station locations during August – September, 2004 to 2007 for the U.S. Bering-Aleutian Salmon International Survey (U.S. BASIS) conducted by scientists from the Alaska Fishery Science Center, Auke Bay Laboratories.

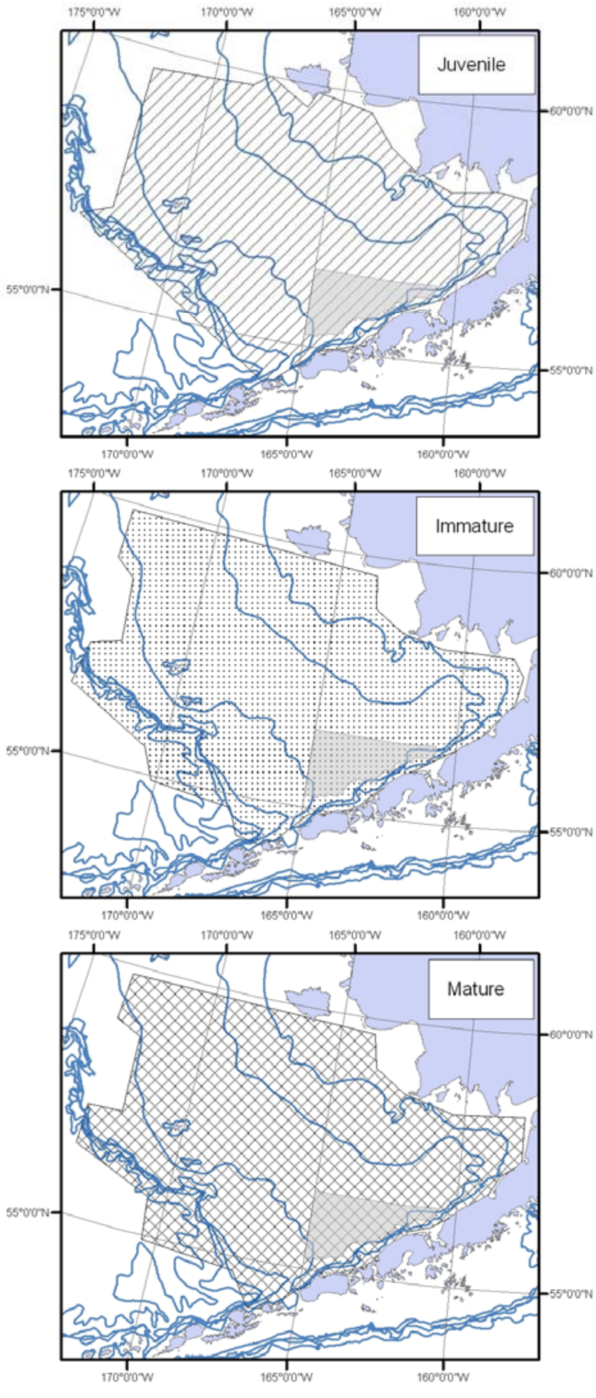

Figure 4. - Combined summer and fall distribution maps for juvenile, immature, and maturing salmon in the southeastern Bering Sea (Source: U.S. BASIS).

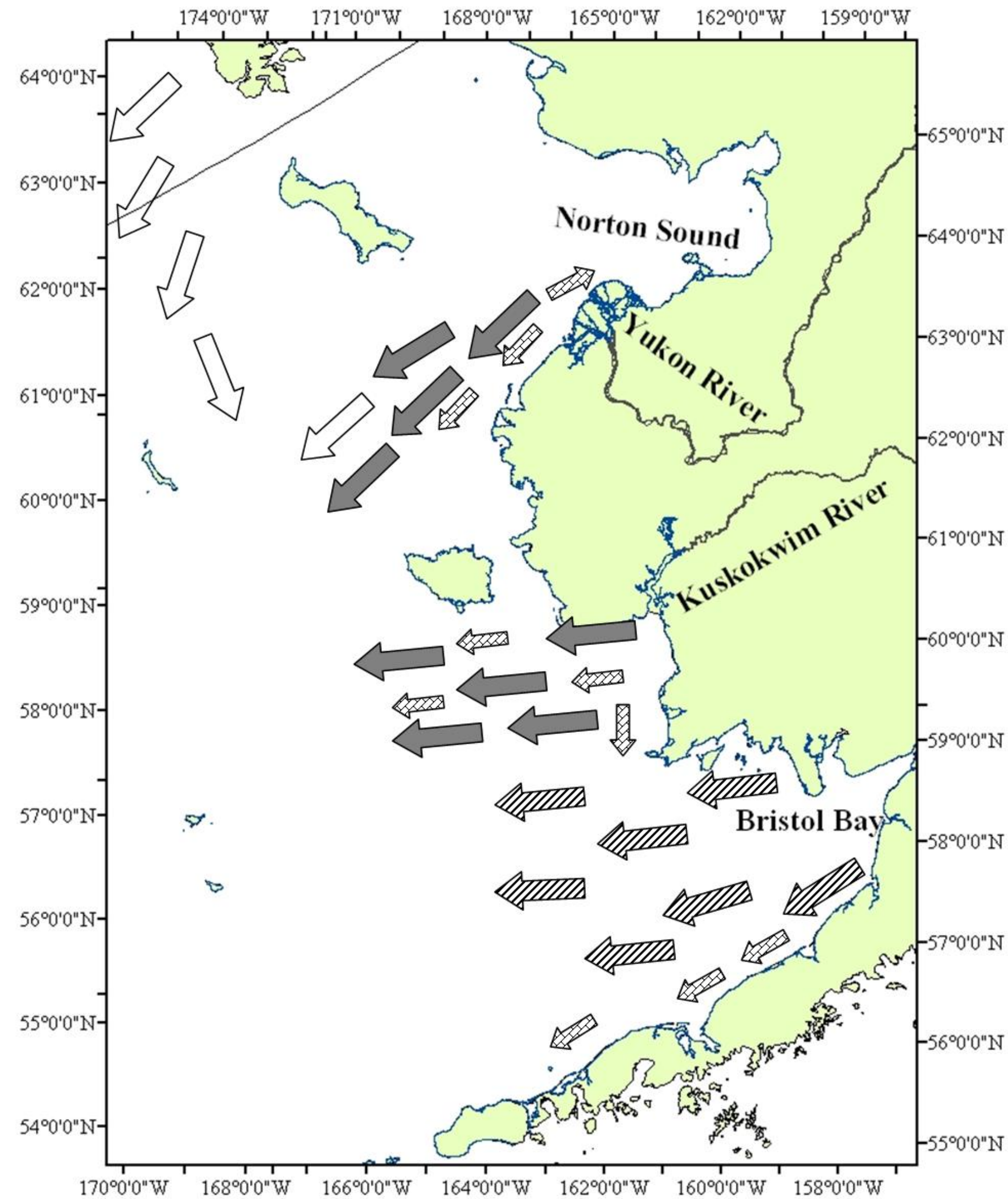

Figure 5. – Seaward migration pathways for juvenile pink (clear arrow), chum (solid arrow), sockeye (slashed arrow), coho, and chinook (boxed line arrow) salmon along the eastern Bering Sea shelf during August through October 2002. (Farley et al. 2005).

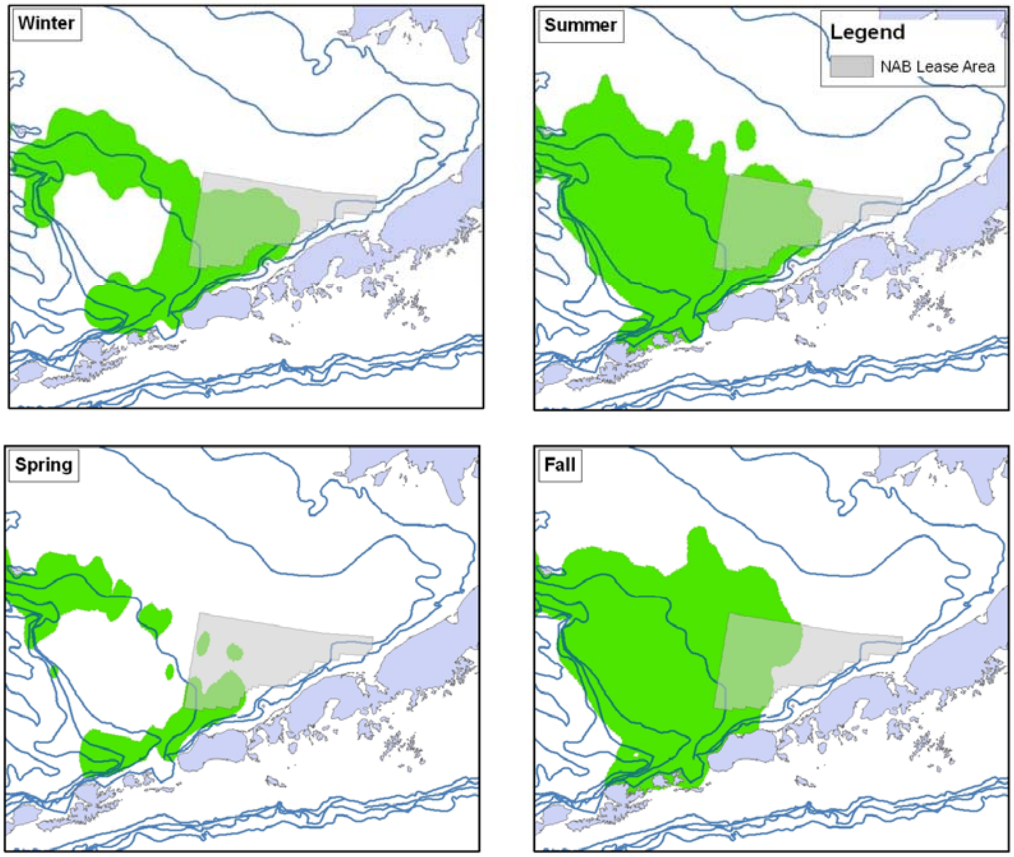

Figure 6. - General location of salmon bycatch (not including chinook) in pelagic trawl gear between 1987 and 2006 (Source: NMFS Observer Program). Plots depict seasonal distributions of predominantly immature salmon bycatch (not including chinook) in the southeastern Bering Sea (SEBS).

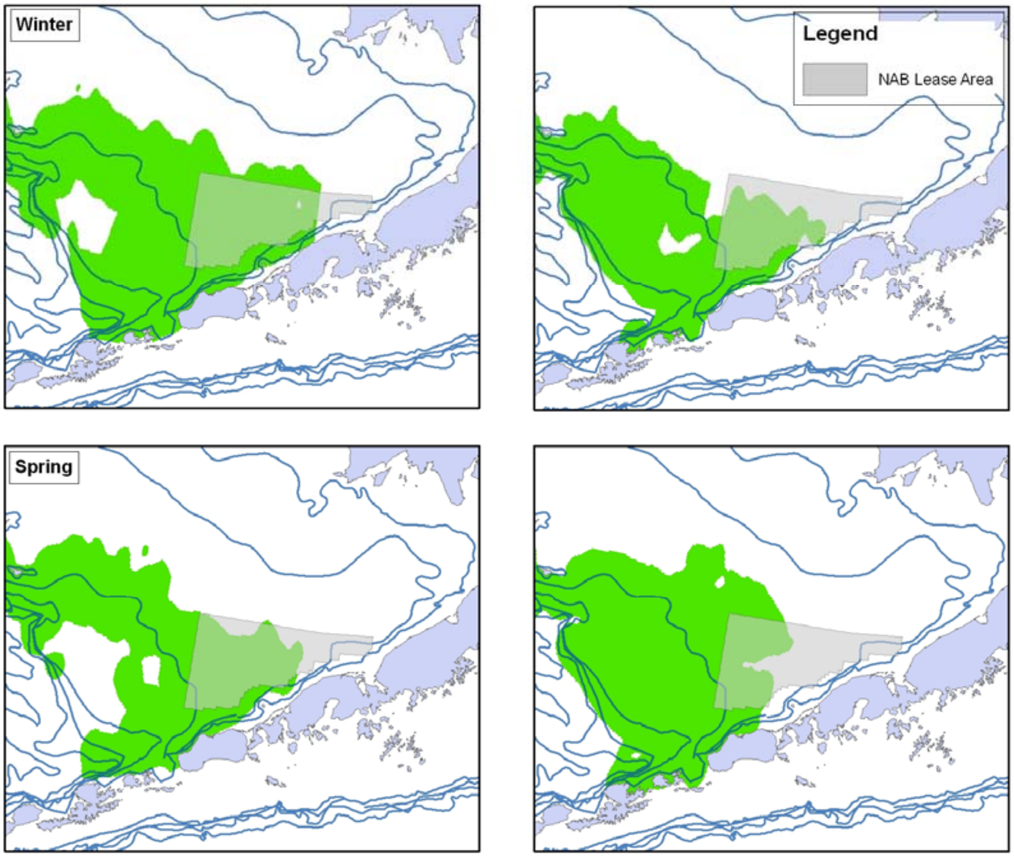

Figure 7. - General location of chinook salmon bycatch in pelagic trawl gear between 1987 and 2006 (Source: NMFS Observer Program). Plots depict seasonal distributions of predominantly immature chinook salmon bycatch in the southeastern Bering Sea (SEBS).

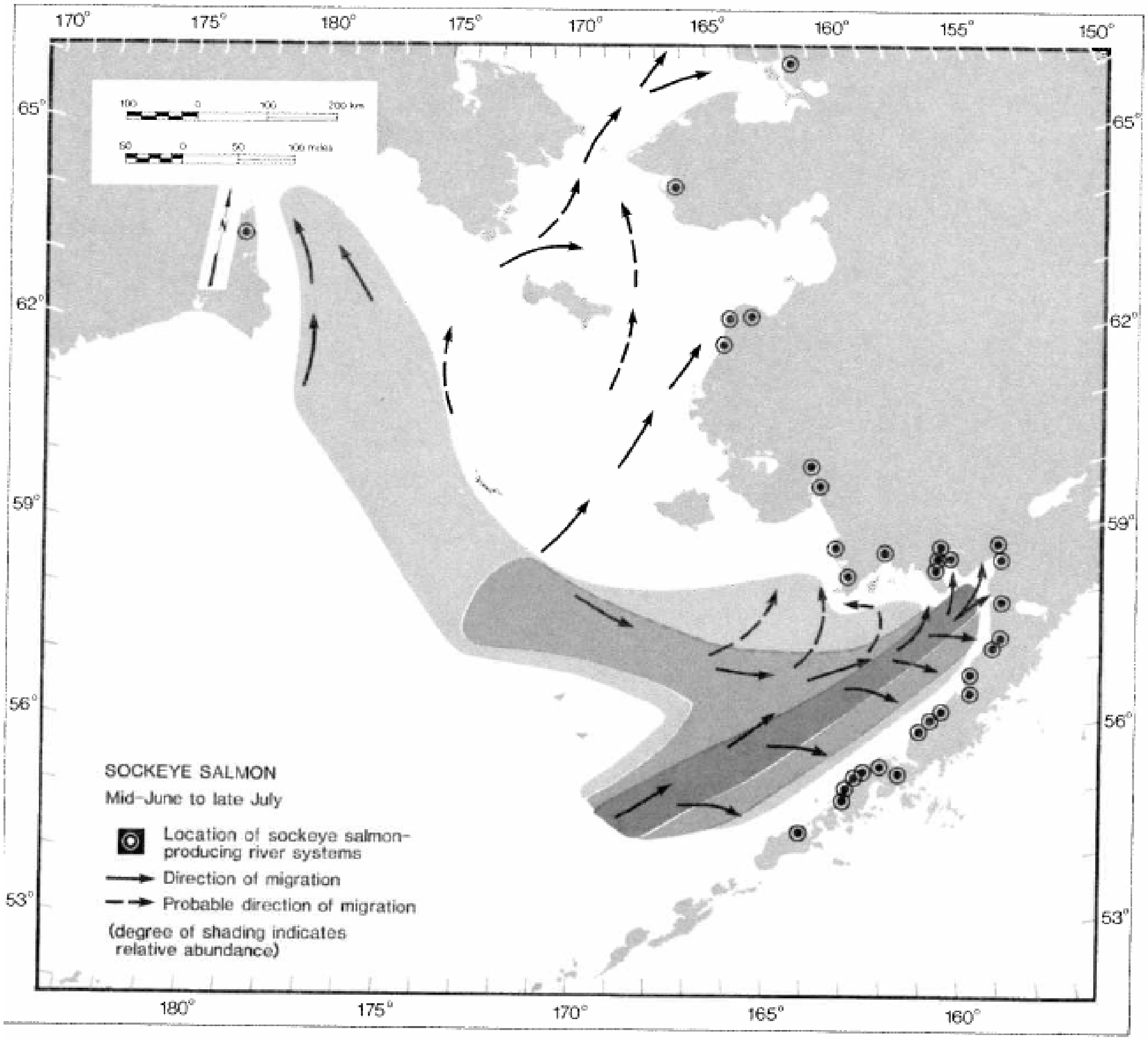

Figure 8. – Distribution of sockeye salmon during spawning migration (Straty 1981).

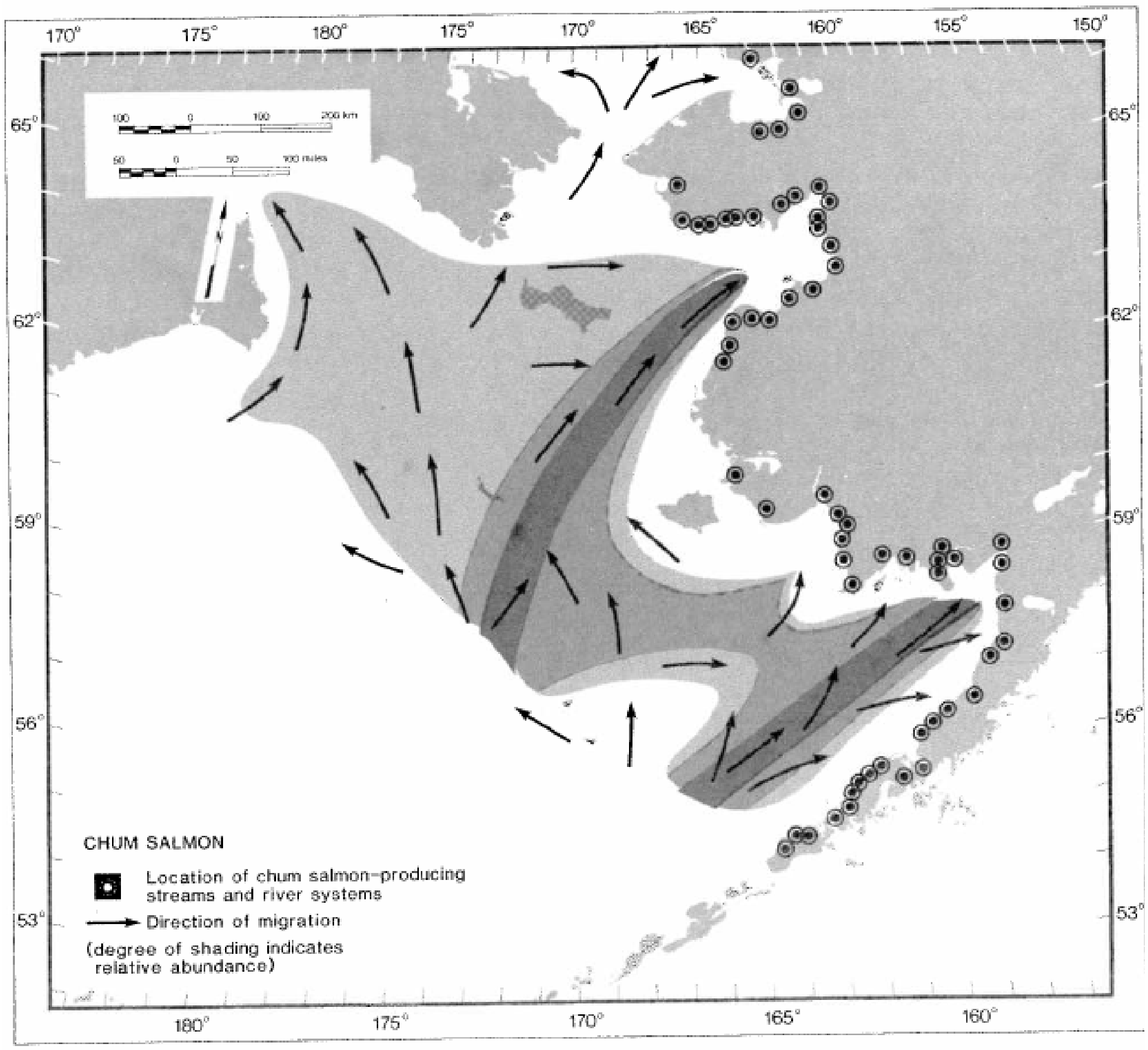

Figure 9. – Distribution of chum salmon during spawning migration, mid-June to early August (Straty 1981).

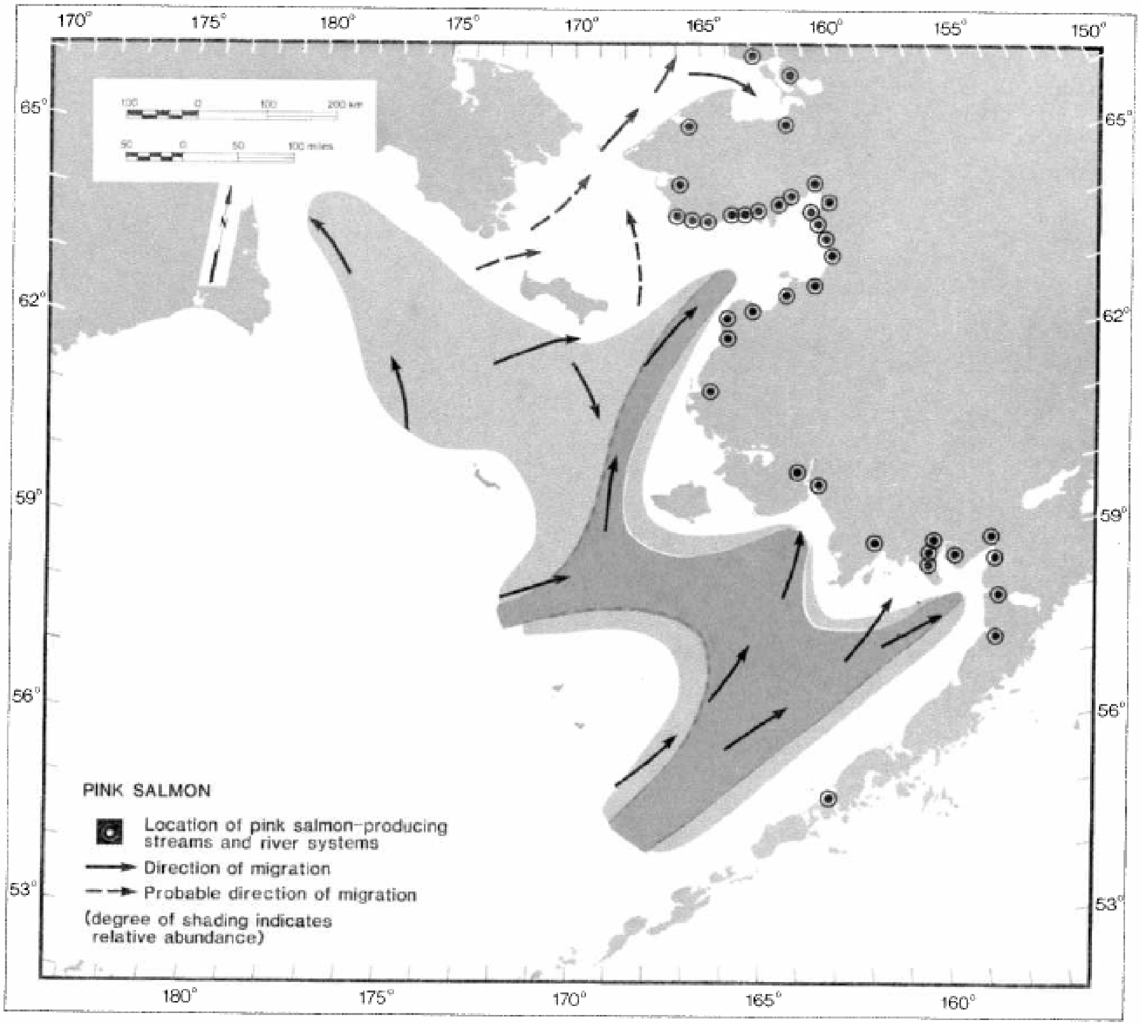

Figure 10. – Distribution of pink salmon during spawning migration, mid-June to mid-August (Straty 1981).

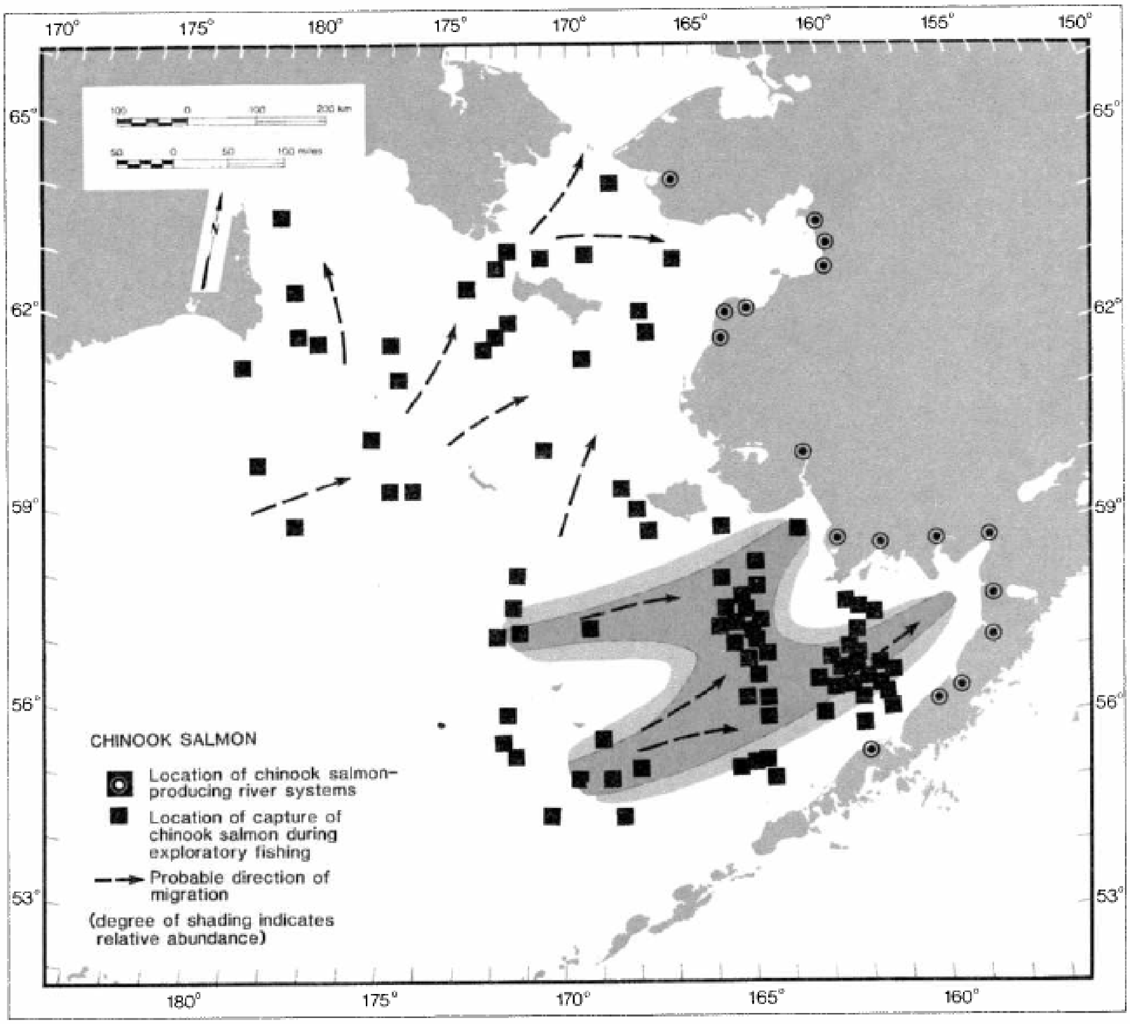

Figure 11. – Distribution of chinook salmon during spawning migration, early June to mid-July (Straty 1981).

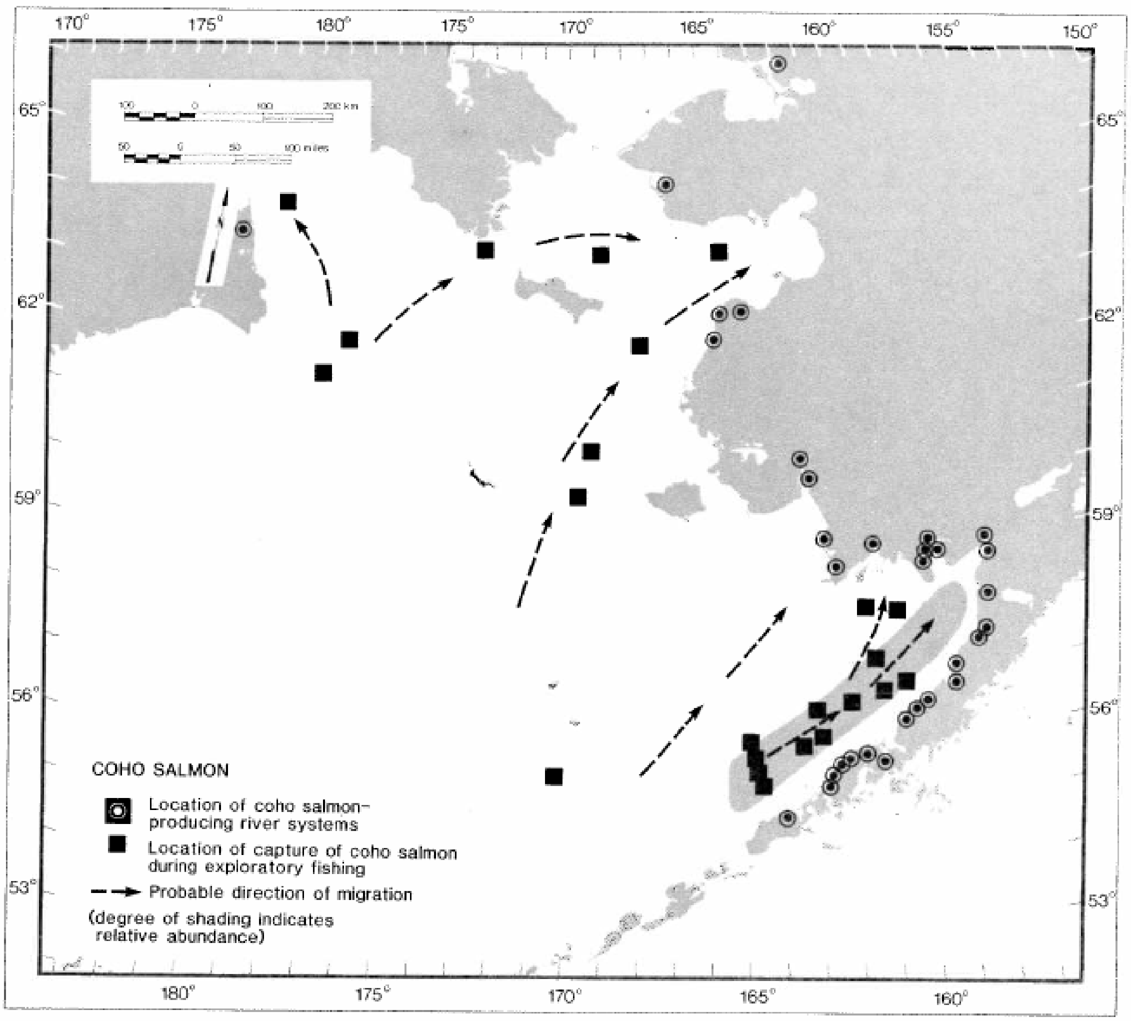

Figure 12. – Distribution of coho salmon during spawning migration, early July to early September (Straty 1981).

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Bureau of Ocean Energy Management, Regulation and Enforcement Mission

As a bureau of the Department of the Interior, the Bureau of Ocean Energy Management, Regulation and Enforcement's (BOEMRE) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS) in an environmentally sound and safe manner.

The BOEMRE Environmental Studies Program Mission

The mission of the Environmental Studies Program (ESP) is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments.