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**KNOWN OCEAN RANGES OF STOCKS OF PACIFIC SALMON AND
STEELHEAD AS SHOWN BY TAGGING EXPERIMENTS, 1956-1989**

by

Katherine W. Myers and Robert V. Walker

FISHERIES RESEARCH INSTITUTE
School of Fisheries
College of Ocean and Fishery Sciences
University of Washington
Seattle, Washington 98195

and

Susan Fowler and Michael L. Dahlberg

ALASKA FISHERIES SCIENCE CENTER
U.S. National Marine Fisheries Service
Auke Bay Laboratory
P.O. Box 210155
Auke Bay, Alaska 99821

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ABSTRACT

This document presents maps of known ocean ranges of major stocks of Pacific salmon and steelhead (*Oncorhynchus* spp.) as shown by recoveries of tagged fish reported to the International North Pacific Fisheries Commission (INPFC). Distribution plots were prepared for all coastal recoveries (1956-1989) of salmonids tagged with external tags during INPFC-related tagging experiments in the North Pacific Ocean (INPFC tag recovery database) and ocean recoveries (1980-1989) of coded-wire tagged salmonids released from North American streams (CWT database). The reader is cautioned against misinterpretation of the results presented in this document. For all species, the known limits of ocean distribution are wider than the known ocean ranges of Asian and North American stocks as shown by tagging experiments. Geographic distribution of salmonids in the North Pacific Ocean varies widely with season, and is influenced by temperature, salinity, food availability, and many other physical, chemical, and biological factors that have not been examined in this document. Quantitative use of these data to determine the extent of intermingling or the degree of dominance regarding specific stocks that are present together in ocean areas is difficult because of differences between stocks in the intensity of fishing effort, in tag recovery effort, in the reporting of recovered tags, and in mortality rates from tagging. For many of the stocks the recoveries of tagged fish simply show their occurrence at certain locations in offshore waters. Despite these limitations, tagging has provided significant new information on ocean ranges of Asian and North American salmonids, and is the method against which all other stock identification methods (e.g., parasites, scale patterns, genetics) are evaluated.

INTRODUCTION

The International North Pacific Fisheries Commission (INPFC) Sub-Committee on Salmon (SCS) reports annually on new information on the extent of ocean ranges of stocks of Pacific salmon and steelhead (*Oncorhynchus* spp.) as determined by tagging experiments. The 1989 SCS agreed that determination of ocean range extensions can be

subjective, that extensions that are not strictly north, south, east, or west are difficult to describe verbally, and that the preparation of graphic representations of ranges and extensions would be useful. In this document, we present maps of known ocean ranges of major stocks of Pacific salmon and steelhead as shown by recoveries of tagged fish reported to INPFC from 1956 through 1989.

METHODS

We prepared distribution plots for all coastal recoveries (1956-1989) of salmonids tagged with external tags during INPFC-related tagging experiments in the North Pacific Ocean (INPFC tag recovery database) and ocean recoveries (1980-1989) of coded-wire tagged salmonids released from North American streams (CWT database). A Canadian scientist created the INPFC tag recovery database, and these data, containing recoveries reported INPFC documents through 1979, were provided to the Fisheries Research Institute (FRI), University of Washington. FRI has added data reported in INPFC documents through 1989 to the database. The Fisheries Agency of Japan assisted FRI in corrections to the 1956-1985 INPFC tag recovery database. Since 1980, the INPFC has coordinated efforts to examine salmonids in convention waters for coded-wire tags. Recoveries of coded-wire tagged salmonids in catches by the Japanese high seas salmon fisheries, by salmon research vessels, by foreign and domestic groundfish vessels, and by Canadian experimental fishing operations have been reported in INPFC documents (Dahlberg et al. 1989, Margolis et al. 1989). The INPFC tag recovery database is archived on magnetic tape at FRI, and the CWT database is archived at the U.S. National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory.

Ocean ranges are depicted for six species: sockeye salmon (*O. nerka*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), coho salmon (*O. kisutch*), chinook salmon (*O. tshawytscha*), and steelhead (*O. mykiss*). Recoveries of sockeye and chum salmon were subdivided into maturing (recovered in the same year as tagging) and immature (recovered in the second or subsequent years after tagging) fish. For each species-maturity group, we prepared summary plots of all Asian (regions 1-9, Table 1) and North American (regions 10-17, Table 1) recoveries and individual plots for each of the general areas used by the SCS to report range extensions (Table 1).

Table 1. General areas and codes used by the INPFC Sub-Committee on Salmon to report range extensions.

No.	General Areas	INPFC Codes ¹
1	Japan	01, 02
2	Kuril Is., Primore, southern Sakhalin	03, 04, 06 (1-3)
3	Amur R., northern Sakhalin	05, 06 (0)
4	north Okhotsk coast, Shelekova	07, 08
5	W. Kamchatka Peninsula	09
6	E. Kamchatka and Karaginsky area to Cape Oliutorsky	10, 11, 12
7	Siberian coast north of Cape Oliutorsky	13, 14
8	U.S.S.R. - unknown	15
9	Asian Coastal - others, unknown	18, 19
10	Arctic coast of Alaska, Yukon R., Kuskokwim R.	40-44
11	Bristol Bay, Aleutian Is.	45-52
12	Central Alaska	53-60
13	Southeast Alaska	61-67
14	Alaska - others, unknown	68, 69
15	British Columbia	70-79
16	Washington, Oregon, California	80-91
17	North American - unknown	98

¹ Refer to Appendix Figs. 1-3 for maps of general areas and INPFC codes.

The ocean location of each tagged fish was plotted (within 1' latitude X 1' longitude) using the World Data Bank II database and mapping package (AMP) on the University of Washington's CYBER computer. The maps were drawn on a Zeta 8 pen plotter. In the figures, black triangles indicate ocean release locations of externally tagged fish (INPFC tag recovery database), and black dots indicate ocean recovery locations of coded-wire tagged fish (CWT database). Because of the small size of the maps, individual points cannot always be discerned. Therefore, each figure caption includes information on total sample size (n), the number of points plotted, and the number of duplicate points. Duplicate locations were not indicated in the figures, as this provides no additional information on ocean ranges. In some figures, arrows were used to indicate points that are

obscured by the outline of the coast or are otherwise difficult to locate. Because of the large number of recoveries of coded-wire tagged chinook salmon near 124°W longitude, separate maps were prepared for Washington, Oregon, California, and Idaho. Shading on the maps indicates region of origin.

RESULTS AND DISCUSSION

Sockeye Salmon (Figs. 1-28)

Sockeye salmon are the third most abundant species of Pacific salmon. In coastal Asia, sockeye salmon are distributed from northern Hokkaido (where they are rare) to the northern sea coast of the U.S.S.R. (Anadyr and Cape Chaplina), and the center of abundance is around the Kamchatka Peninsula, U.S.S.R. (Hart 1973, French et al. 1976). A reported 90% of the U.S.S.R. commercial catch comes from the Ozernaya River in West Kamchatka and the Kamchatka River in East Kamchatka (French et al. 1976). The INPFC tag recovery database contains information on only 78 recoveries of Asian sockeye salmon (both maturing and immature) tagged at sea (Fig. 1). The majority (78%) of these were maturing fish recovered in Kamchatka (Figs. 18 and 19). The known ocean range of U.S.S.R. sockeye salmon as shown by tagging experiments extends eastward to 176°20'W just south of Adak I. in the central Aleutians, southward to 42°29'N in the central North Pacific, and northward to 57°00'N in the western Bering Sea (Fig. 1).

In North America, sockeye salmon are distributed from the Columbia River in Washington to Northern Alaska (Yukon River and Kotzebue Sound) and the Canadian Arctic (where they are rare) (Hart 1973, French et al. 1976). North American sockeye salmon are much more abundant than Asian sockeye salmon. For example, annual commercial catches (1971-1987) of sockeye salmon averaged 32 million fish in North America and 1.5 million fish in the U.S.S.R.² The most abundant North American stocks occur in the Bristol Bay and British Columbia (Fraser R.) regions. Recoveries of 5,517 tagged sockeye salmon in North America show them to be broadly distributed across the North Pacific Ocean and Bering Sea (Fig. 2). The known range of North American sockeye salmon extends westward to 166°51'E in the western North Pacific, southward to 44°29'N in the central North Pacific, and northward to 58°42'N in the Bering Sea (Fig. 2).

² Catch data reported in this document were compiled by the authors from INPFC statistical yearbooks and agency reports, and do not include high seas interceptions.

The known ranges of Asian and North American sockeye salmon overlap primarily in the North Pacific, south to about 44°N between 167°E and 176°W (Figs. 1 and 2). There are many fewer recoveries for immature than for maturing North American sockeye salmon, and the known range of maturing fish extends further to the southwest than that of immature fish (Figs. 4 and 16). The known range of Bristol Bay sockeye salmon is much broader (particularly in the Bering Sea) than that of more southerly stocks (Figs. 9-11, 13, 22-24, 26).

Chum Salmon (Figs. 29-64)

Chum salmon are the second most abundant species of Pacific salmon, and the abundance of Asian stocks has always been greater than that of North American stocks (Shepard et al. 1968, Neave et al. 1976). Annual commercial catches (1971-1987) of chum salmon have averaged 28 million fish in Asia and 12 million fish in North America. In Asia, chum salmon are distributed from northern Kyushu, Japan (at about 33°N) northward to the Siberian Arctic (Providence Bay to the Kolyma and Lena rivers) (Shepard et al. 1968, Hart 1973). Recoveries in Asia of 1,095 chum salmon (both maturing and immature) tagged at sea show Asian chum salmon to have the widest ocean distribution of any stock of Pacific salmon (Fig. 29). The known ocean range of Asian chum salmon is remarkable, extending from 63°28'N in the Bering Sea, southward to 40°07'N in the western North Pacific and 41°27'N in the central North Pacific, eastward to 140°00'W in the eastern North Pacific, and northward to 55°49'N in the central Gulf of Alaska (Fig. 29). The large number (n=581) of recoveries of tagged maturing chum salmon of Japanese origin compared to recoveries of other stocks is attributed to intense coastal fisheries and close examination of hatchery returns in Japan (Fig. 50) (Shepard et al. 1968, French et al. 1975).

In North America, chum salmon are distributed along the coastline from California northward to the Mackenzie River in the Canadian Arctic (Shepard et al. 1968, Hart 1973). The known ocean range of North American chum salmon is more restricted than that of Asian chum salmon, extending southward to 44°47'N in the eastern North Pacific and 45°26'N in the central North Pacific, westward to 177°E along the northern side of the Aleutians, and northwest to 60°09'N, 174°30'E in the Bering Sea (Fig. 30). Data from coastal recoveries of external tags (INPFC tag recovery database) indicates that North American stocks originating south of the Alaska Peninsula do not enter the Bering Sea (Figs. 43-46, 61-64), but recoveries by trawl fisheries in the eastern Bering Sea in 1984-1986 of four coded-wire tagged chum salmon from Southeast Alaska, British Columbia,

and Washington show that these stocks do range into the Bering Sea, at least in some years (Fig. 47).

The known ranges of Asian and North American chum salmon are broadly overlapping in the Bering Sea south of about 60°N, between 174°E and 169°W, along the central and eastern Aleutians, and in the Gulf of Alaska south to about 45°N and east to 140°W (Figs. 29 and 30). The known ranges of maturing chum salmon of both Asian and North American origin appear to be wider than those of immature fish, but there are many fewer recoveries of chum salmon tagged as immature fish than for those tagged as maturing fish (Figs. 31,32,48,49). Information from a recent tagging study conducted by the Alaska Department of Fish and Game also shows intermingling of Asian (U.S.S.R. and Japan) and North American chum salmon in the South Unimak and Shumagin Islands area (Eggers et al. 1989).

Pink Salmon (Figs. 65-83)

Pink salmon are the most abundant species of Pacific salmon. In Asia, pink salmon are distributed along the coast from North Korea and Hokkaido, Japan, to the Arctic Ocean (Yana and Lena rivers), and in North America from California to the Arctic Ocean (Mackenzie R.) (Hart 1973, Takagi et al. 1981). Although Asian pink salmon are considered to be substantially more abundant than North American pink salmon, commercial catches (1971-1987) of pink salmon on both continents have been similar (average annual catch of 58 million fish in North America and 57 million fish in Asia). The known ocean range of Asian pink salmon is less extensive than the range of Asian chum salmon, extending from 58°02'N in the Bering Sea southward to 38°41'N in the Sea of Japan and 40°50'N in the western North Pacific, and eastward to 161°55'W in the central North Pacific (Fig. 65). The known ocean range of North American pink salmon extends from 57°10'N in the eastern Bering Sea, westward to 176°30'E in the central Bering Sea, to 177°38'E in the Aleutians, and to 178°35'W in the central North Pacific, southward to 43°30'N in the central North Pacific and to 42°58'N in the eastern North Pacific (Fig. 66). Stocks originating south of the Alaska Peninsula in North America and south and west of East Kamchatka in Asia do not appear to enter the Bering Sea (Figs. 67-79). Pink salmon recovered in central and southeast Alaska were more widely distributed throughout the Gulf of Alaska than pink salmon recovered in British Columbia and Washington (Figs. 76-79). The known ranges of Asian and North American (Arctic, Yukon, and Kuskokwim and Bristol Bay regions) pink salmon overlap in the Bering Sea south of about 57°N, between

176°E and 172°W, and in the North Pacific south to about 43°N, between 177° E and 161°W (Figs. 65 and 66).

Coho Salmon (Figs. 84-98)

Coho salmon are the fourth most abundant species of Pacific salmon. In Asia, coho salmon are found on Shantorskii, Hokkaido, Sakhalin, and Shimushiru islands and from the Amur River, U.S.S.R., northward to the Anadyr River (center of abundance is the Kamchatka Peninsula), and in North America from California northward to at least the Nome River on the Seward Peninsula of western Alaska (center of abundance is between Oregon and southeast Alaska) (Hart 1973, Godfrey et al. 1975). Based on catch data, North American stocks are considerably more abundant than Asian stocks (Godfrey et al. 1975). For example, commercial catches of coho salmon (1971-1987) in the U.S.S.R. averaged 1.1 million fish annually, and sport and commercial catches in North America during the same period averaged 10.6 million fish annually. The known ocean range of Asian coho salmon extends from 58°30'N in the Bering Sea, south to 46°58'N in the western North Pacific and 41°32'N in the central North Pacific, and east to 173°31'W in the central North Pacific and 179°32'W in the central Bering Sea (Fig. 84). There is no information from tagging experiments on the distribution of North American coho salmon in the Bering Sea. In the North Pacific, the known ocean range of North American coho salmon extends from about 42°N (just off the coast of the Oregon-California border), northward along the coast to the central Aleutian Islands, and further offshore throughout the eastern and central North Pacific (south to 44°00'N and west to 177°33'E) (Fig. 85). The known ranges of Asian and North American coho salmon overlap in the area just south of the central Aleutians and further south (to about 44°N) between 177°E and 173°W (Figs. 84 and 85).

Chinook Salmon (Figs. 99-110)

Chinook salmon are the least abundant of the five species of Pacific salmon discussed in this report. In Asia, chinook salmon occur primarily in the U.S.S.R., from the Amur River, northward to the Anadyr River (center of abundance is the Kamchatka Peninsula), and in North America, chinook salmon occur from the Ventura River, California, north to the Canadian Arctic (Coppermine River) (Hart 1973, Major et al. 1978). North American chinook salmon are considerably more abundant than Asian chinook salmon. For example, commercial catches (1971-1987) of chinook salmon in the U.S.S.R. averaged 0.2 million fish annually, and sport and commercial catches in North America during the same period averaged 4.1 million fish annually.

INPFC-related tagging experiments have provided little information on ocean ranges of Asian chinook salmon. There have been only two Asian coastal recoveries of tagged chinook salmon. One was a fish released just off the coast of Japan and recovered in Japan, and the other was a fish released south of the Aleutians in the central North Pacific ($172^{\circ}03'W$, $49^{\circ}35'N$) and recovered in East Kamchatka (Kamchatka River) (Fig. 99).

The known range of North American chinook salmon as shown by tagging experiments extends across almost the entire Bering Sea, north to $60^{\circ}03'N$ and west to $172^{\circ}12'E$ (Fig. 100). In the North Pacific, the known ocean range of North American chinook salmon extends north from about $40^{\circ}N$ (in the coastal waters just off California) and west to the waters just south of Adak I. in the central Aleutians ($176^{\circ}34'W$, $51^{\circ}29'N$). The majority of recoveries in the North Pacific are from fish tagged or recovered in coastal waters, but there have been a few coded-wire tagged chinook salmon from Oregon recovered well offshore (west to $146^{\circ}22'W$) in the central eastern North Pacific (Fig. 107). Recent information from coded-wire tags has also shown that chinook salmon from North American stocks originating south of the Alaska Peninsula (Central and Southeast Alaska, British Columbia, and Oregon) range northward into the Bering Sea (Figs. 103-105, 107). The known ranges of Asian and North American chinook salmon overlap in the area just south of the central Aleutians between $177^{\circ}W$ and $172^{\circ}W$ (Figs. 99 and 100).

Steelhead (Figs. 111-115)

In Asia, steelhead are found in the U.S.S.R. along the mainland coast of the Sea of Okhotsk and on the Kamchatka Peninsula, and in North America they occur primarily from central California to the Alaska Peninsula (Hart 1973, Light et al. 1989). The abundance of U.S.S.R. stocks is not known, but they are thought to be considerably less abundant than North American steelhead trout. The average number of adult steelhead returning to the Pacific coast of North America each year has been estimated to be about 1.6 million fish (Light 1987). At present, there are no reported recoveries of tagged Asian steelhead. There is no information from tagging experiments on the ocean distribution of stocks in the Bering Sea, although steelhead do occur in this area (Light et al. 1989). The known ocean range of North American steelhead extends across almost the entire North Pacific, south to $41^{\circ}00'N$ and west to $163^{\circ}32'E$.

The recovery locations of four coded-wire tagged steelhead that were recovered during port sampling of salmonid catches from the Japanese landbased driftnet salmon fishery in 1987 and 1988 are not shown in Figs. 111 and 115 because the exact recovery locations are unknown. These steelhead were caught in the area between 42-45°N latitude and 166-173°E longitude, and were from Idaho (n=3) and Washington (n=1) (Margolis et al. 1989).

CONCLUSIONS

The reader is cautioned against misinterpretation of the results presented in Figs. 1-115. For all species, the known limits of ocean distribution are wider than the known ocean ranges of Asian and North American stocks as shown by tagging experiments. Geographic distribution of salmonids in the North Pacific Ocean varies widely with season, and is influenced by temperature, salinity, food availability, and many other physical, chemical, and biological factors that have not been examined in this document. Because of differences between stocks in the intensity of fishing effort, in tag recovery effort, in the reporting of recovered tags, and in mortality rates from tagging, the use of recoveries of tagged fish to make "quantitative determinations of the extent of intermingling or the degree of dominance regarding specific stocks that are present together in ocean areas" is difficult (Margolis et al. 1966). As noted by French et al. (1975), "for many of the minor stocks the recoveries of tagged fish simply reveal their occurrence at certain locations in offshore waters." Despite these limitations, tagging has provided significant new information on ocean ranges of Asian and North American salmonids, and is the method against which all other stock identification methods (e.g., parasites, scale patterns, genetics) are evaluated.

ACKNOWLEDGMENTS

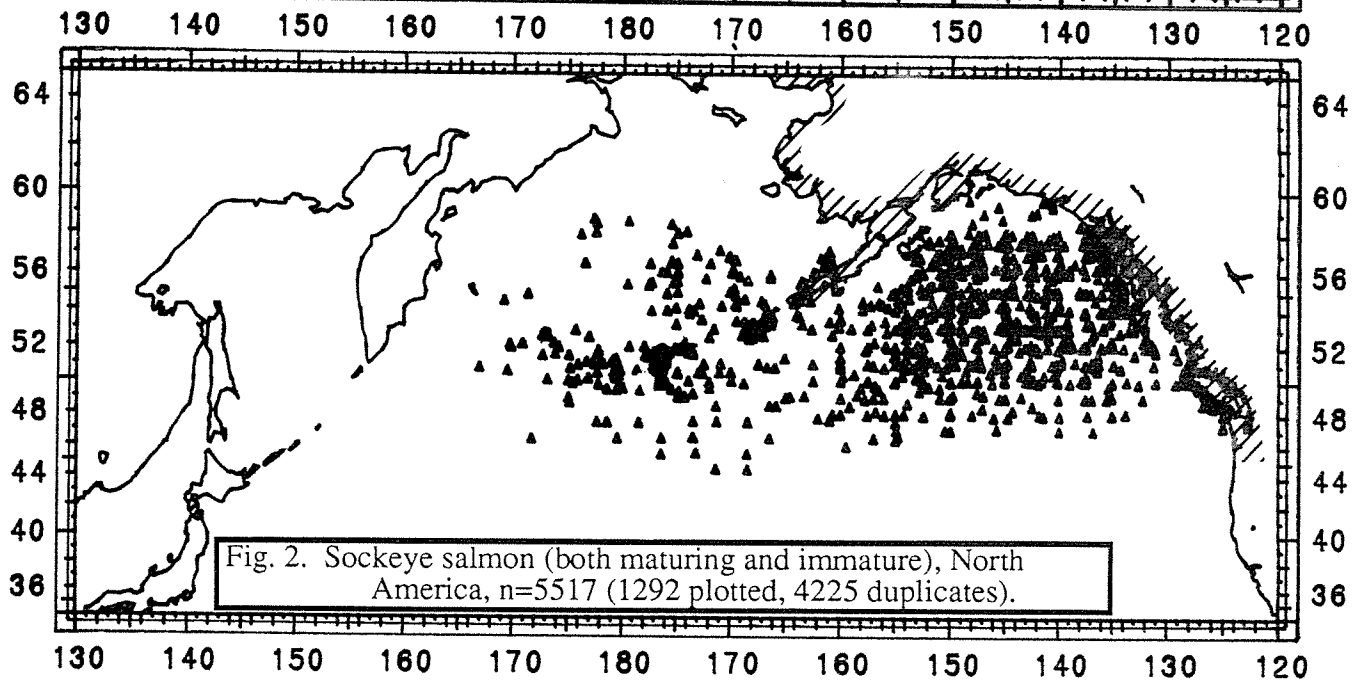
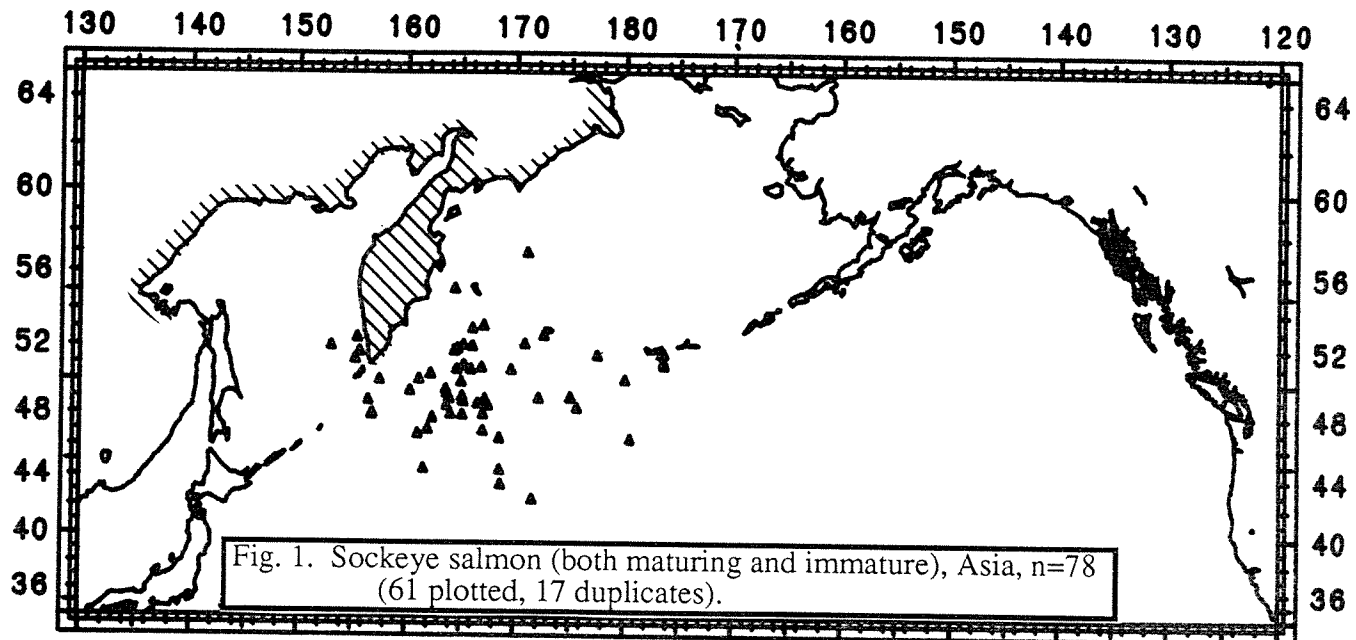
A Canadian scientist, K.V. Aro, created the INPFC tag recovery database, and these data, through recoveries reported in 1979 documents, were provided to the Fisheries Research Institute by the Canadian Department of Fisheries and Oceans. Dr. Colin K. Harris spent many hours correcting the INPFC tag recovery database. Kenji Takagi and Jun Ito, Fisheries Agency of Japan, assisted in corrections to the 1956-1985 INPFC tag recovery database. The Pacific Research Institute of Fisheries and Oceanography (TINRO) provided information on U.S.S.R. tag recoveries. Anatoly B. Dekshstein and the other scientists, Captain, and crew of the R/V Nemirov are gratefully acknowledged for their work in cooperative U.S.-U.S.S.R. high seas salmonid tagging, and for allowing their

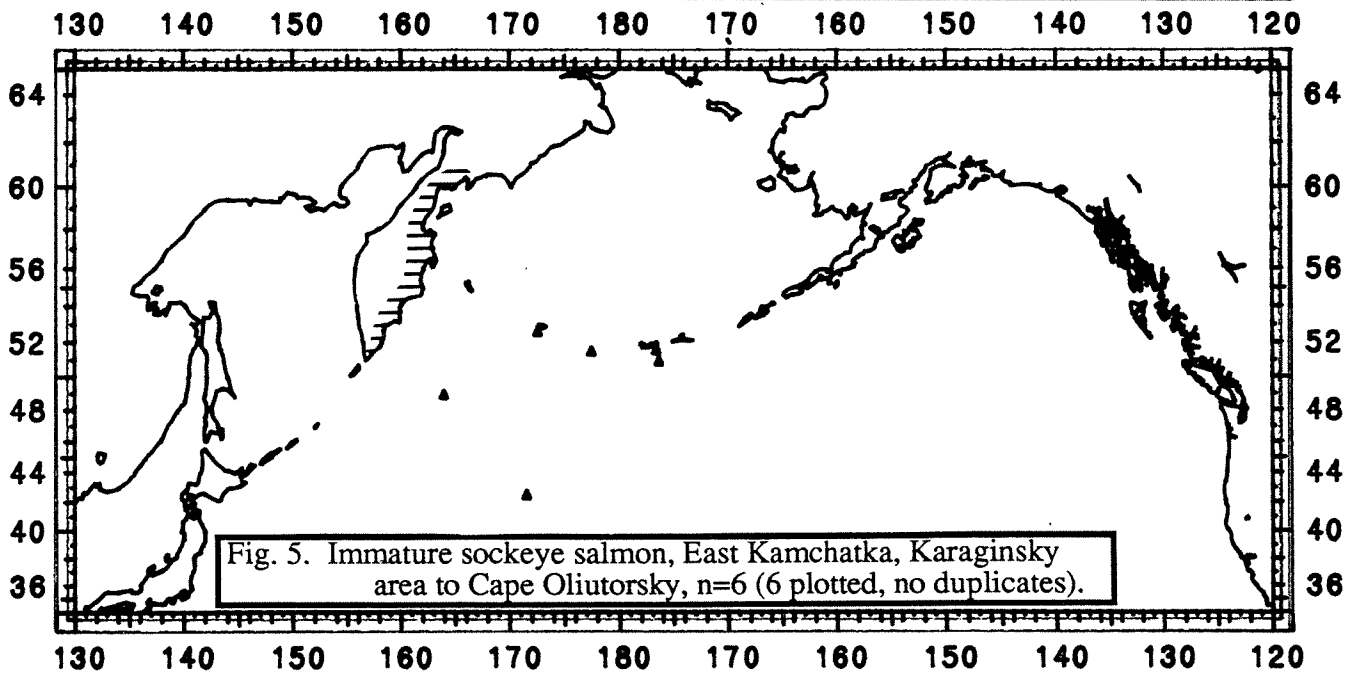
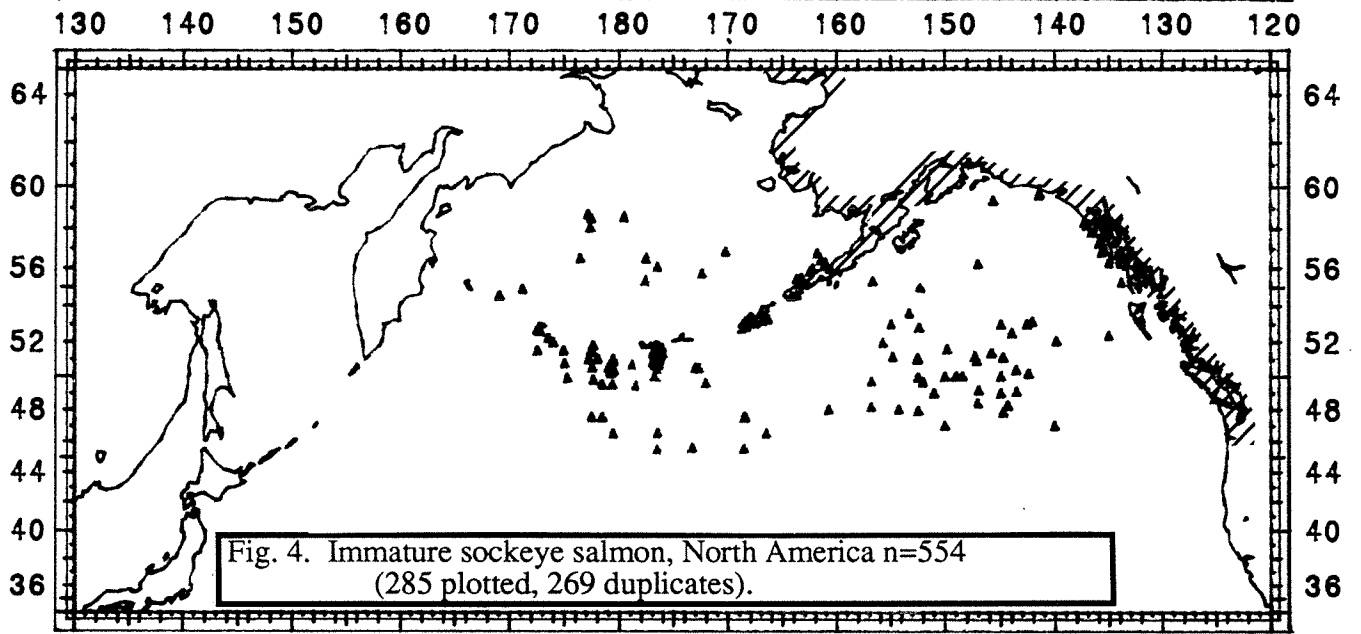
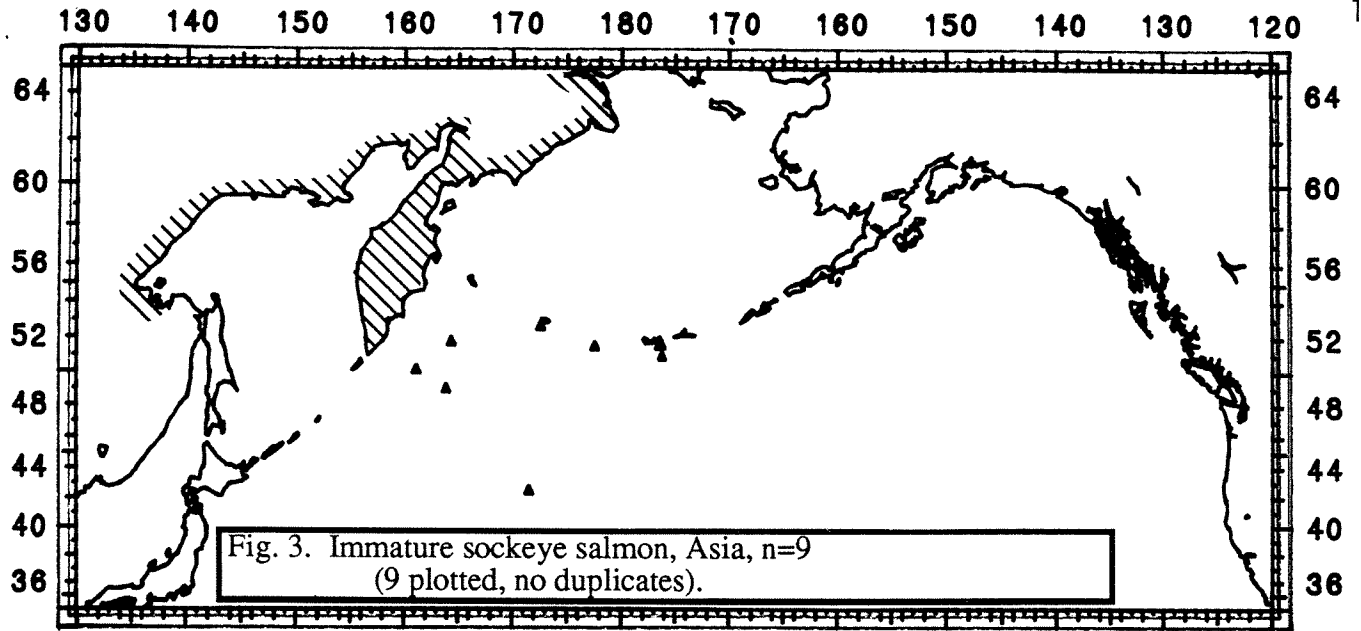
data to be integrated into the INPFC database. Funding for this project was provided by the U.S. National Oceanic and Atmospheric Administration (NOAA, Contract No. 50-ABNF-7-00002).

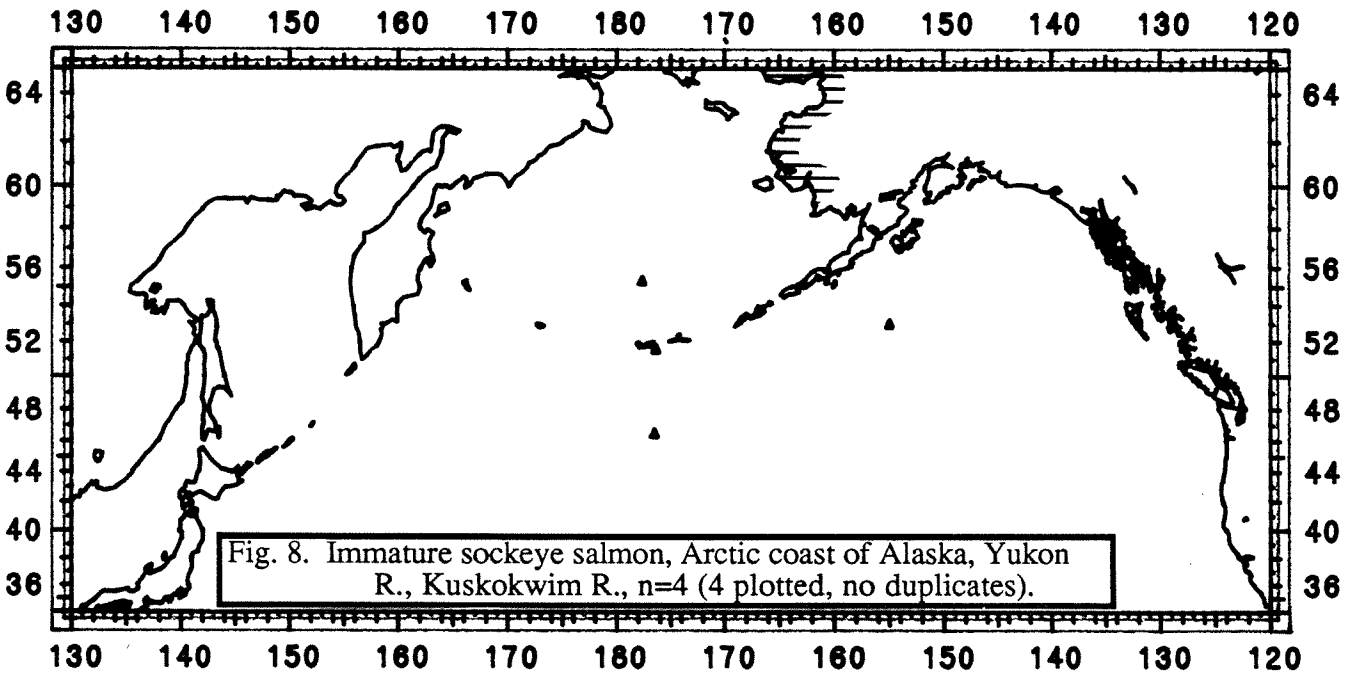
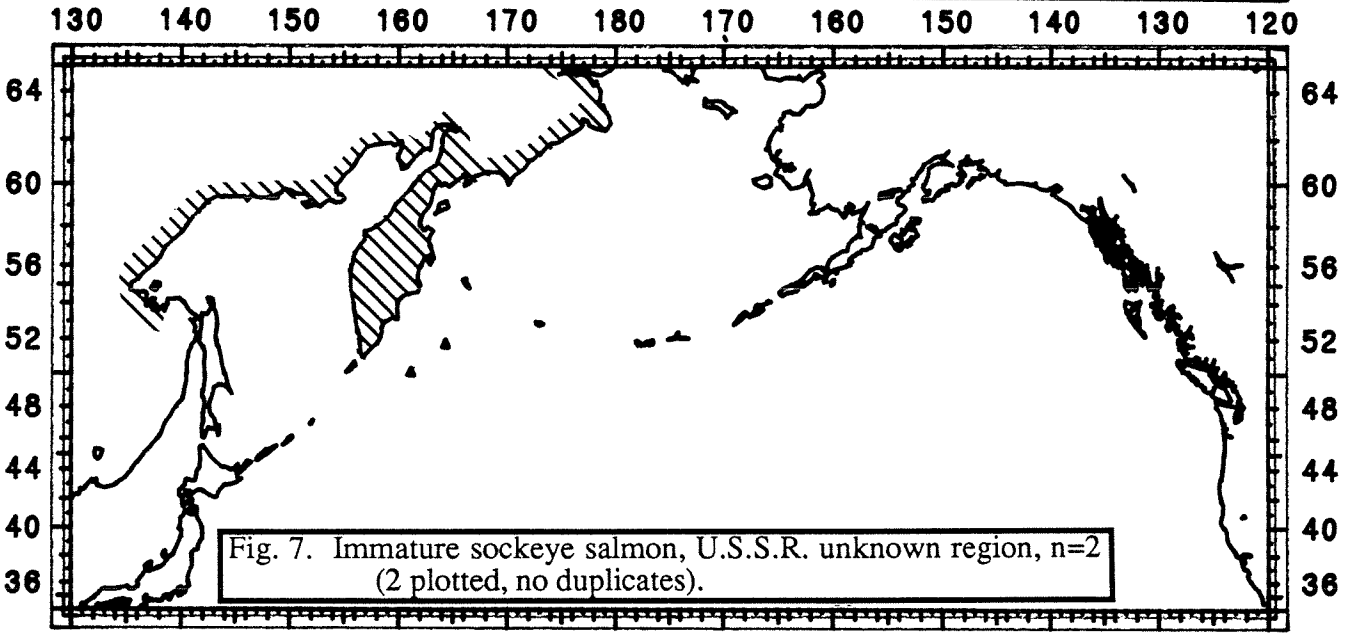
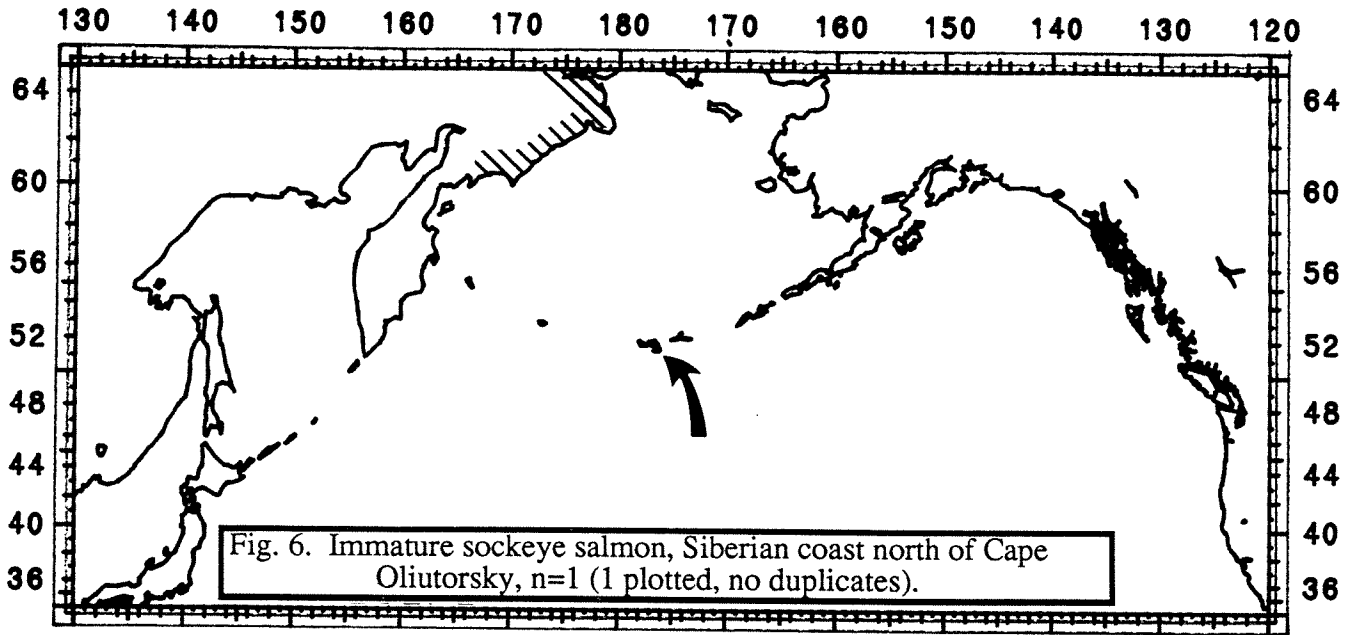
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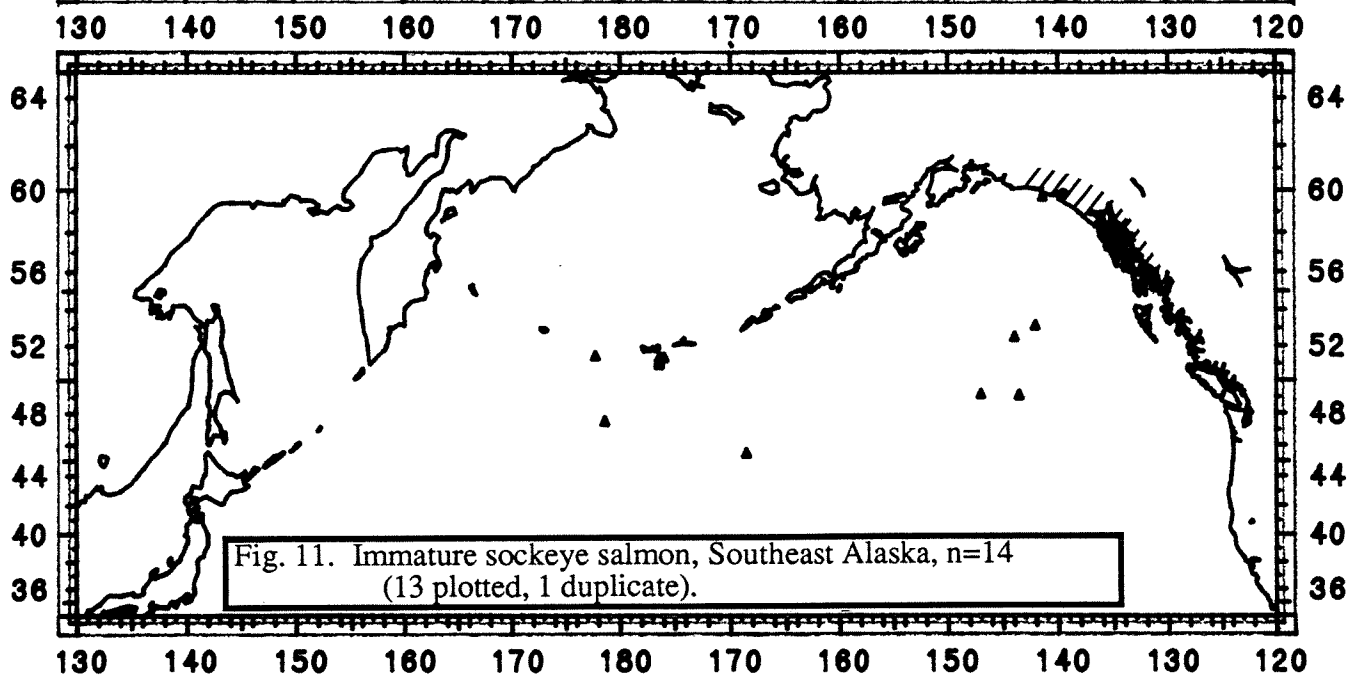
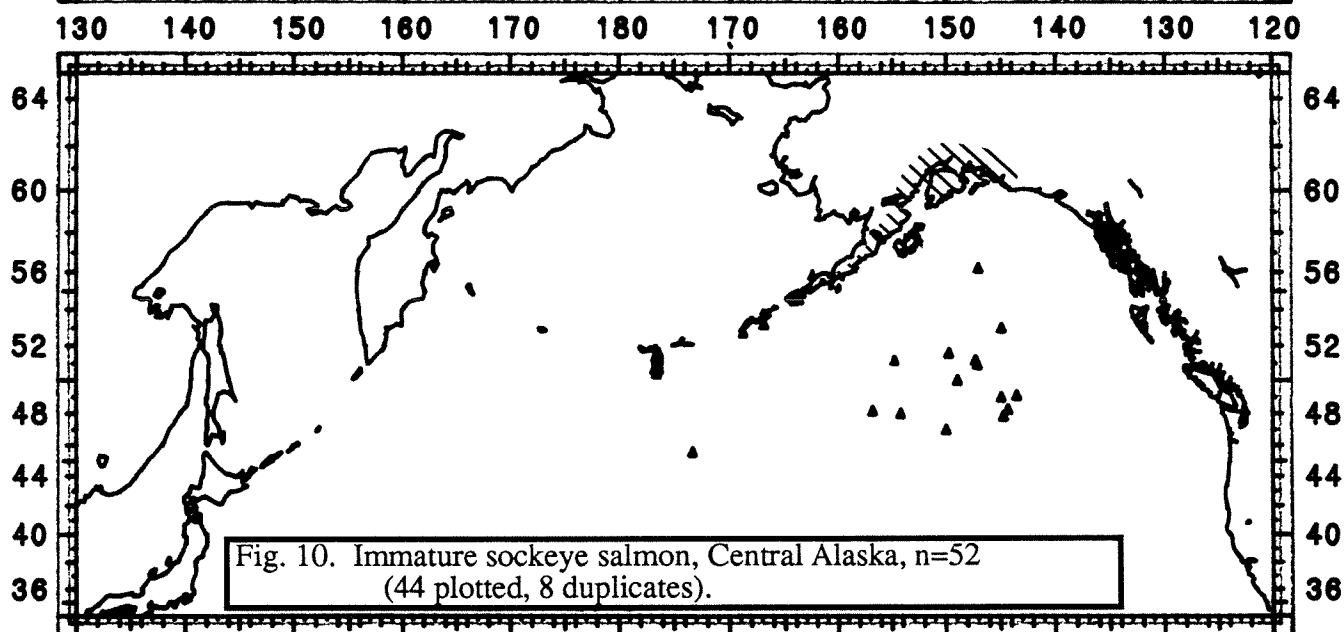
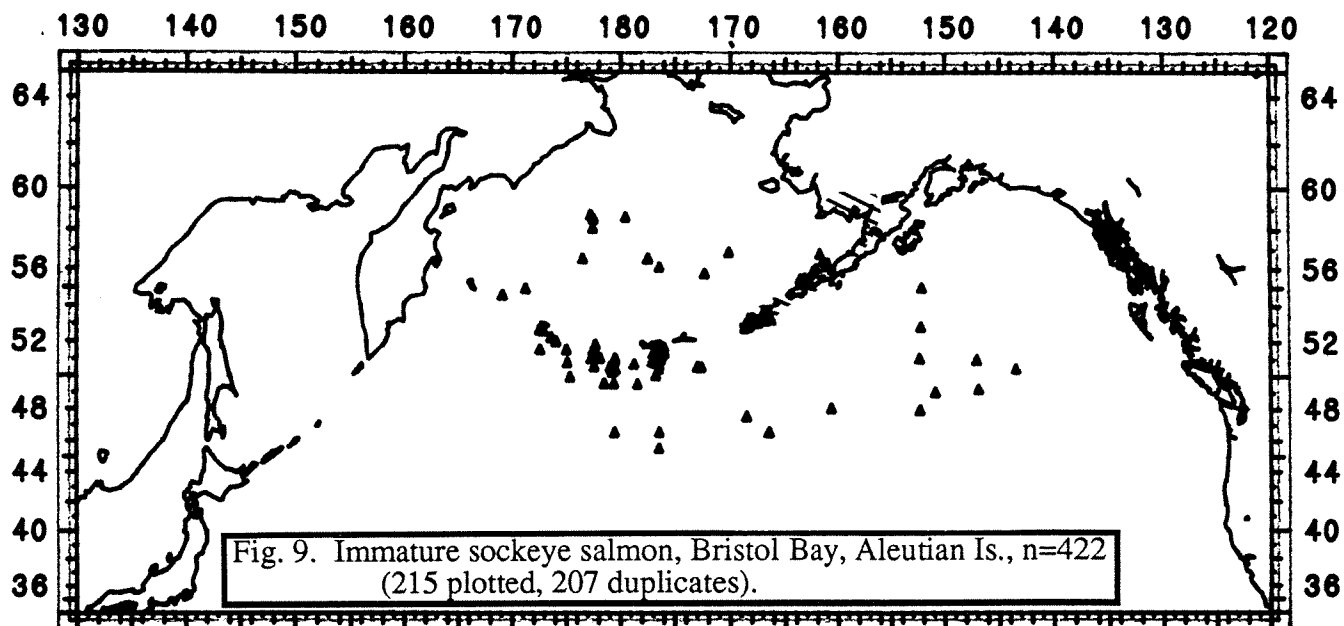
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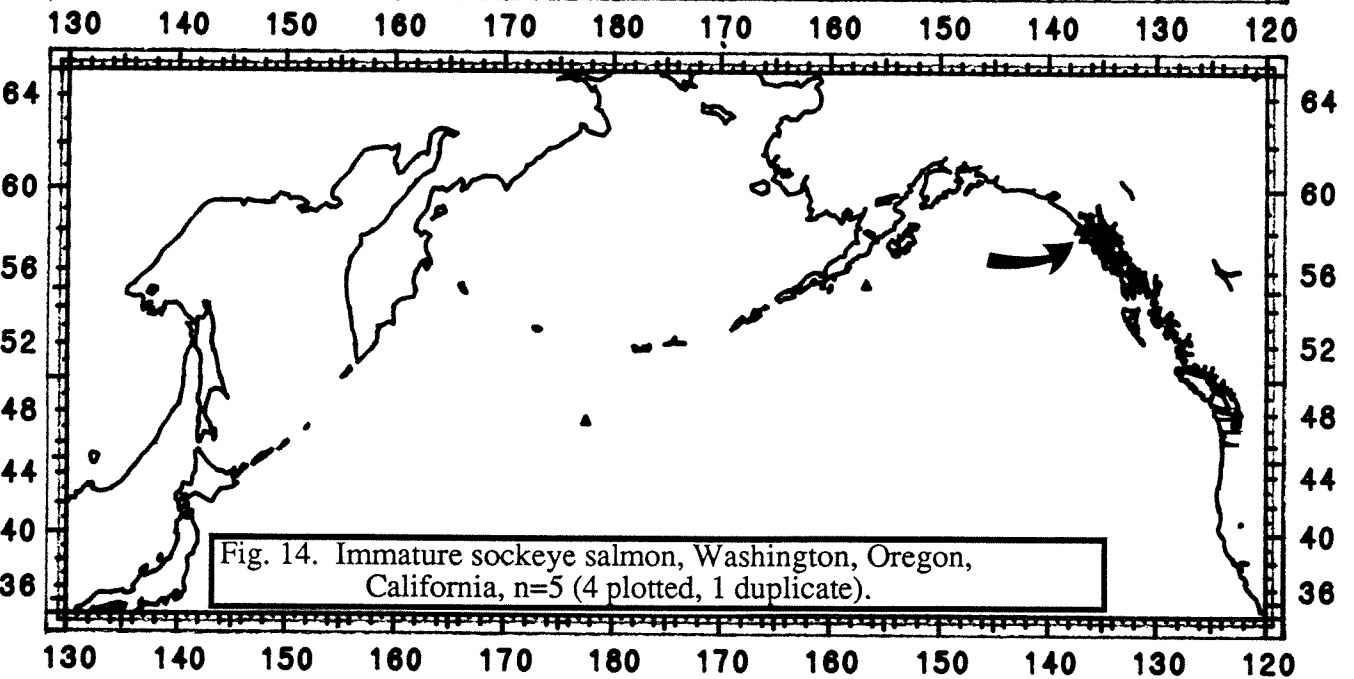
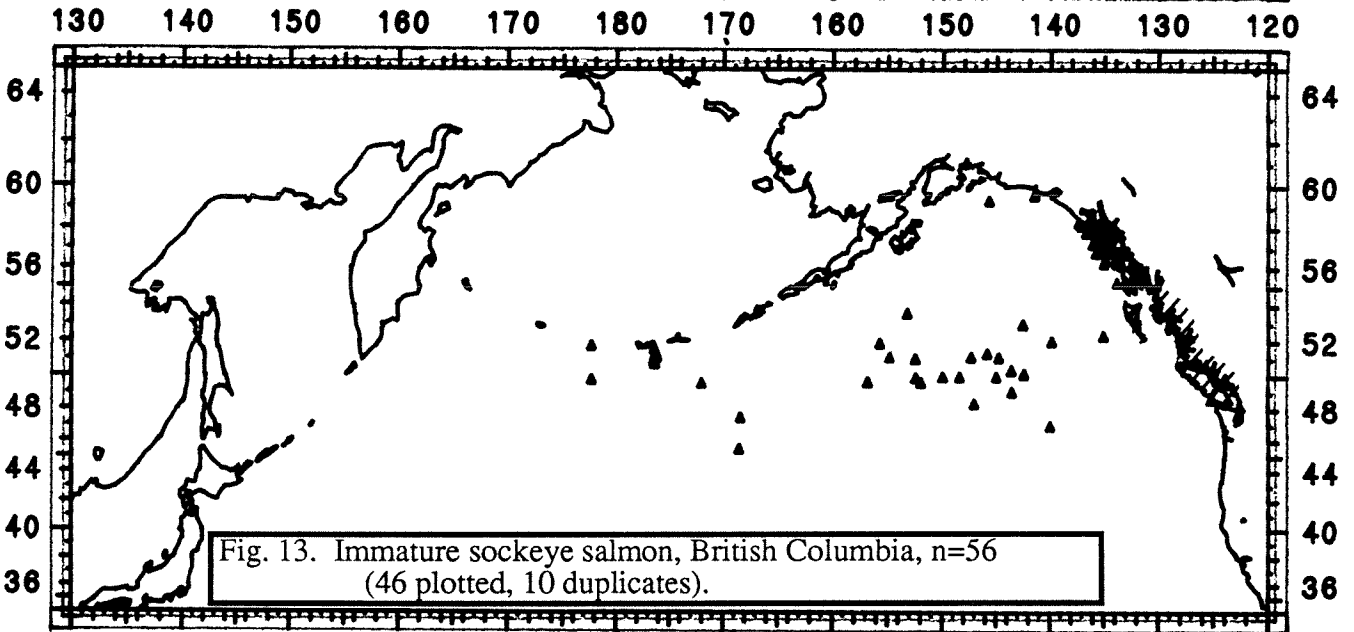
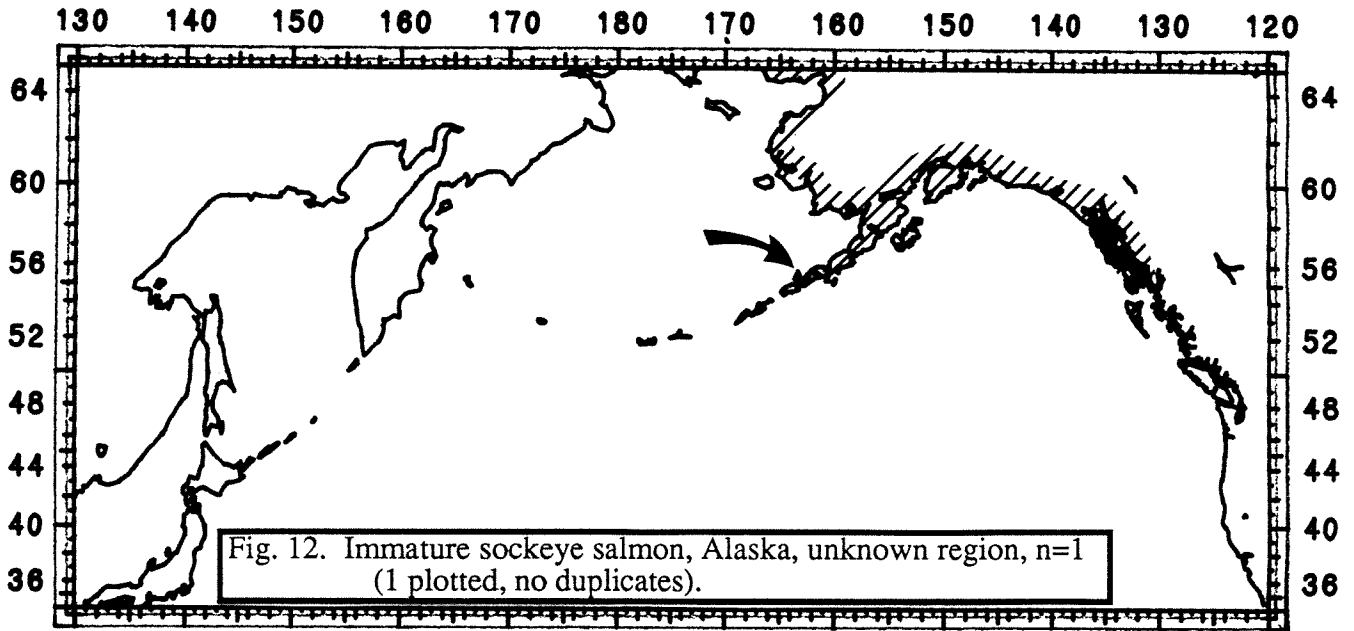
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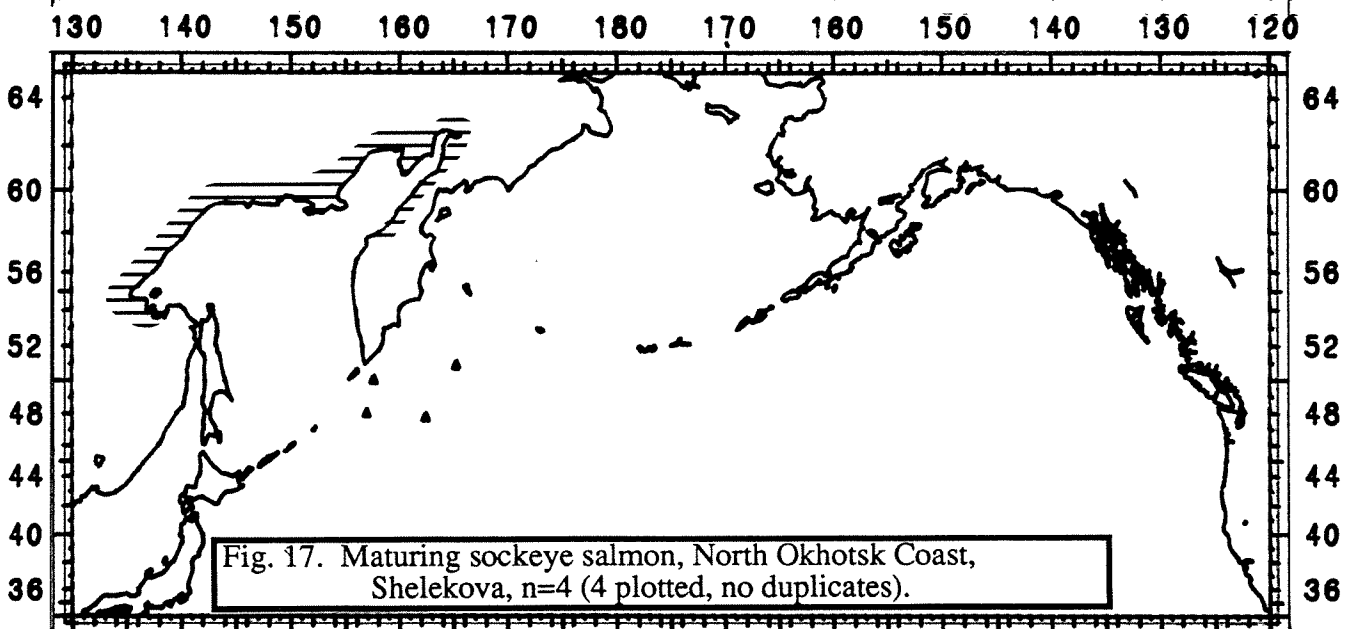
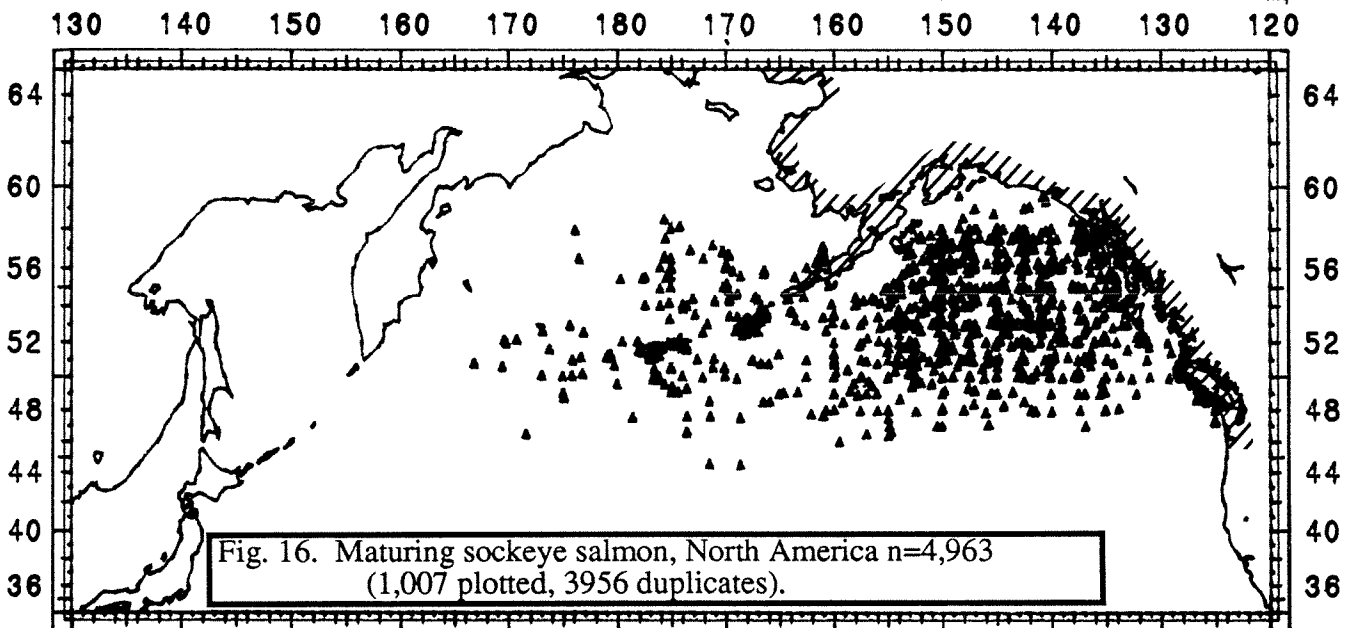
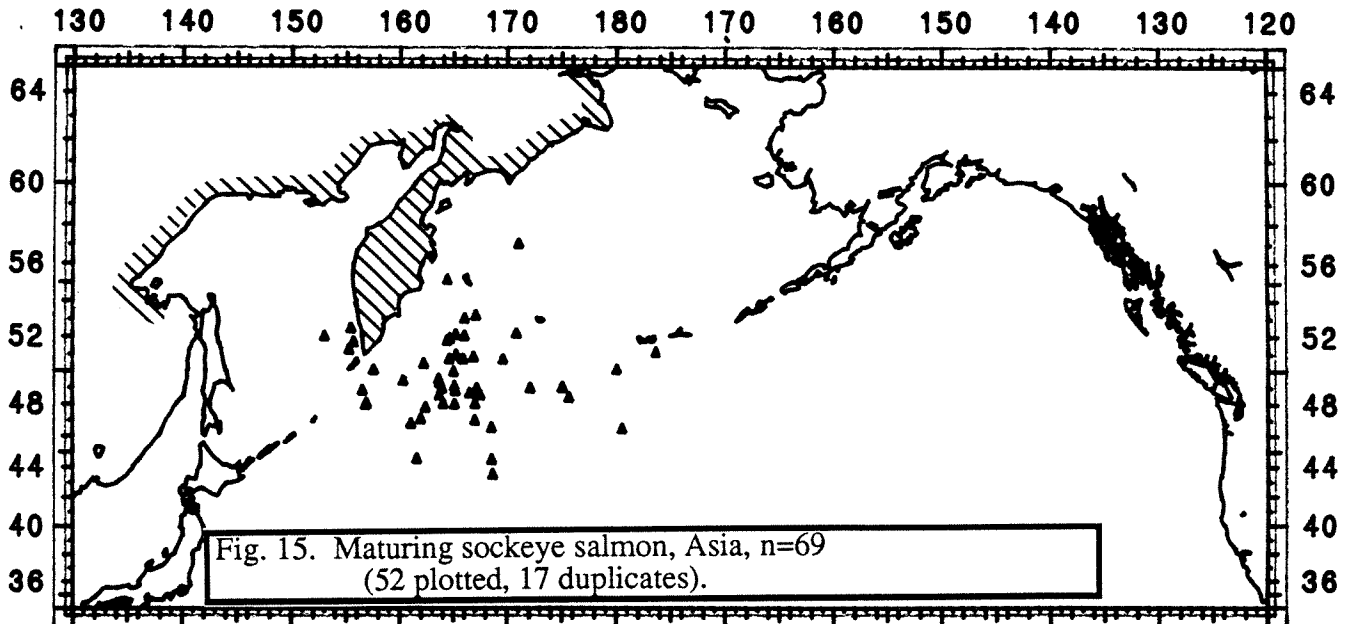




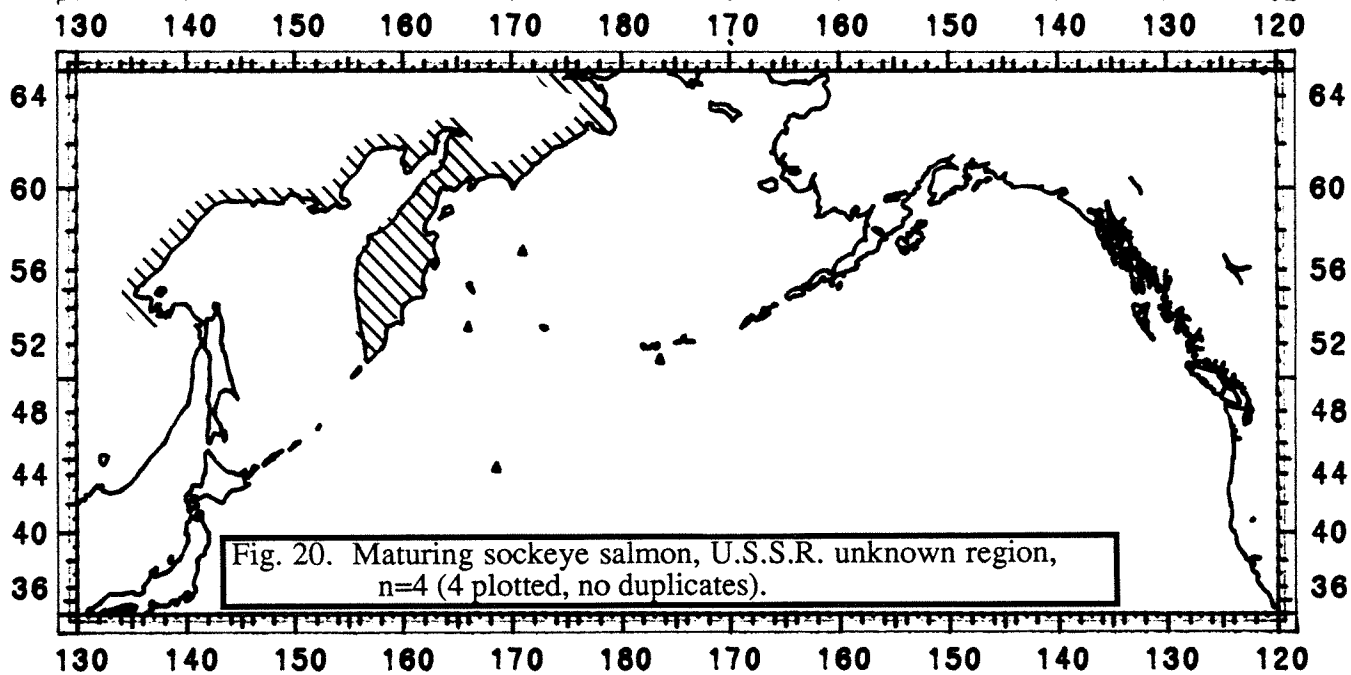
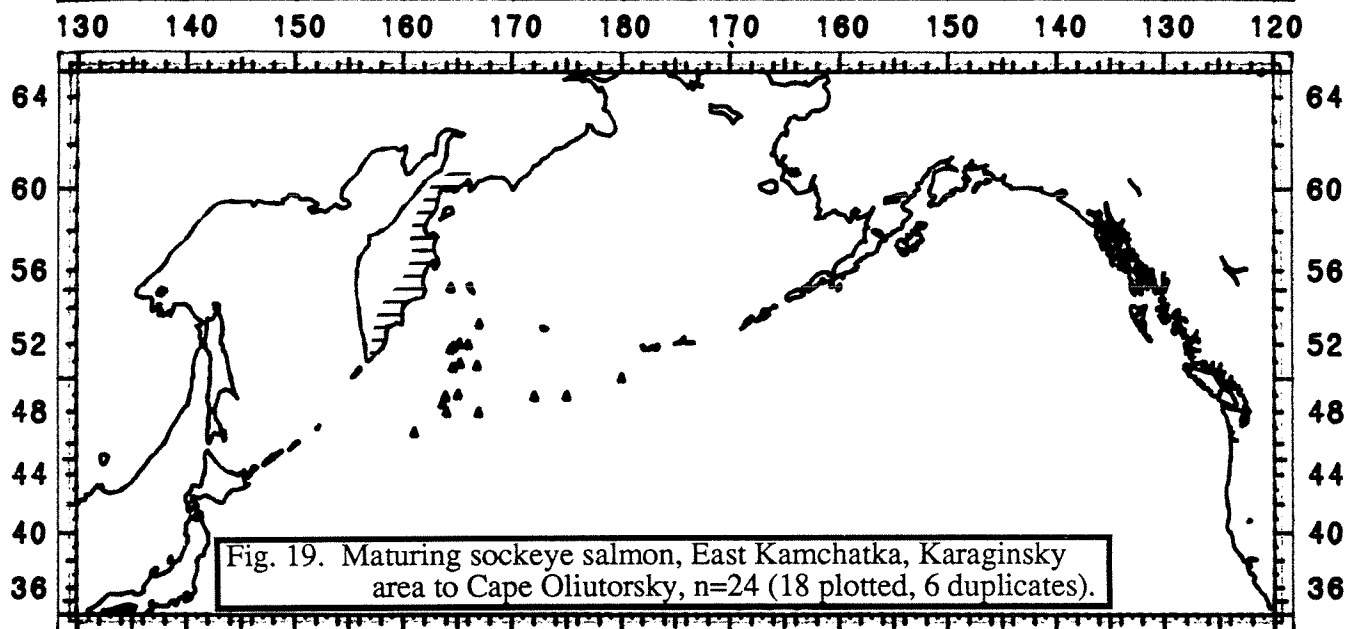
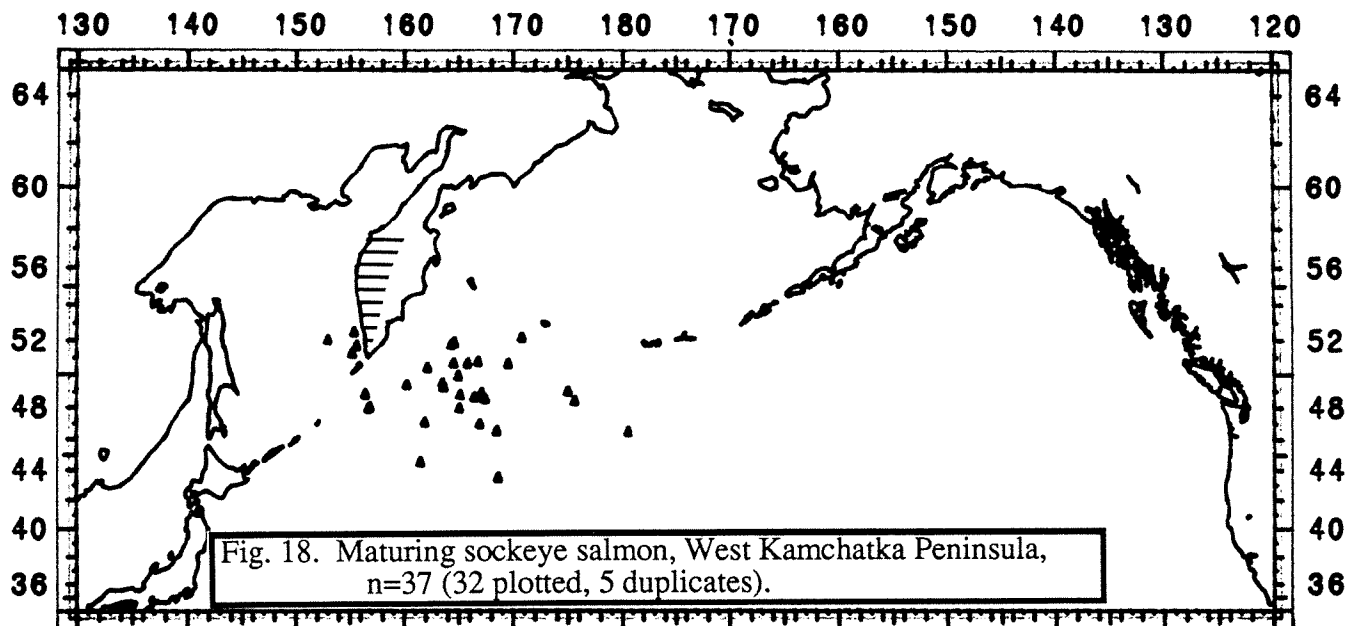


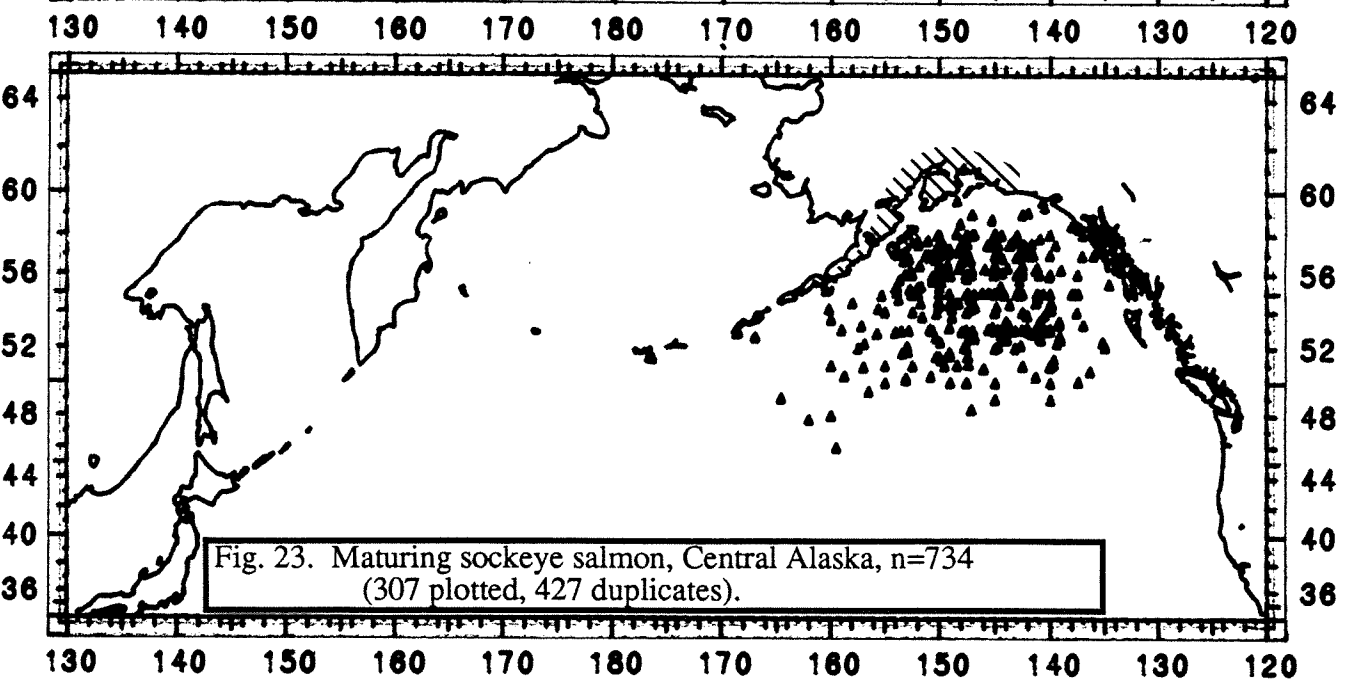
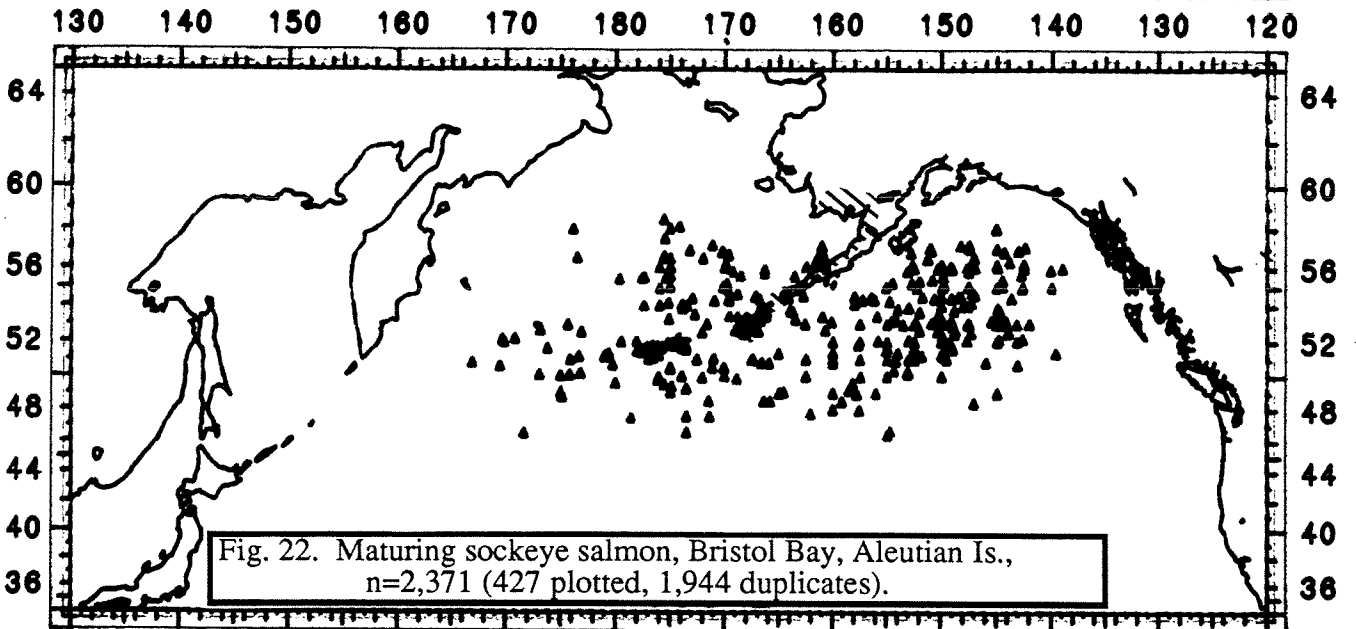
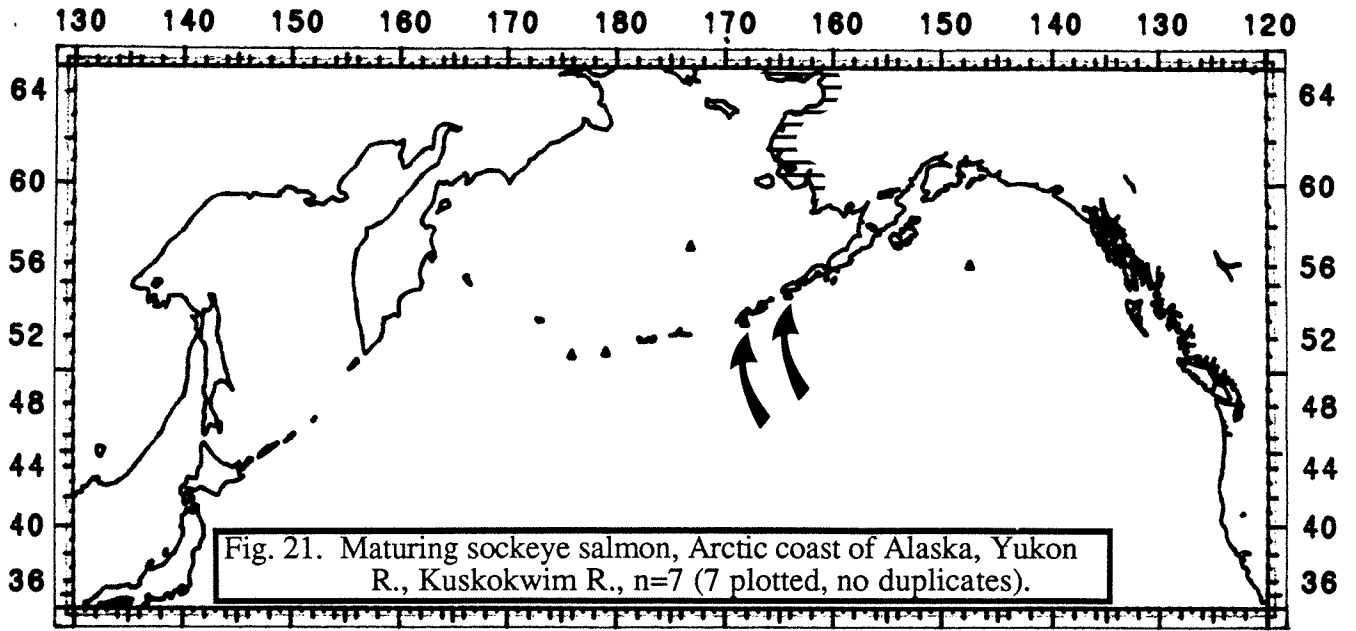


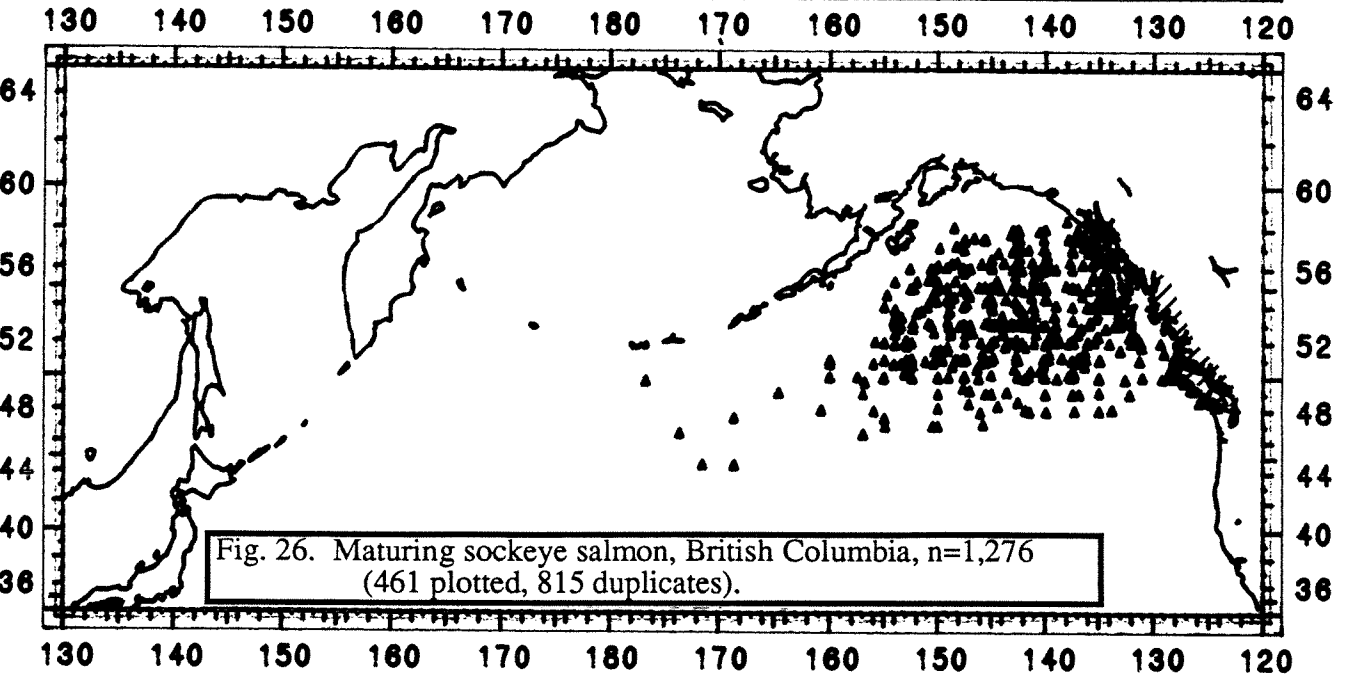
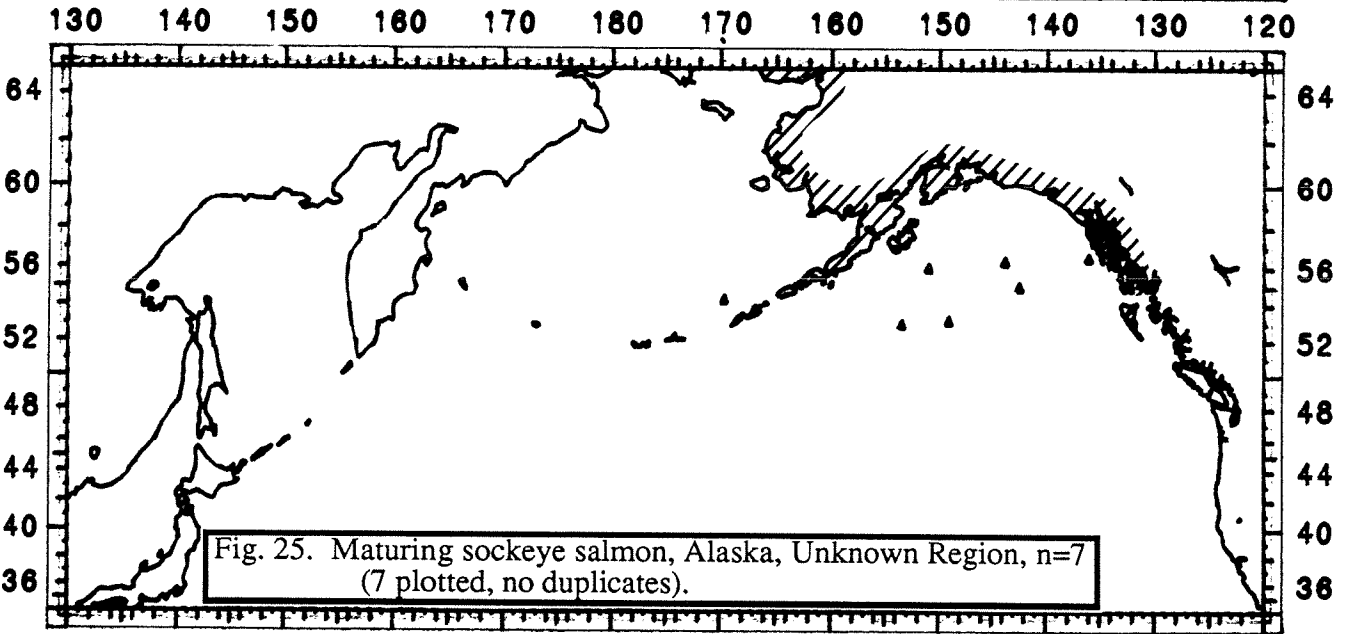
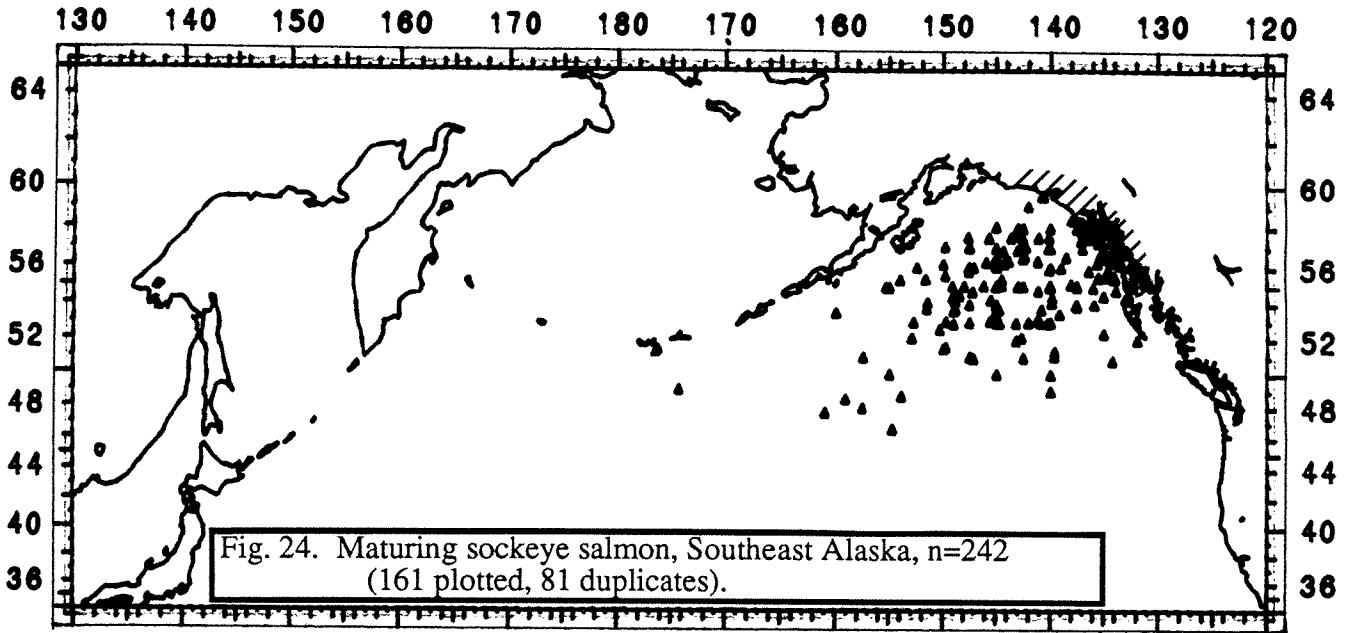


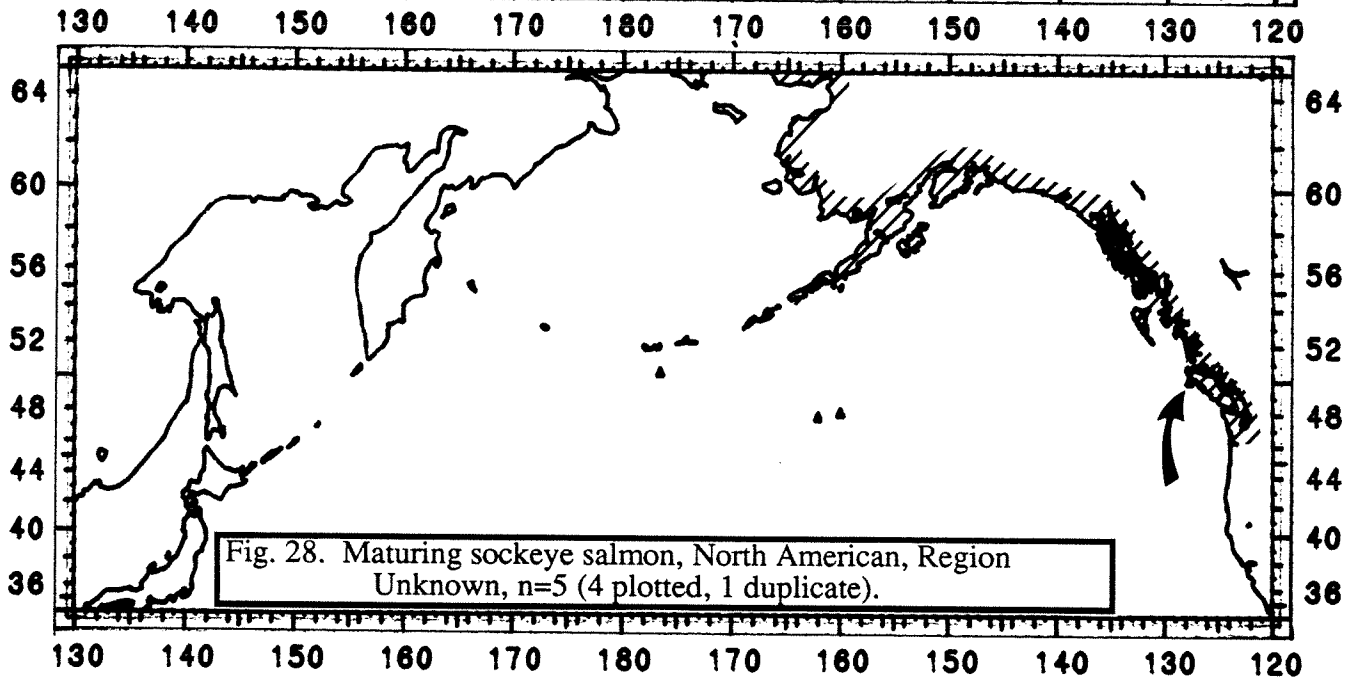
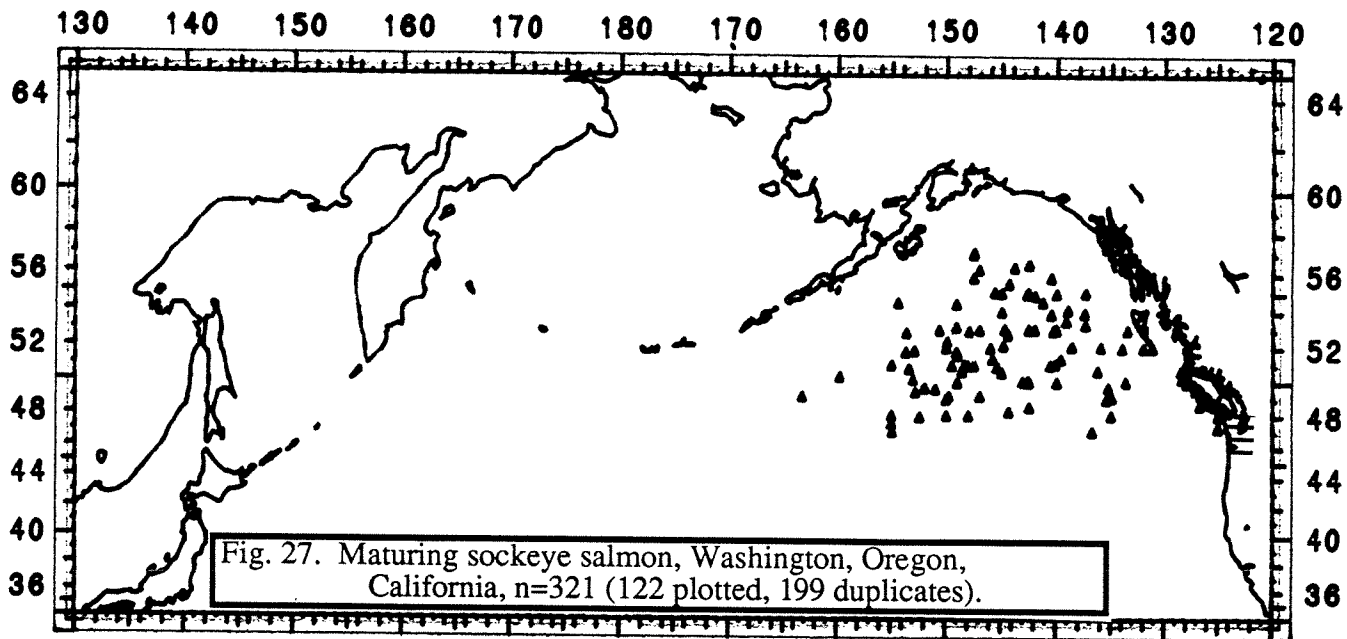


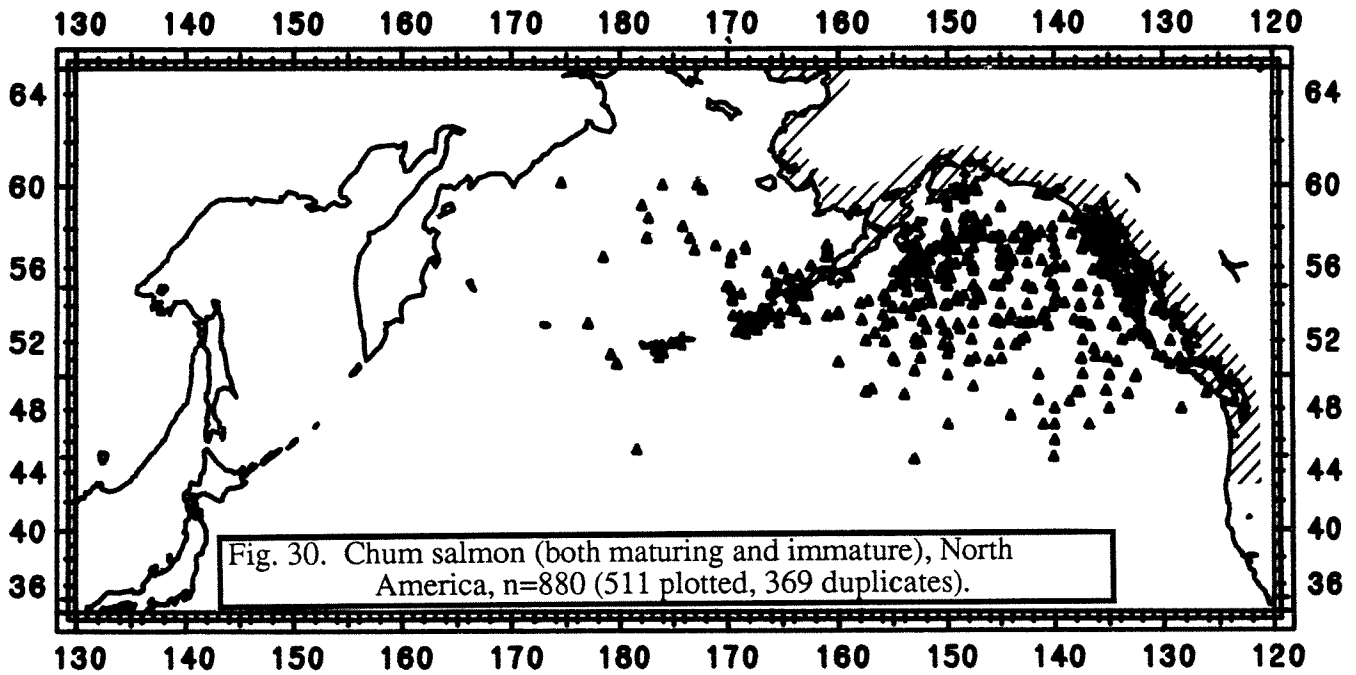
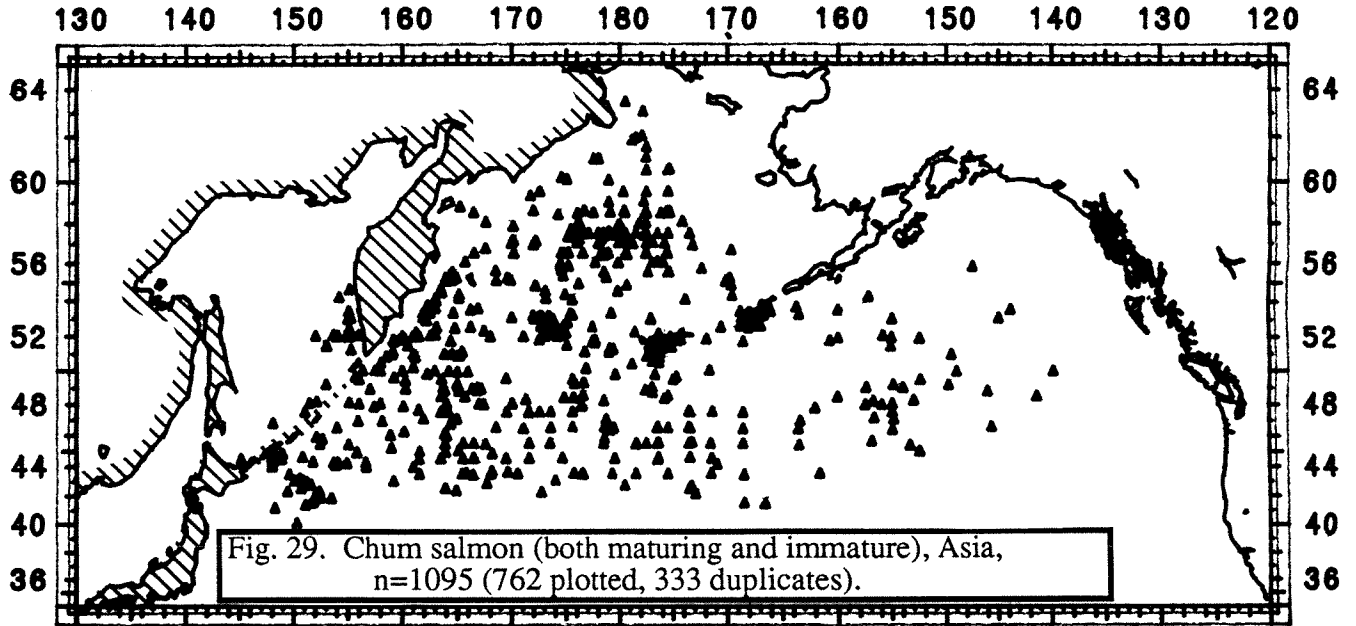
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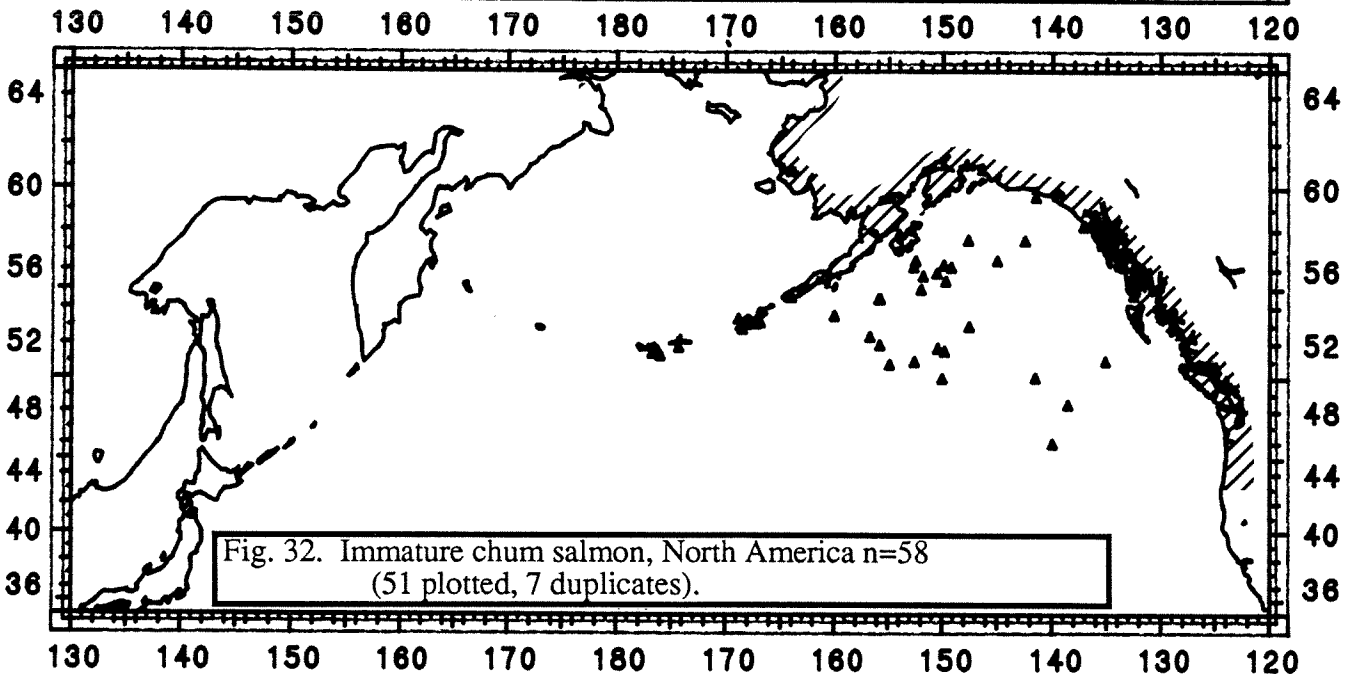
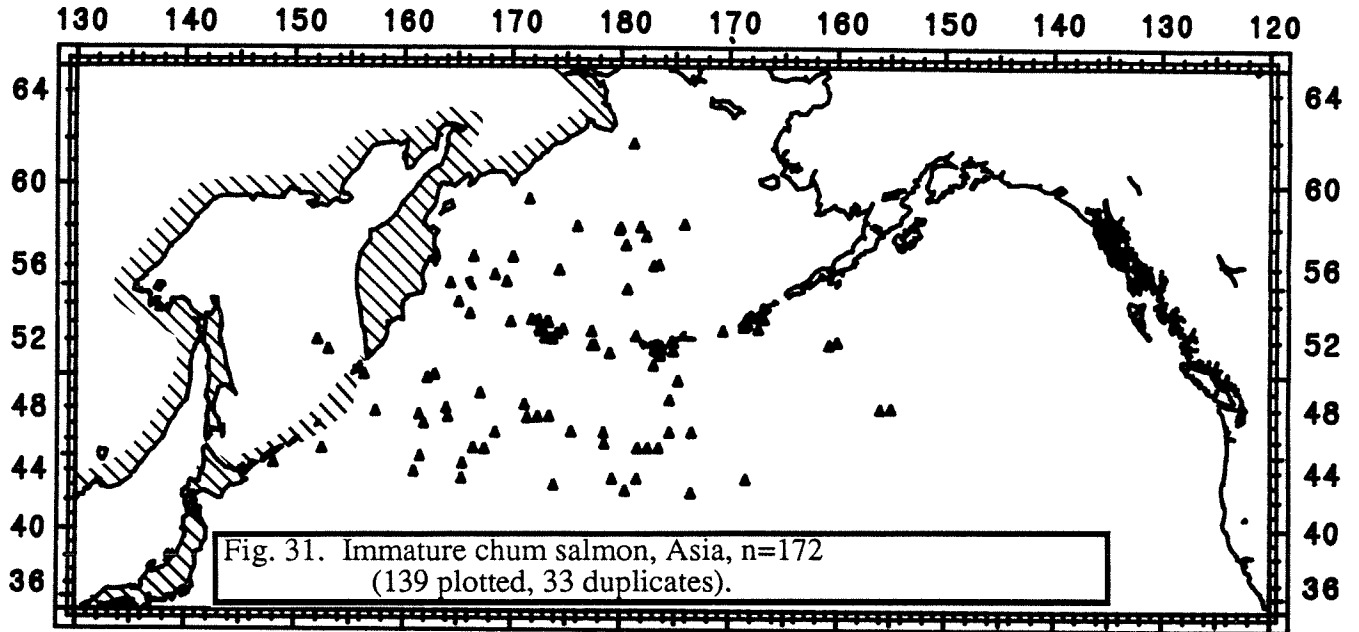


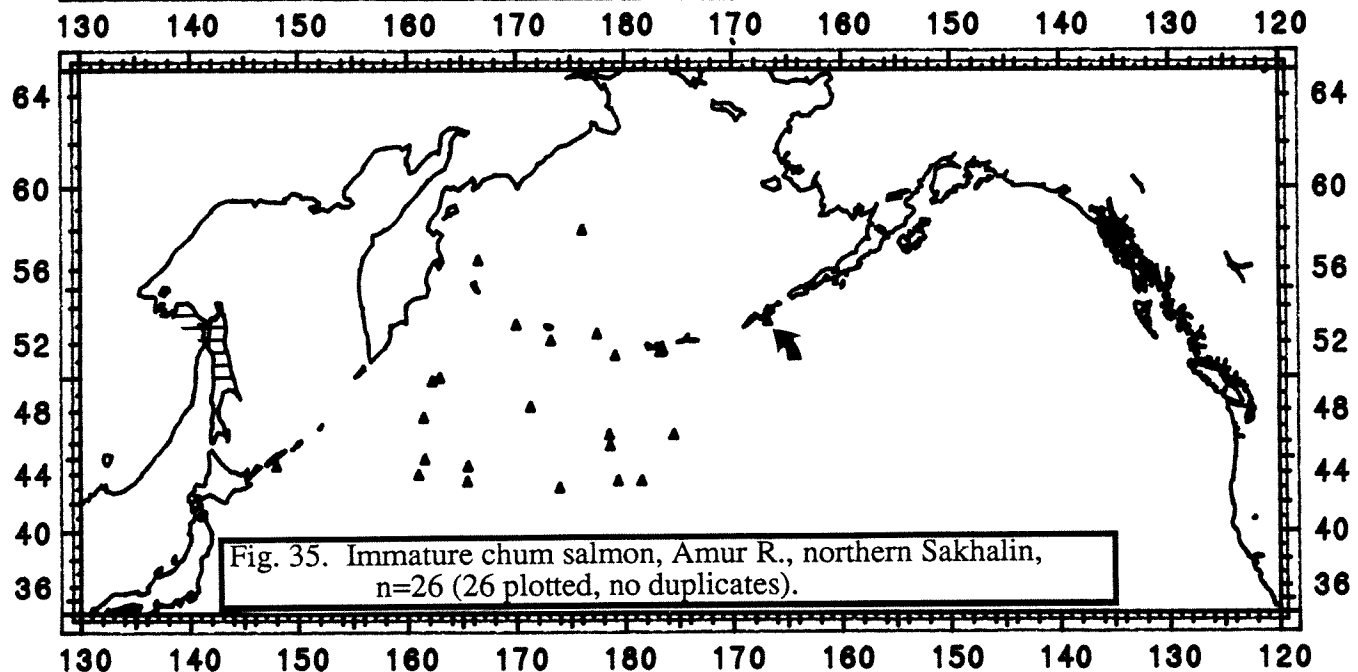
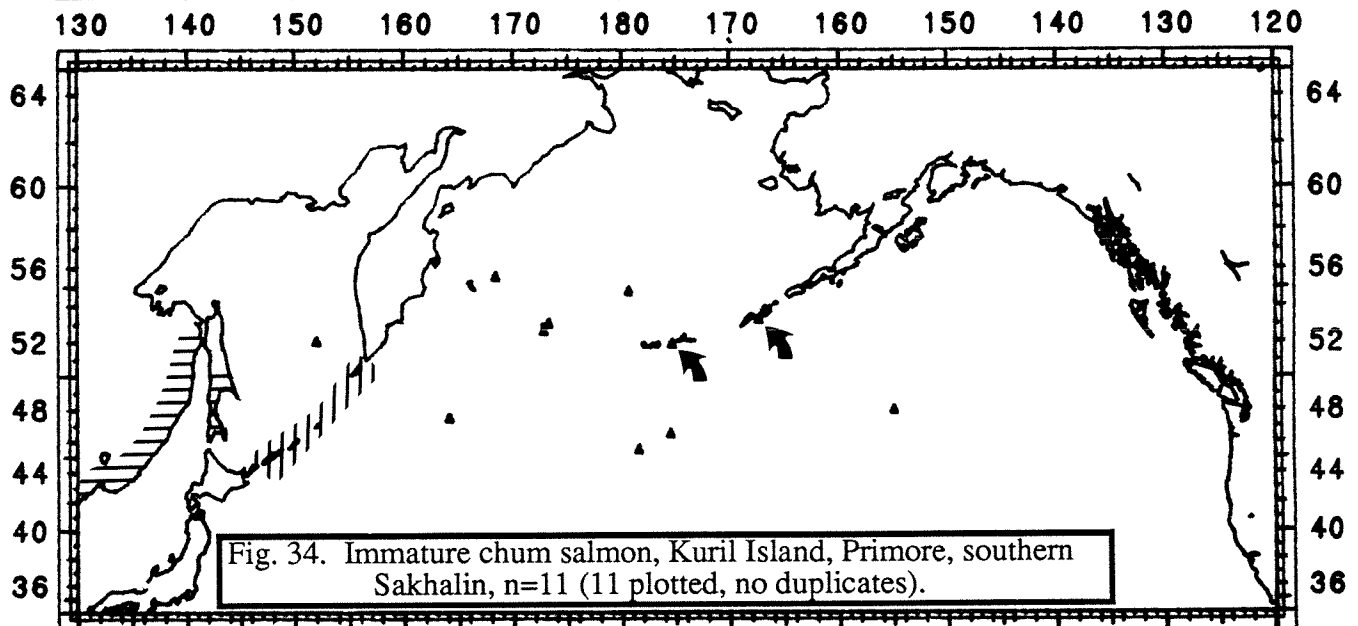
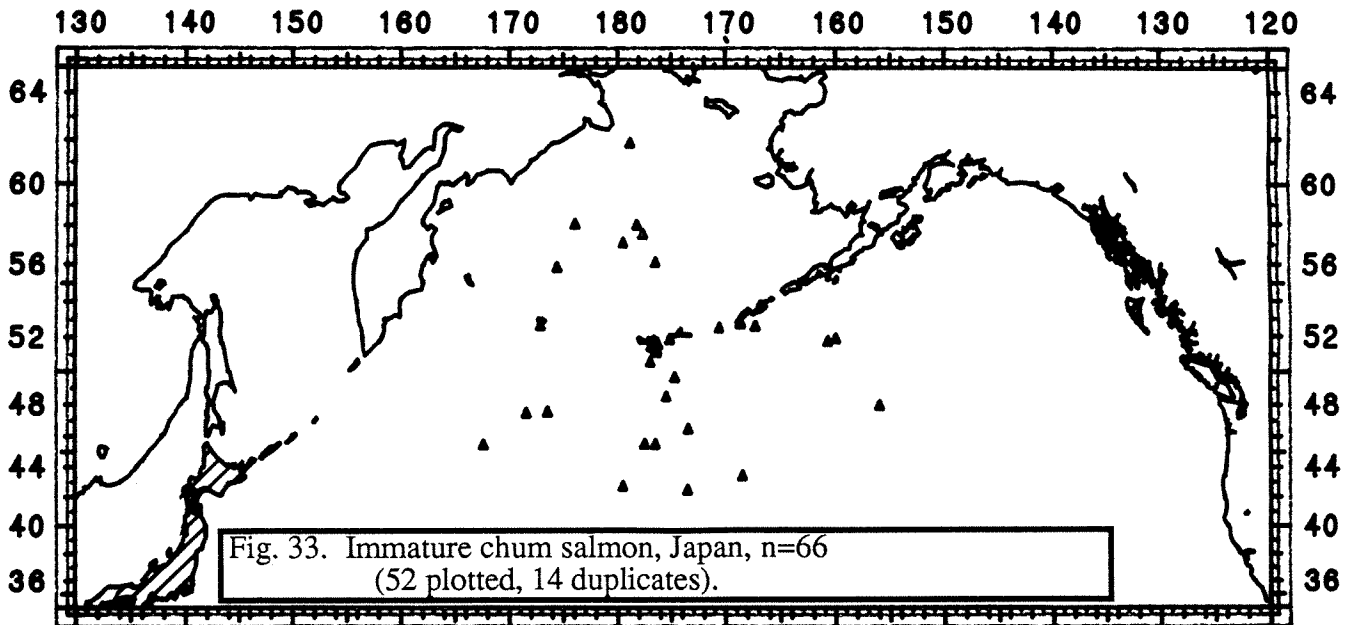


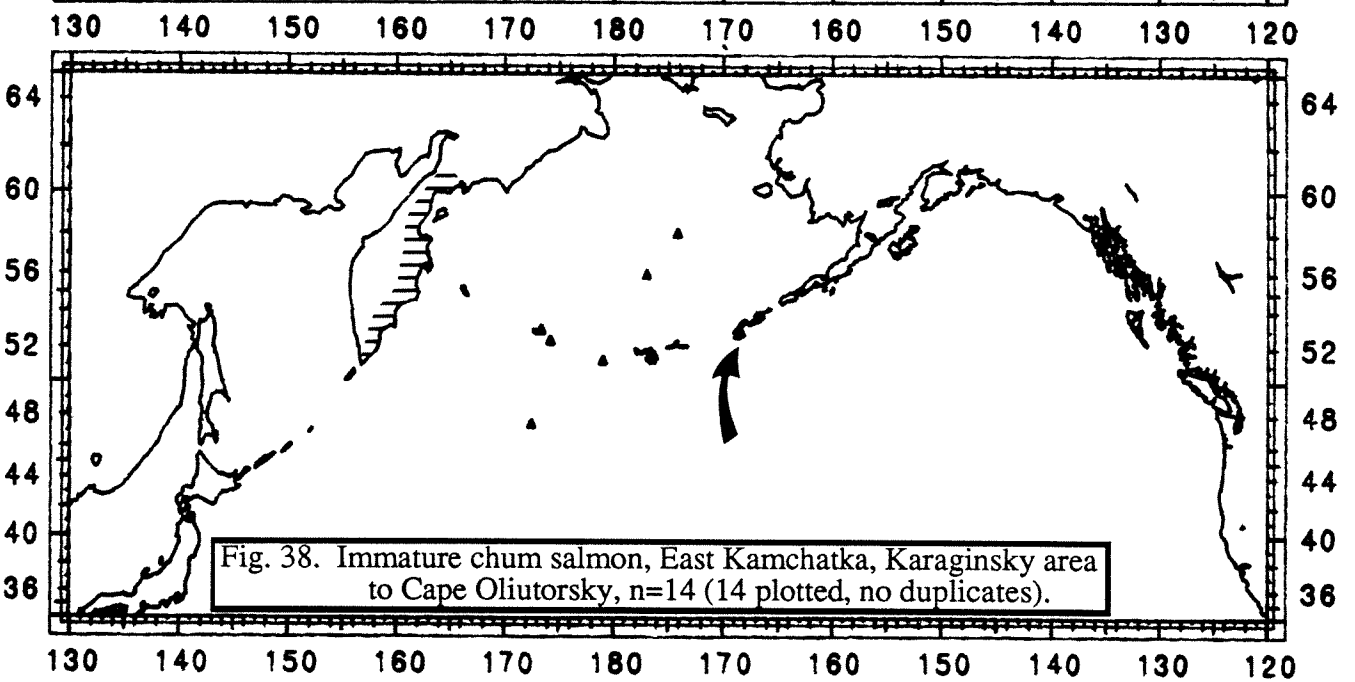
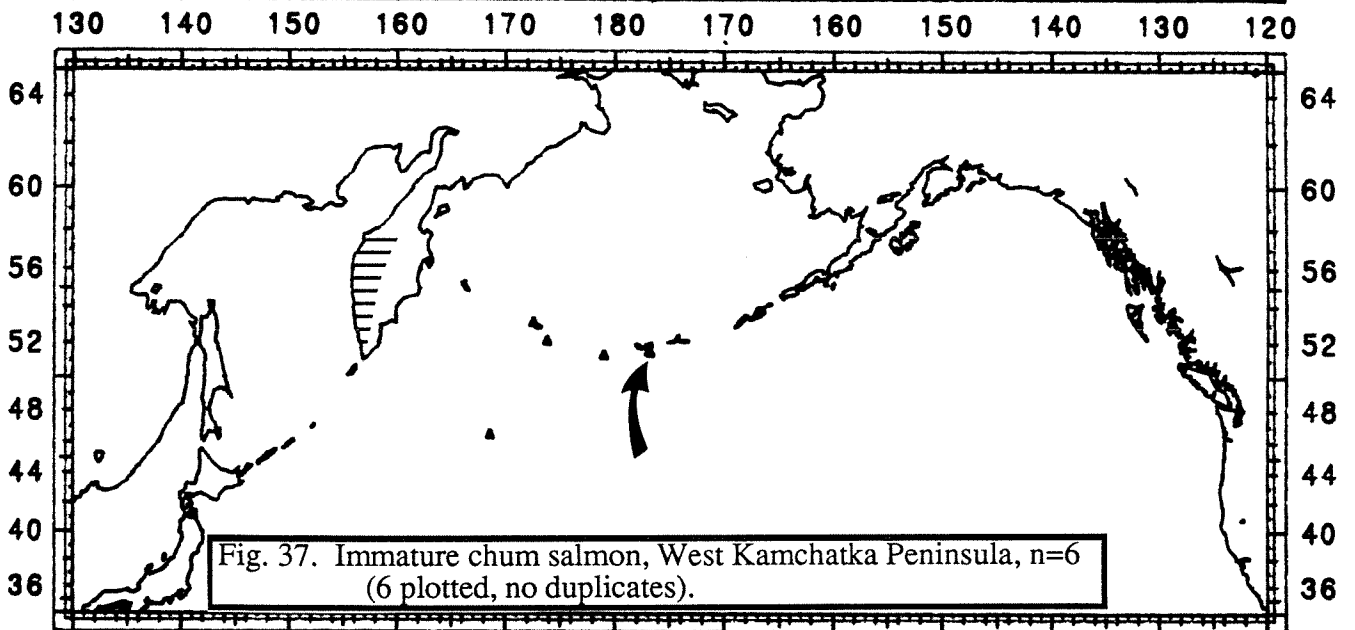
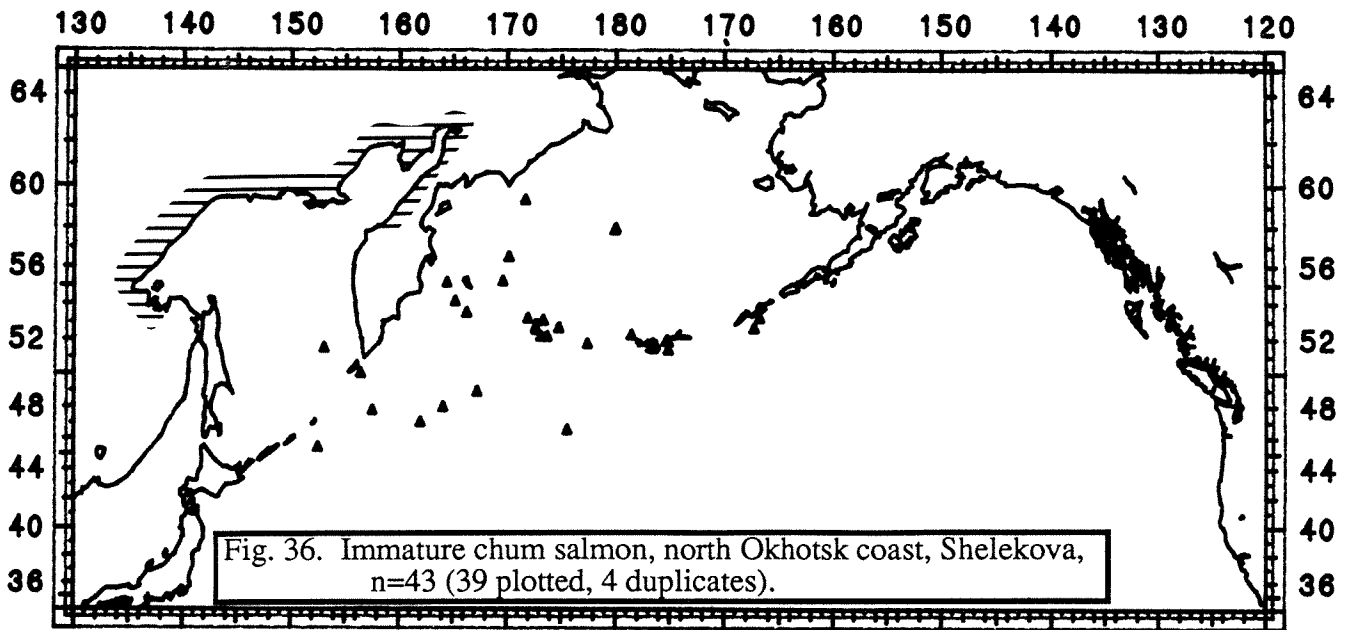


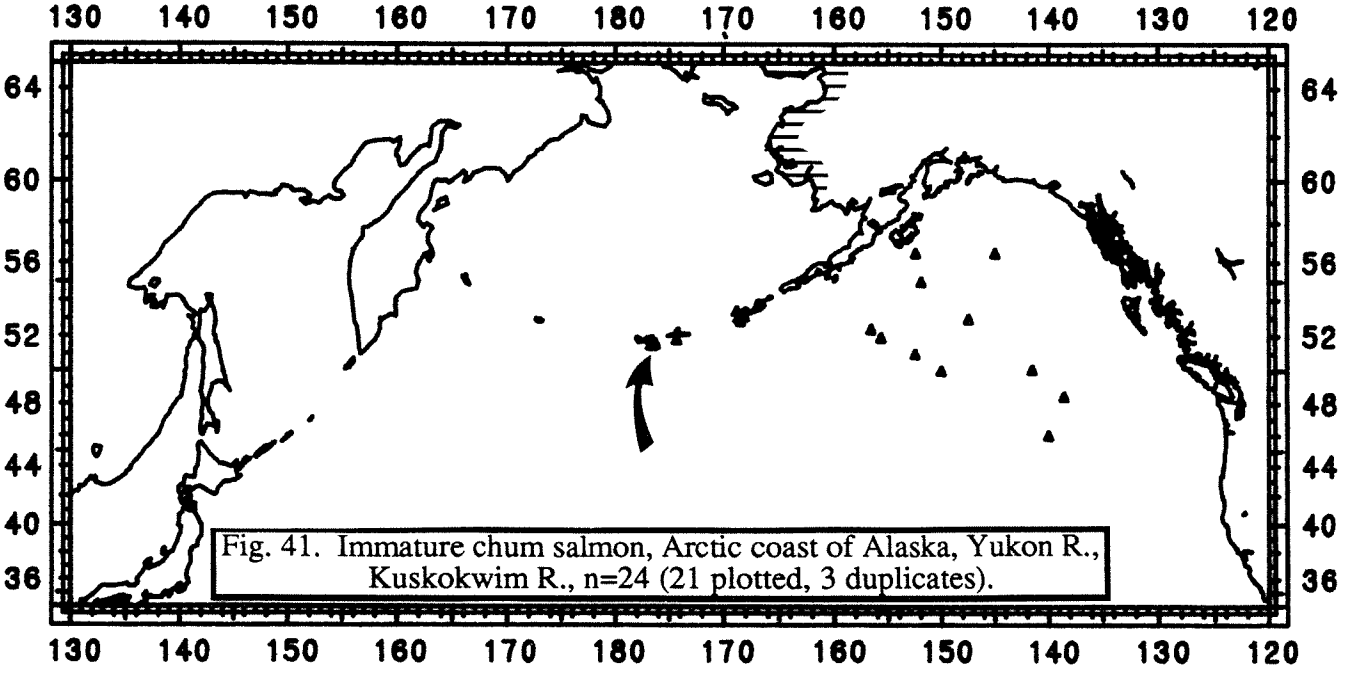
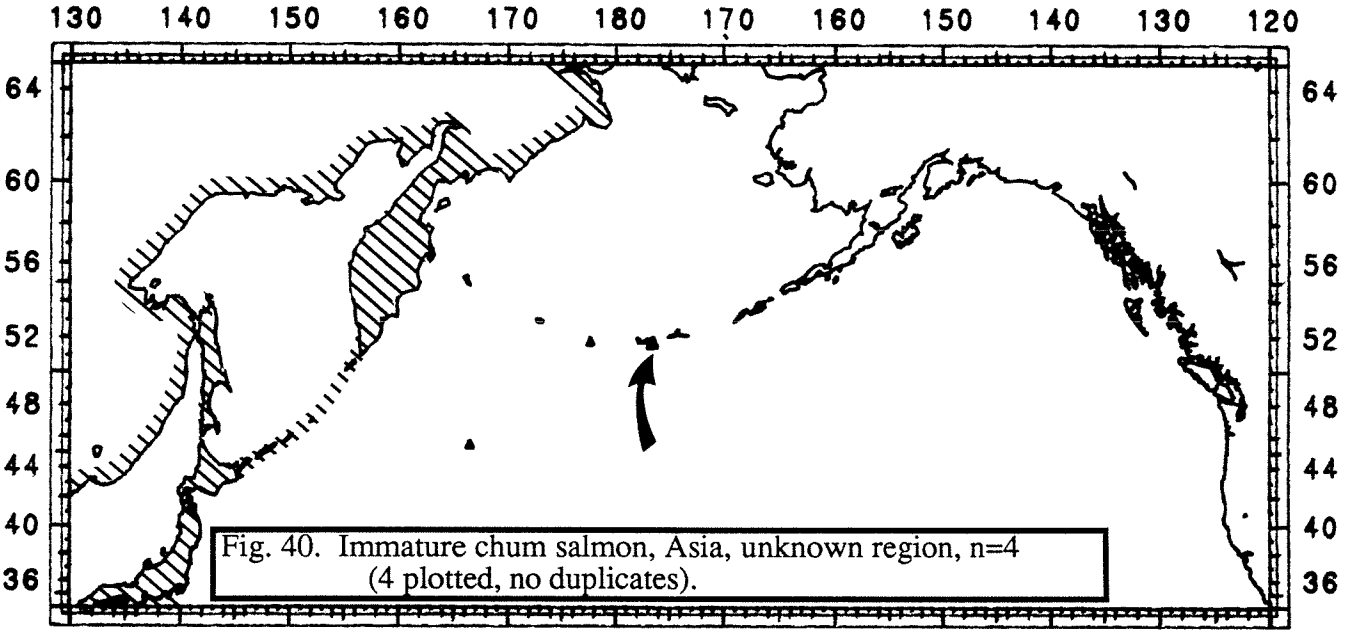
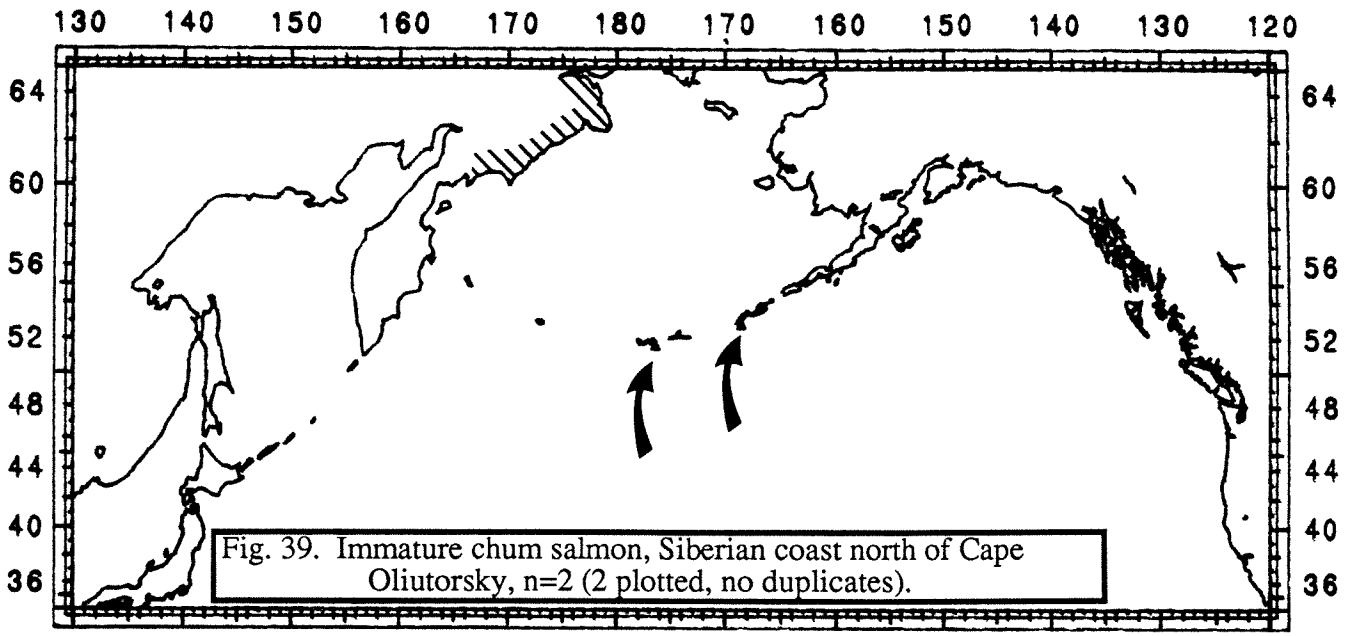


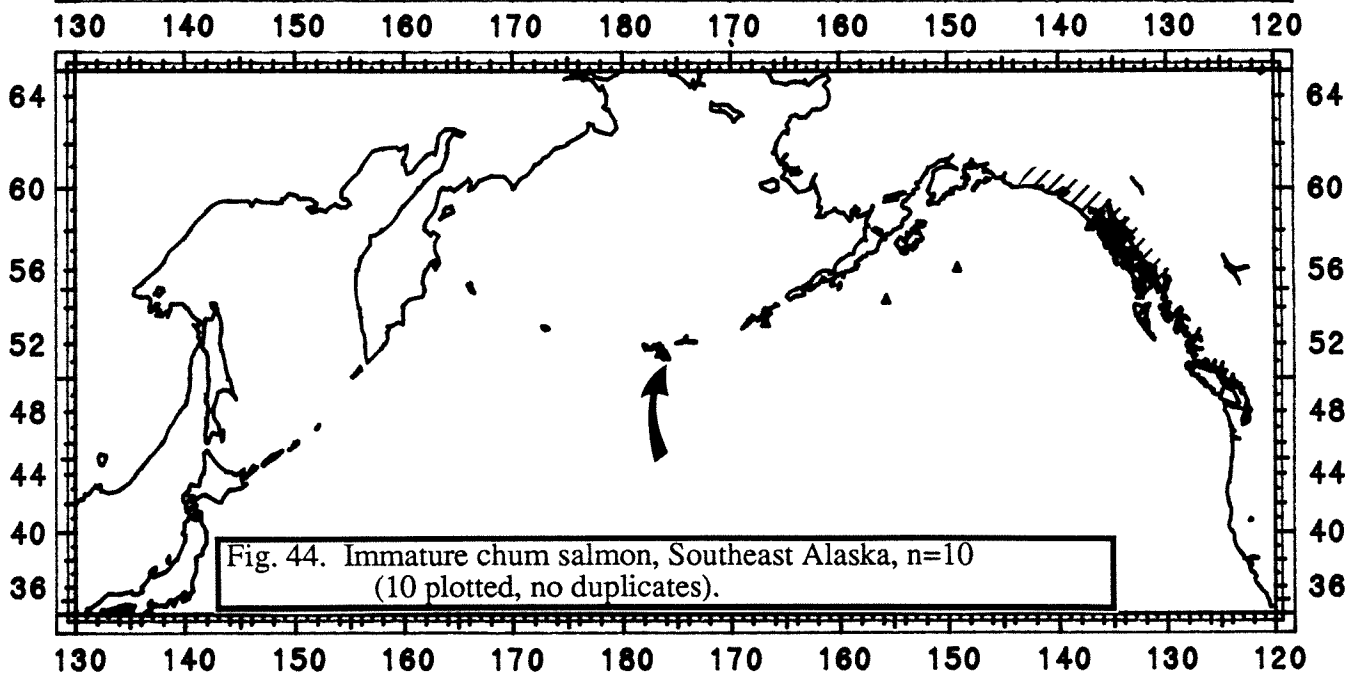
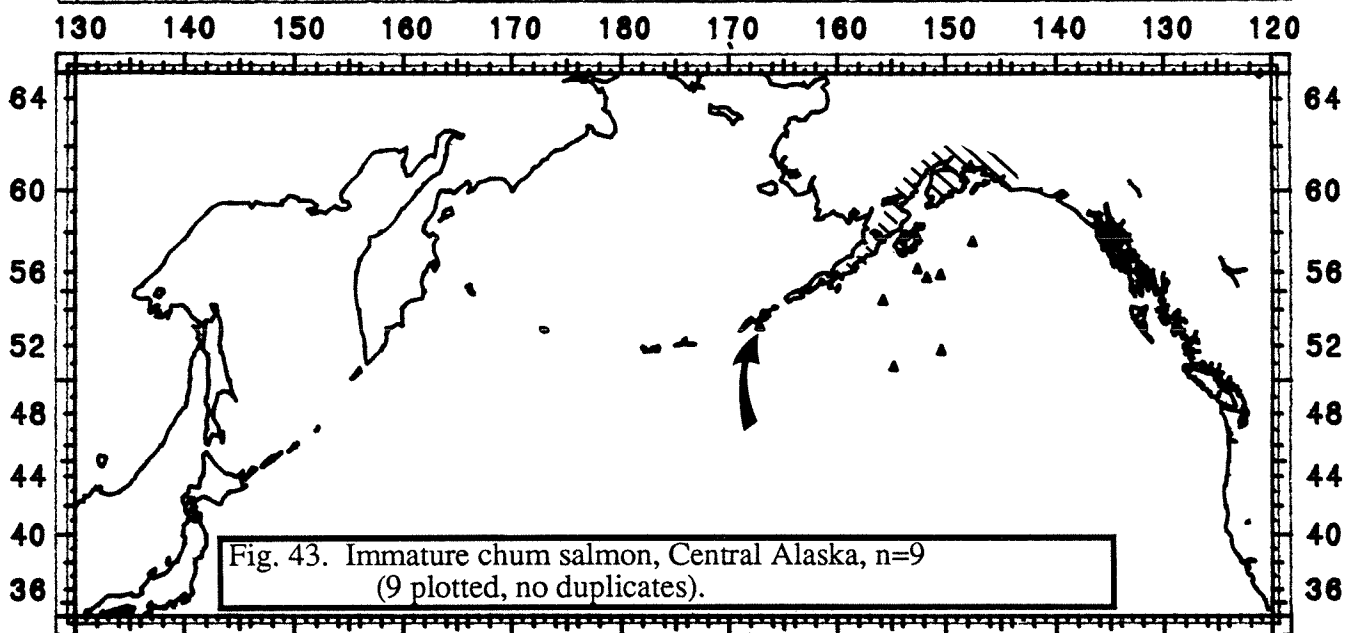
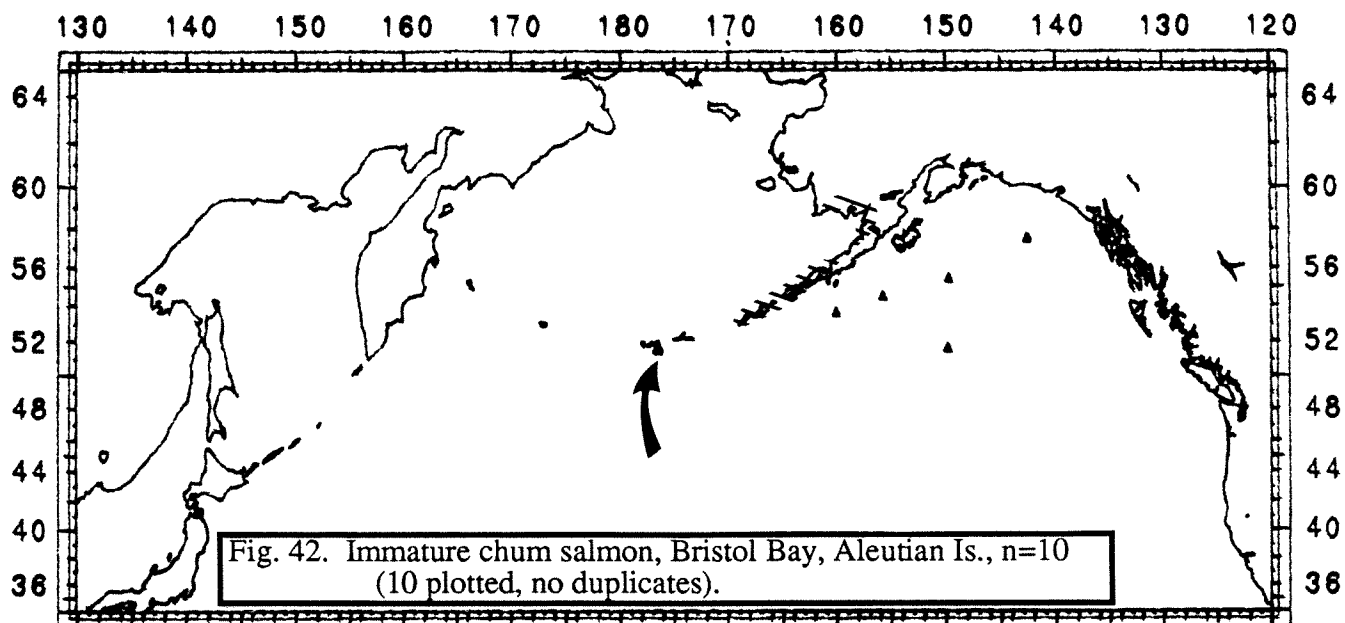


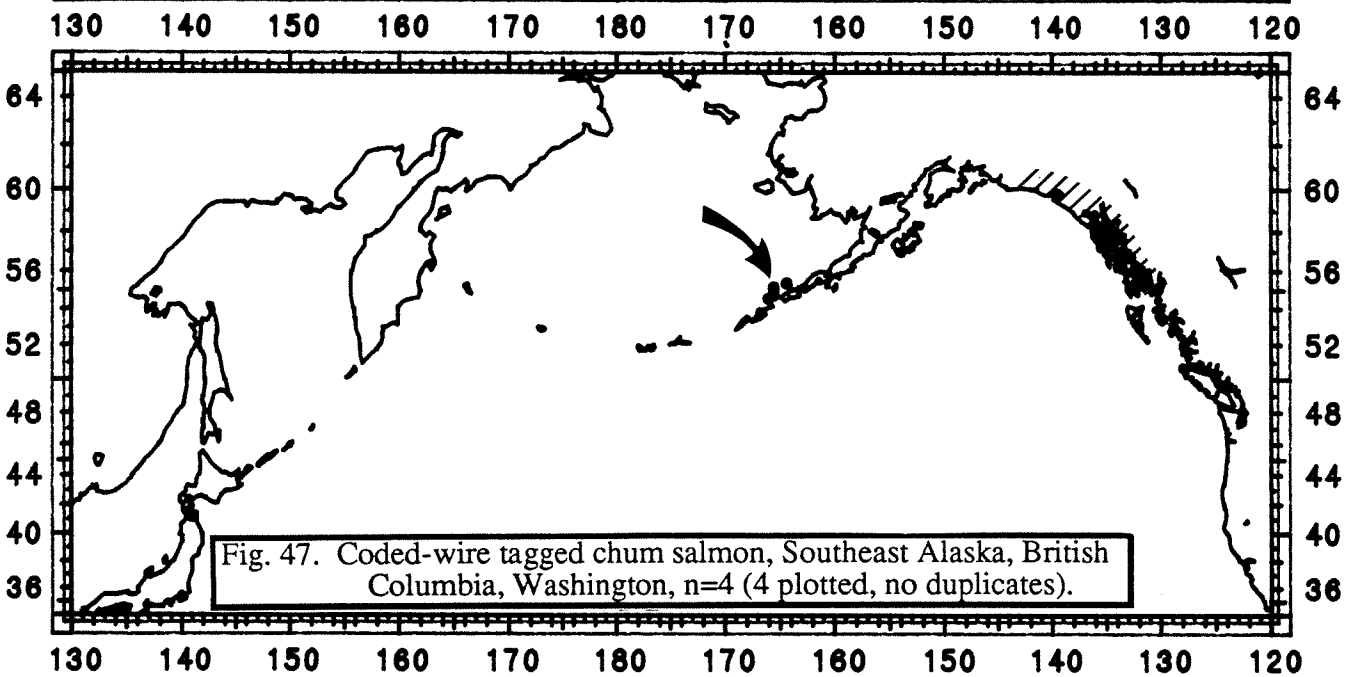
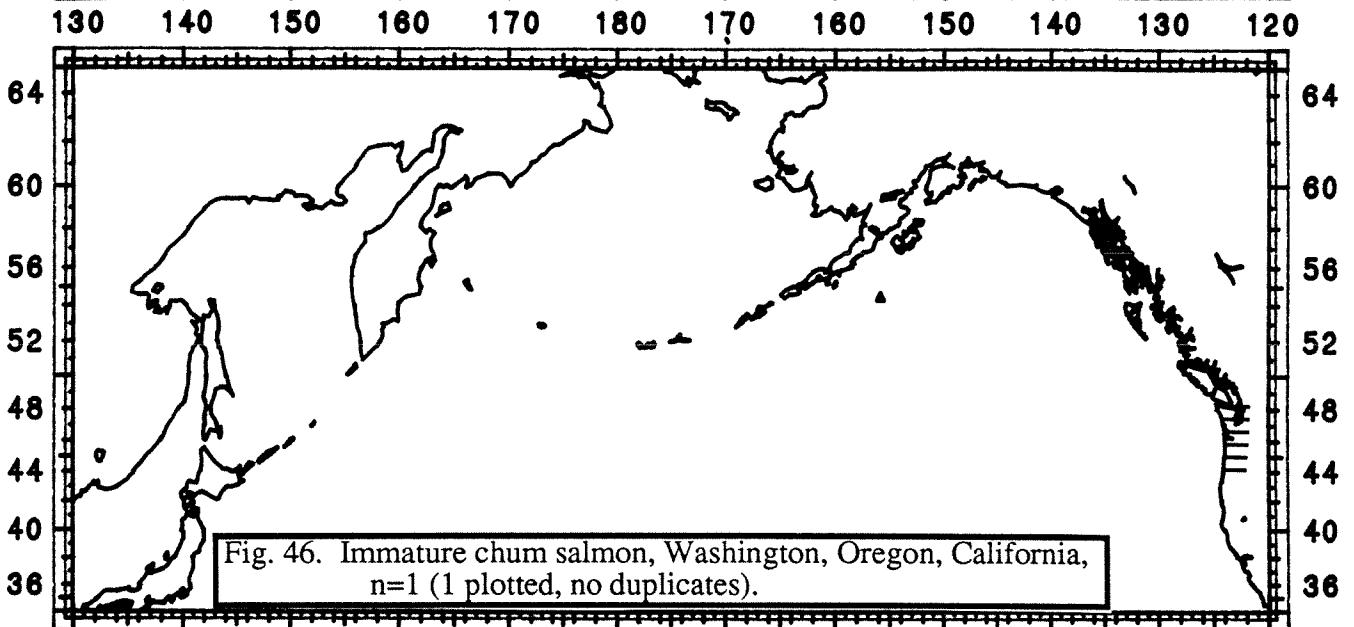
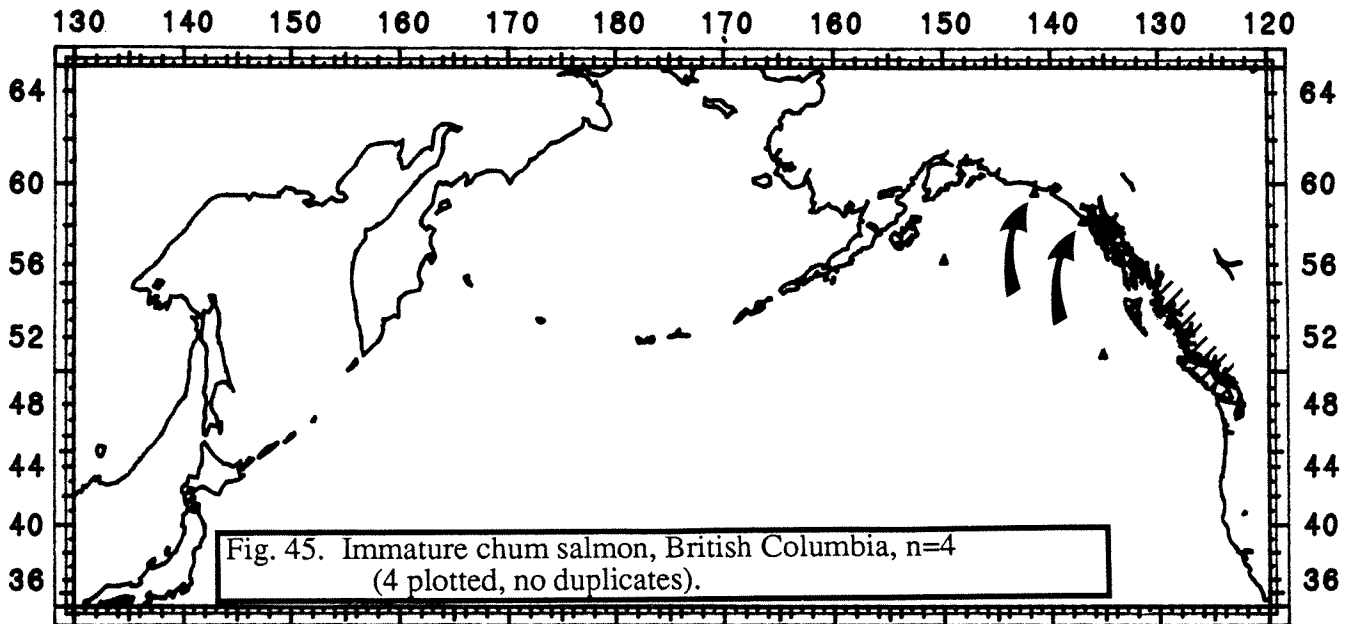


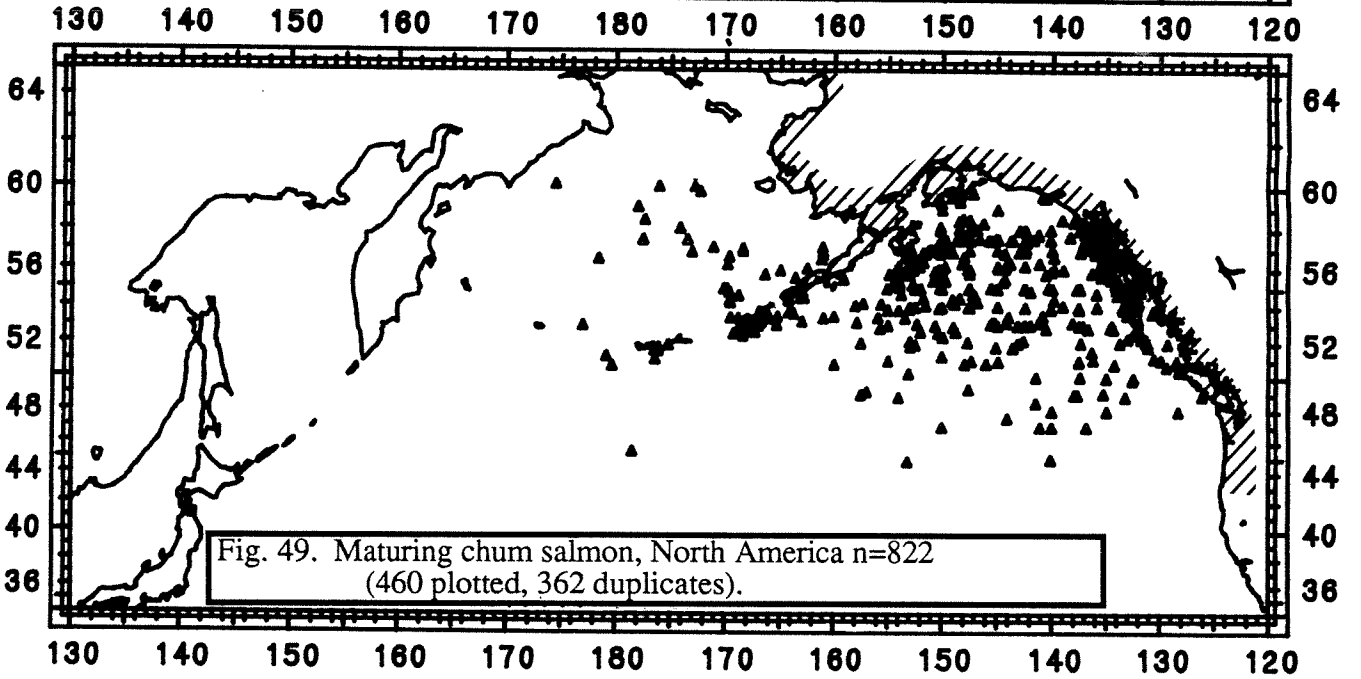
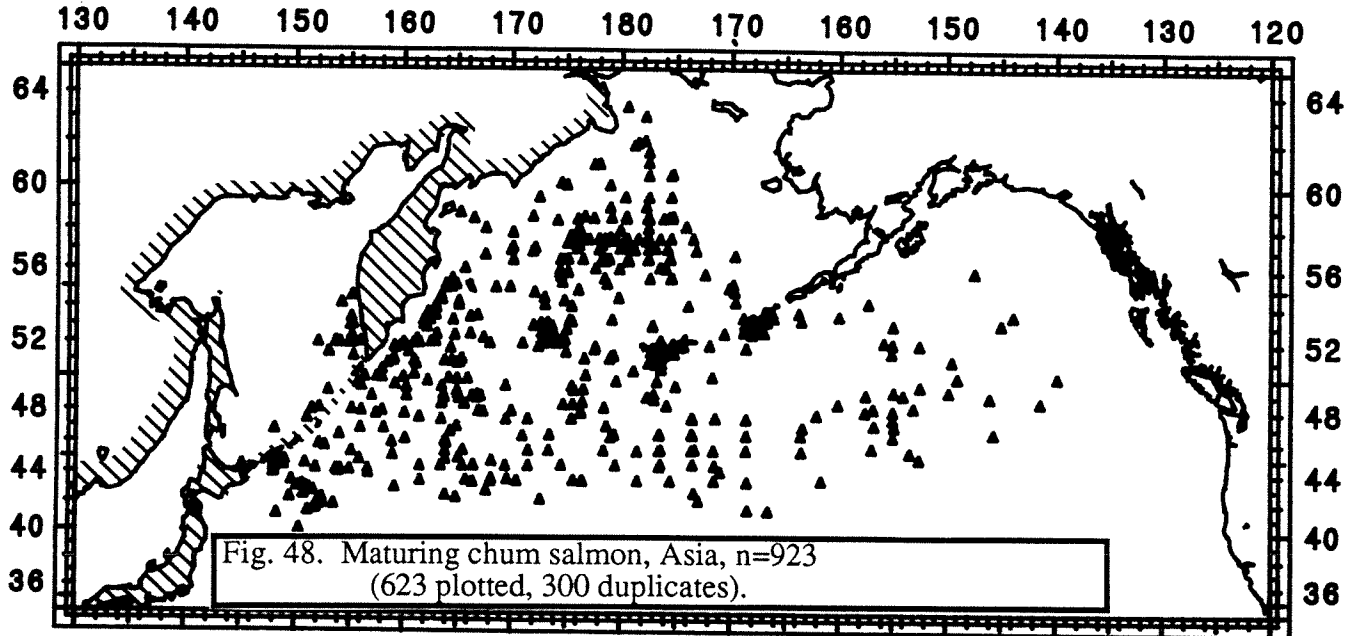


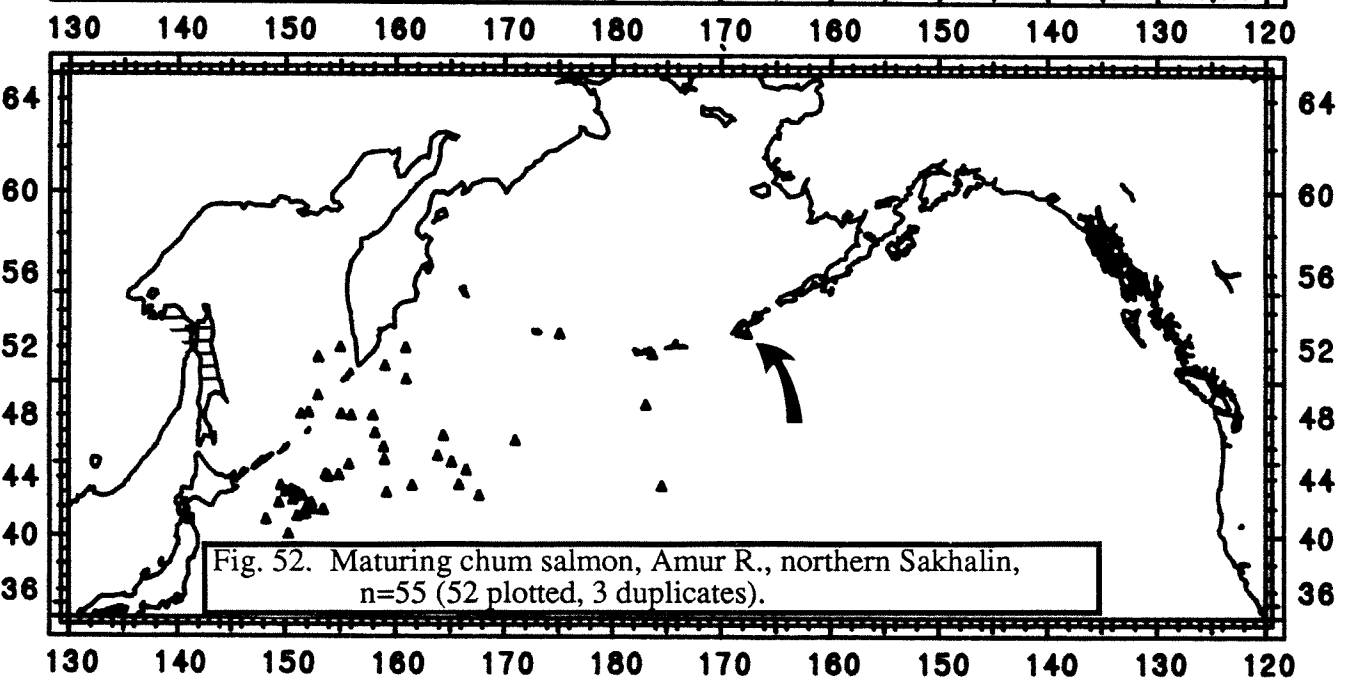
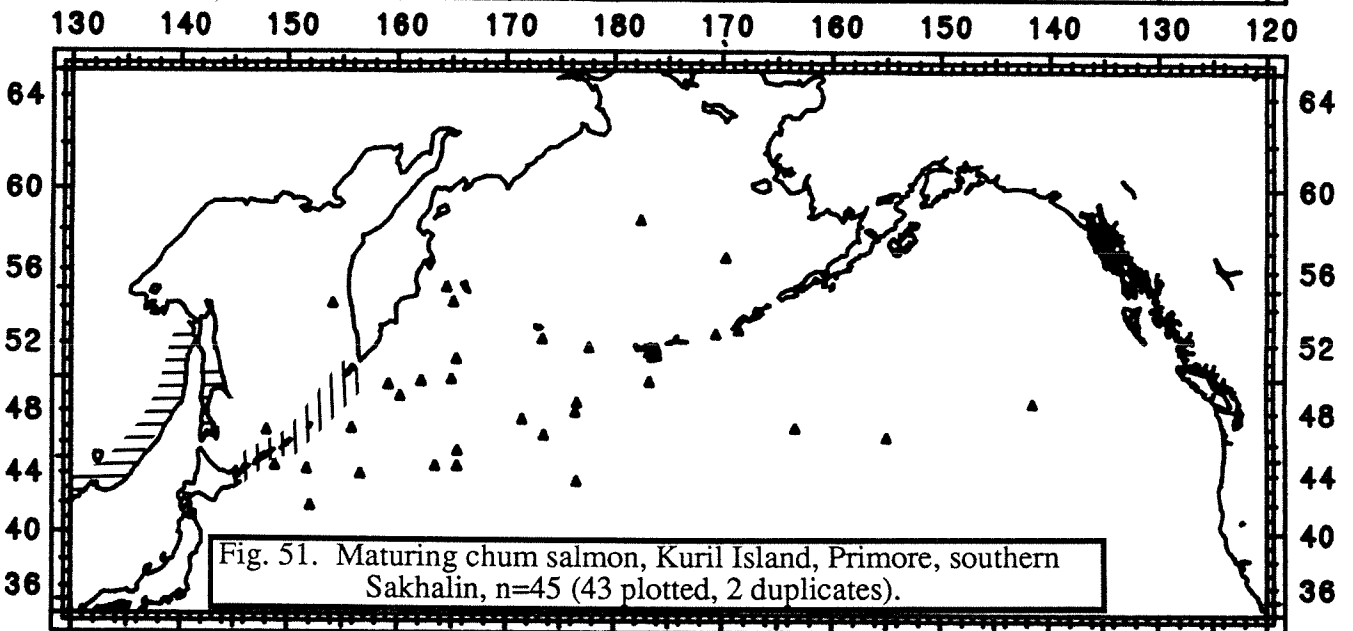
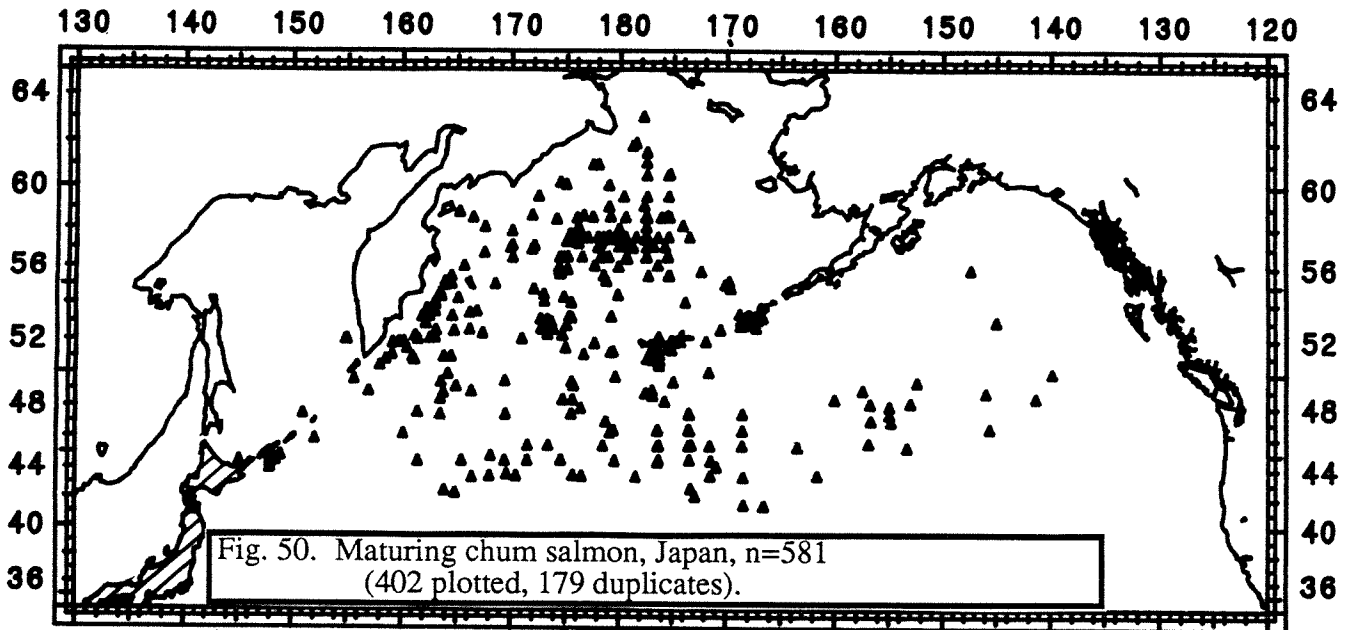


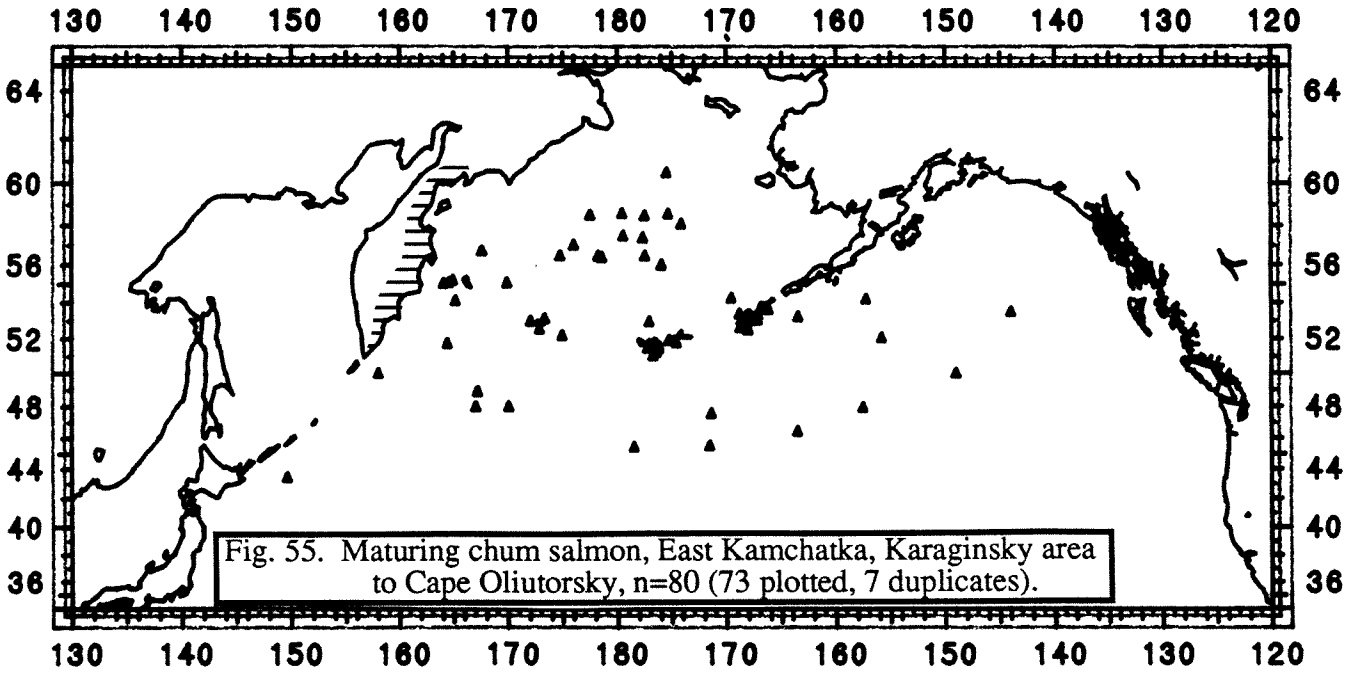
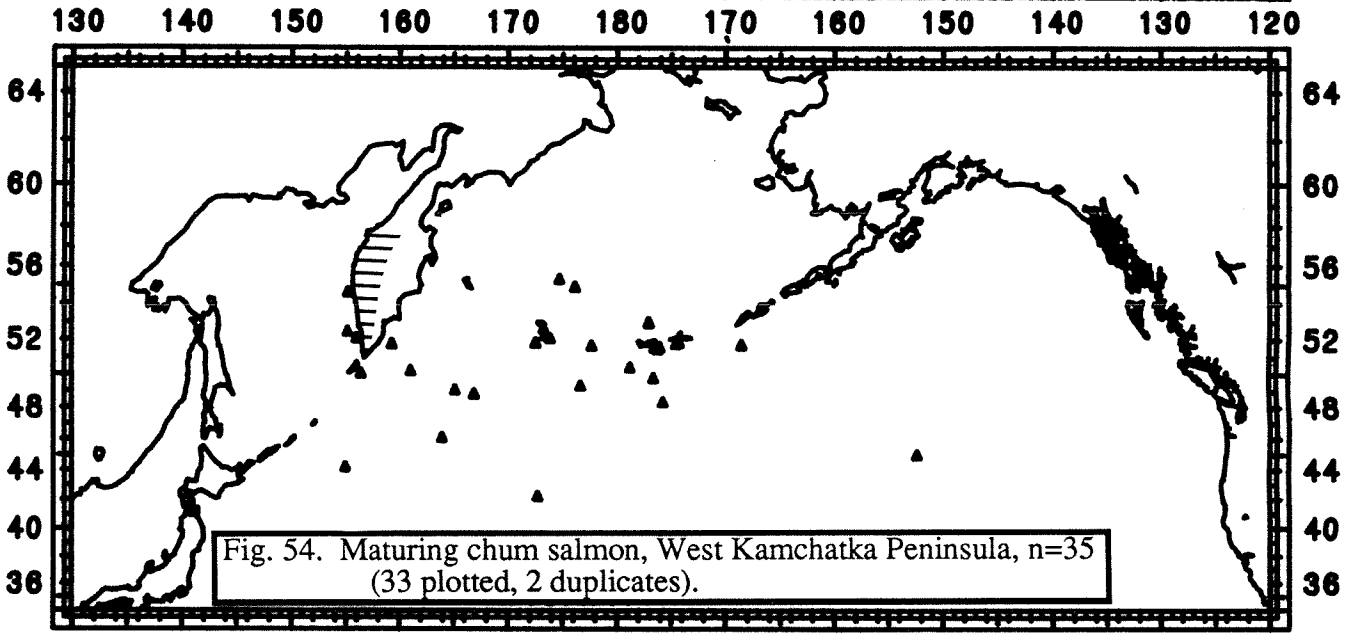
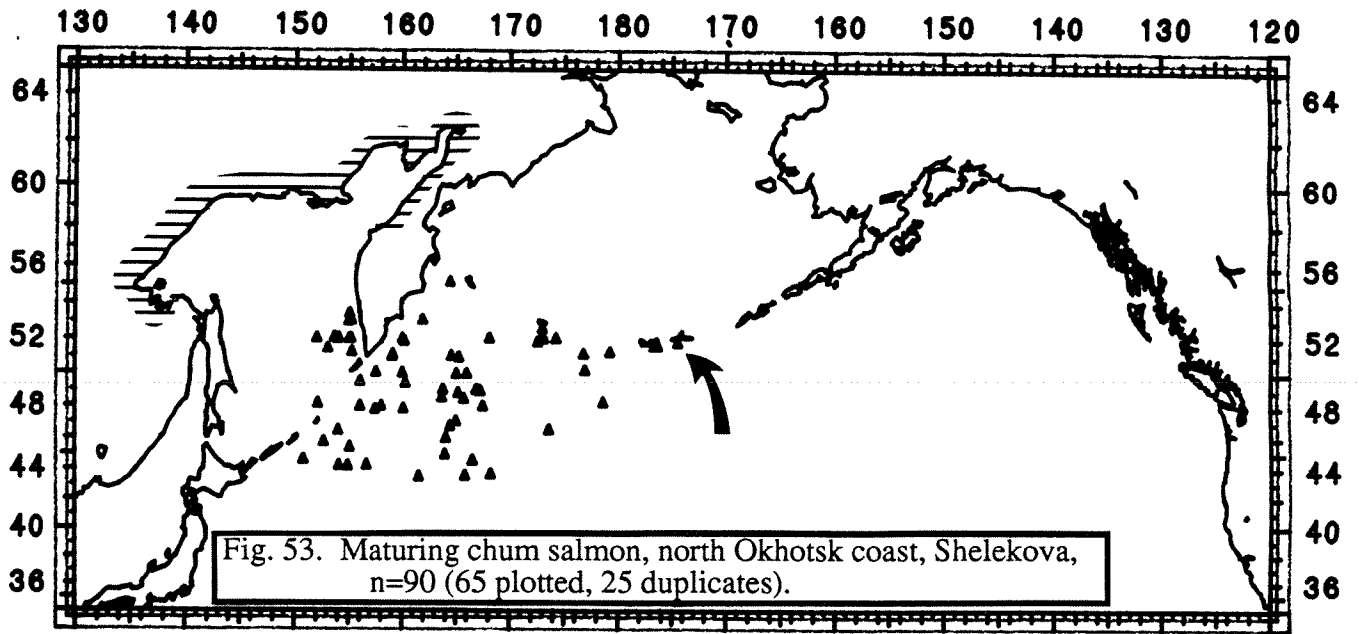


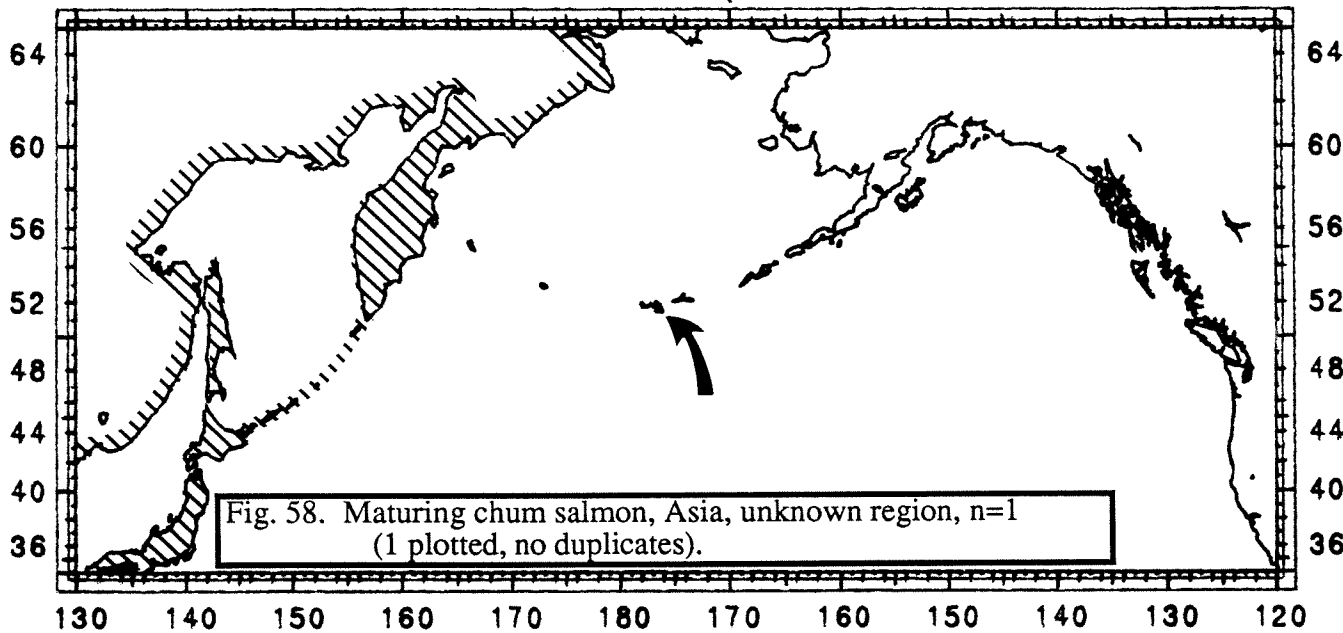
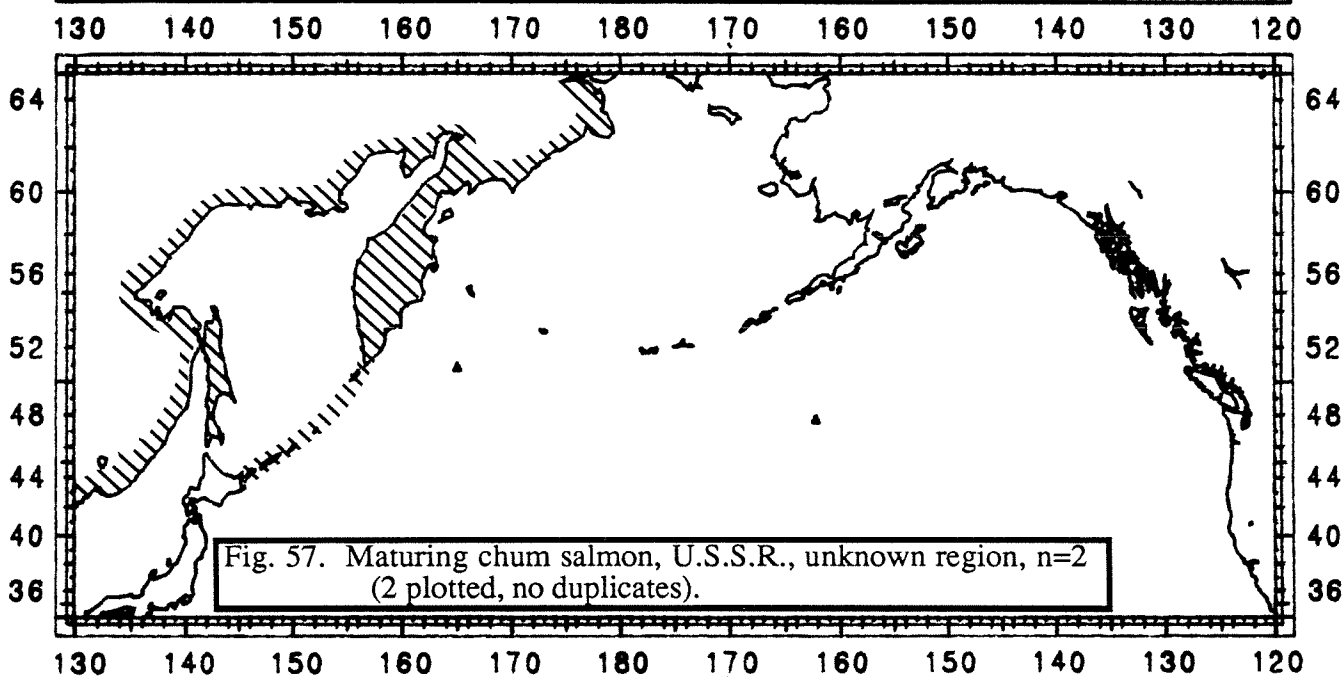
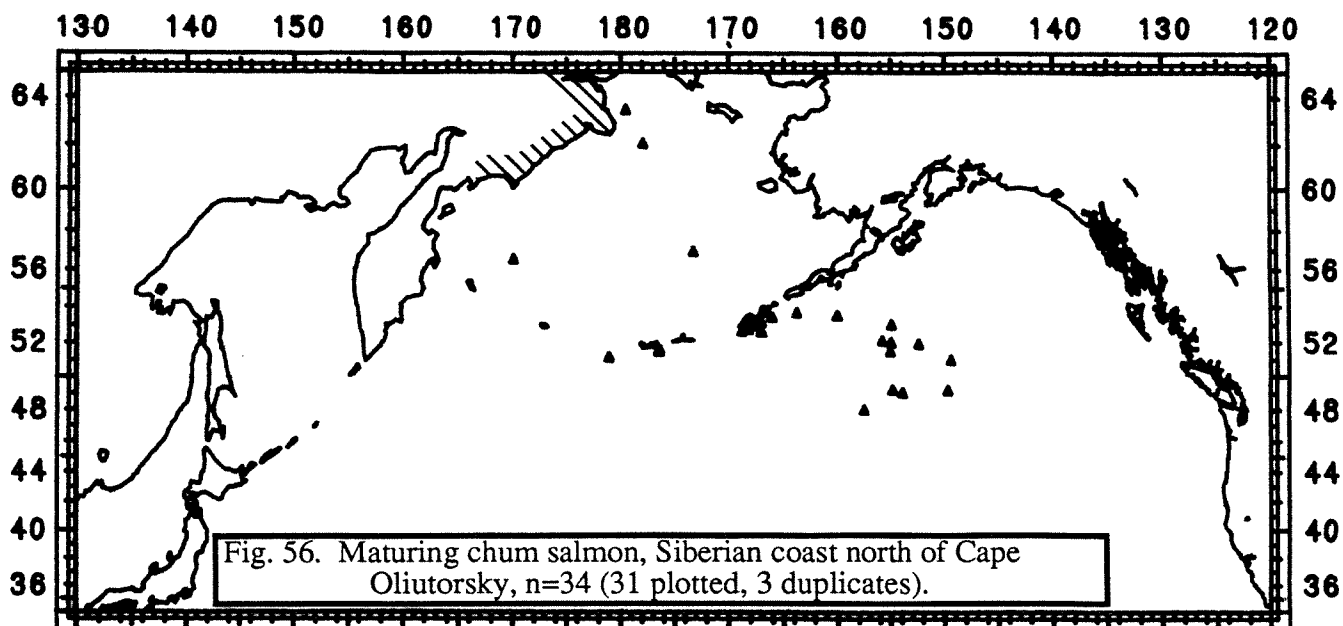


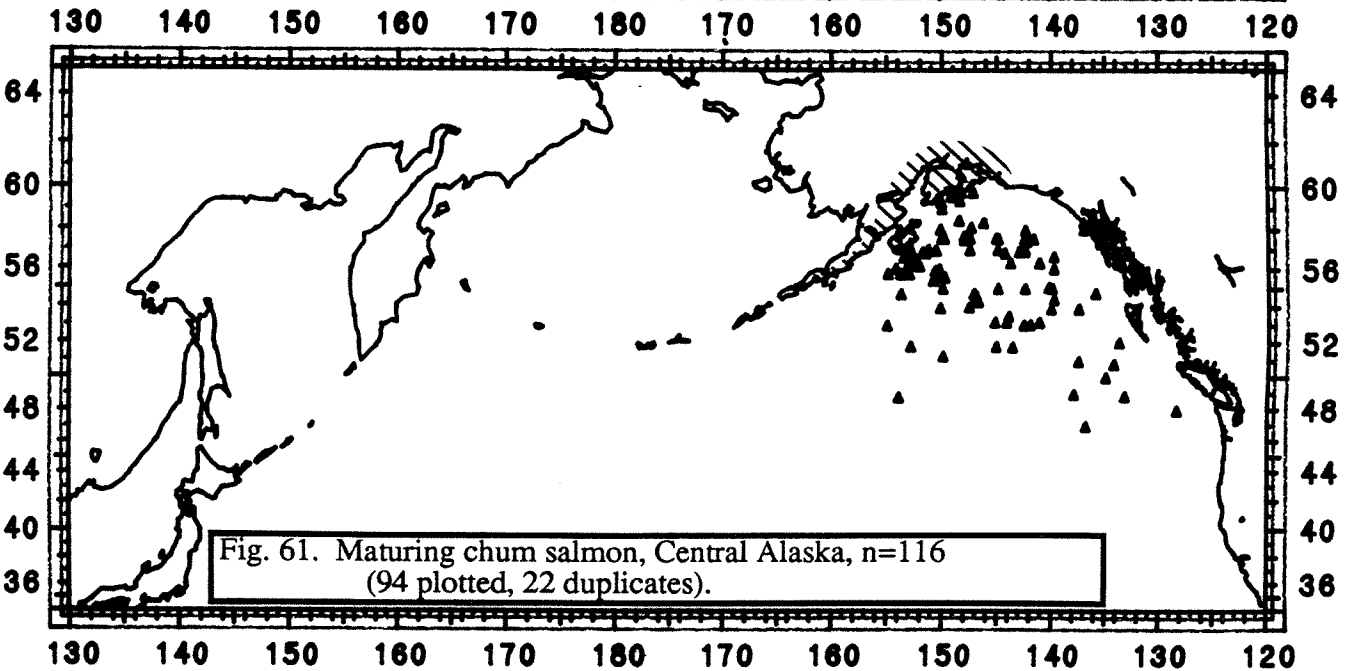
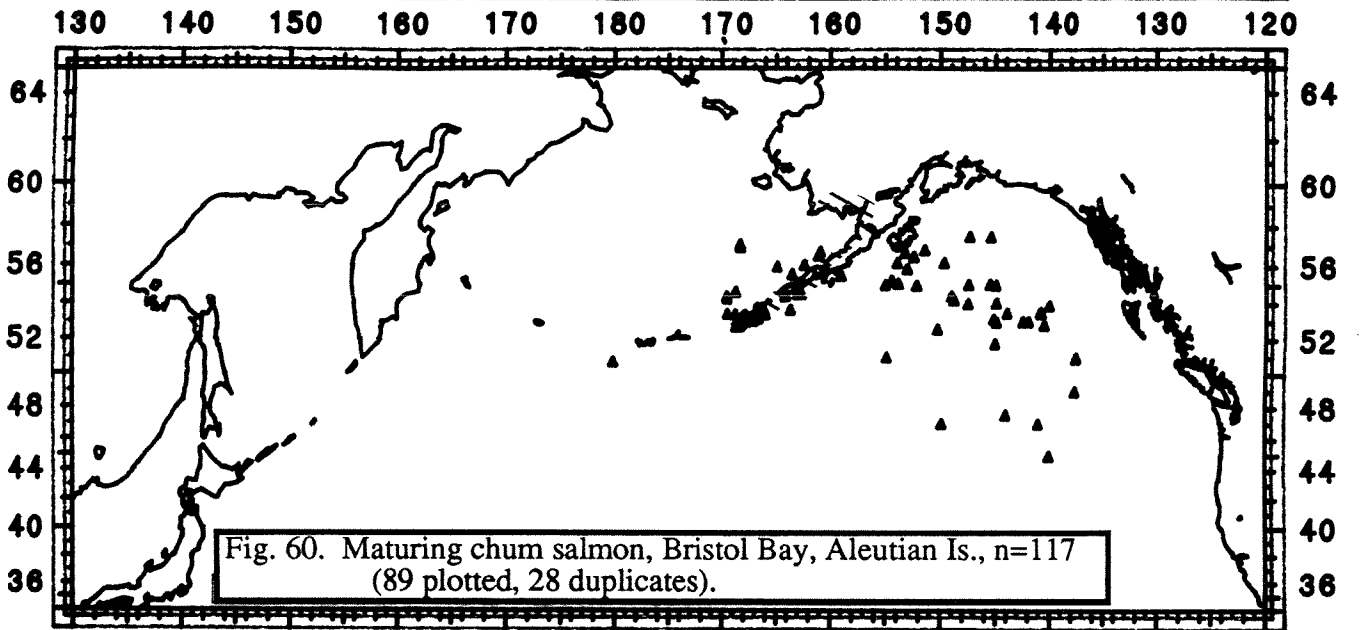
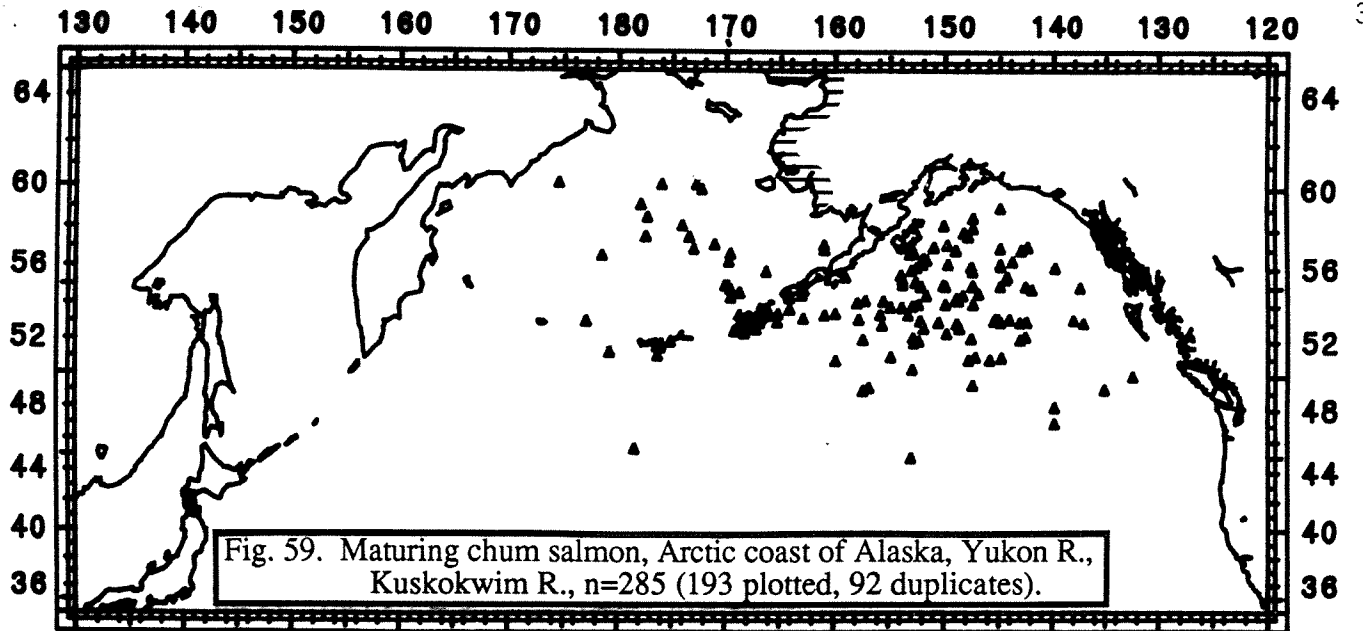


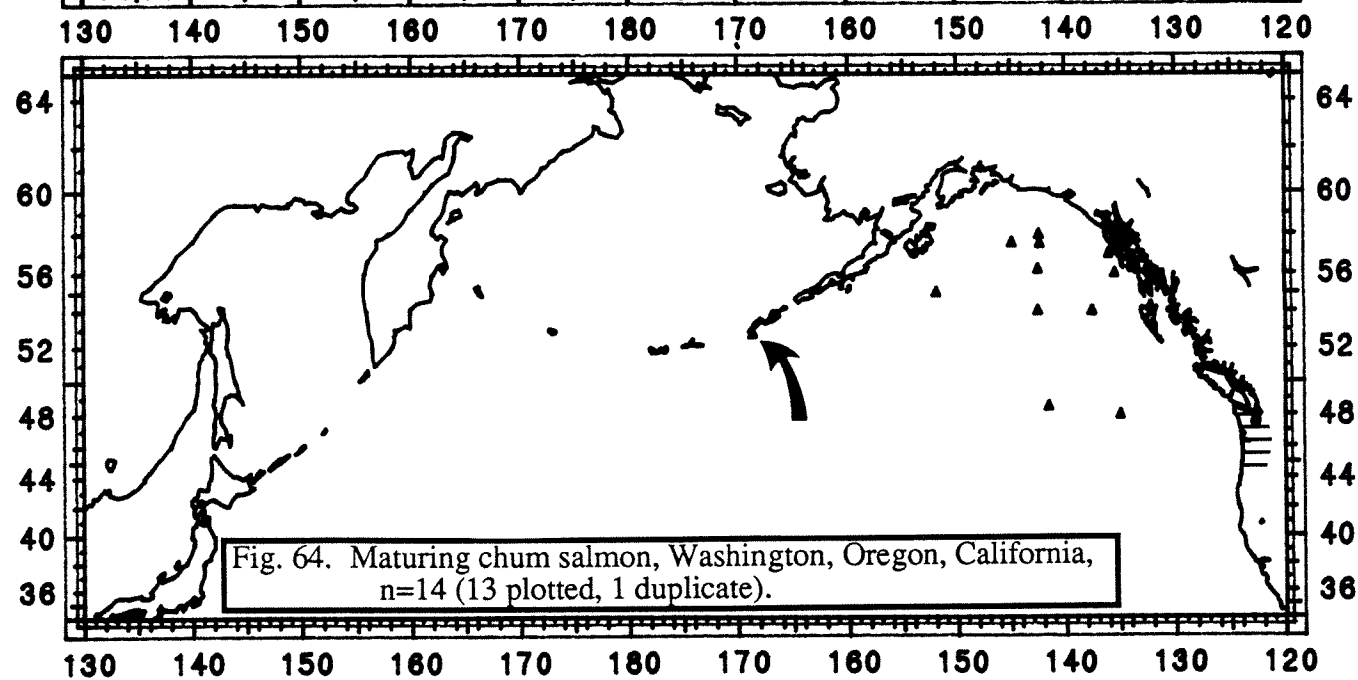
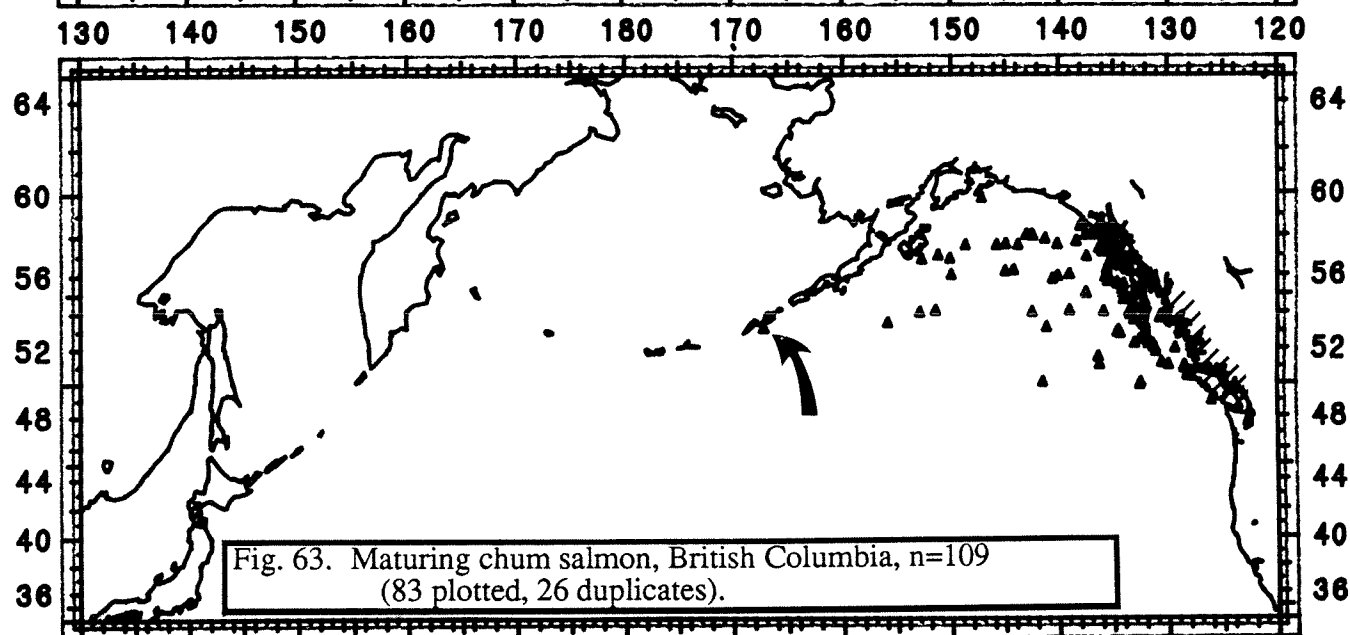
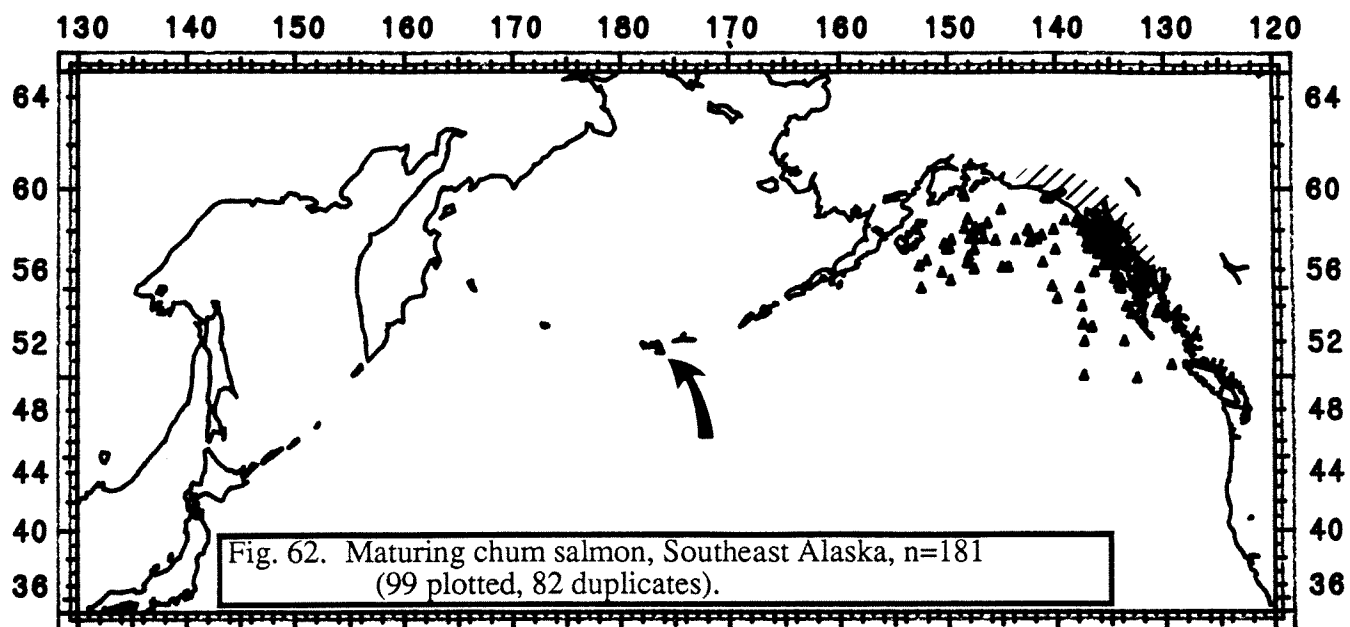


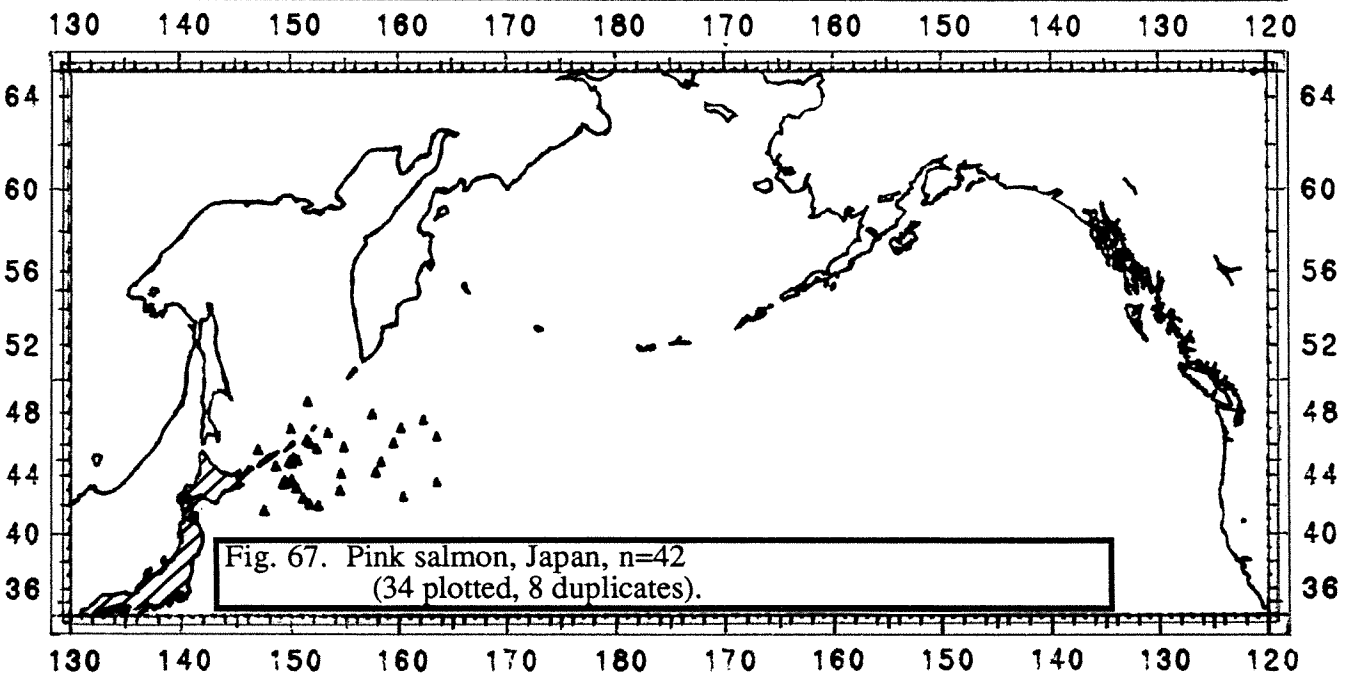
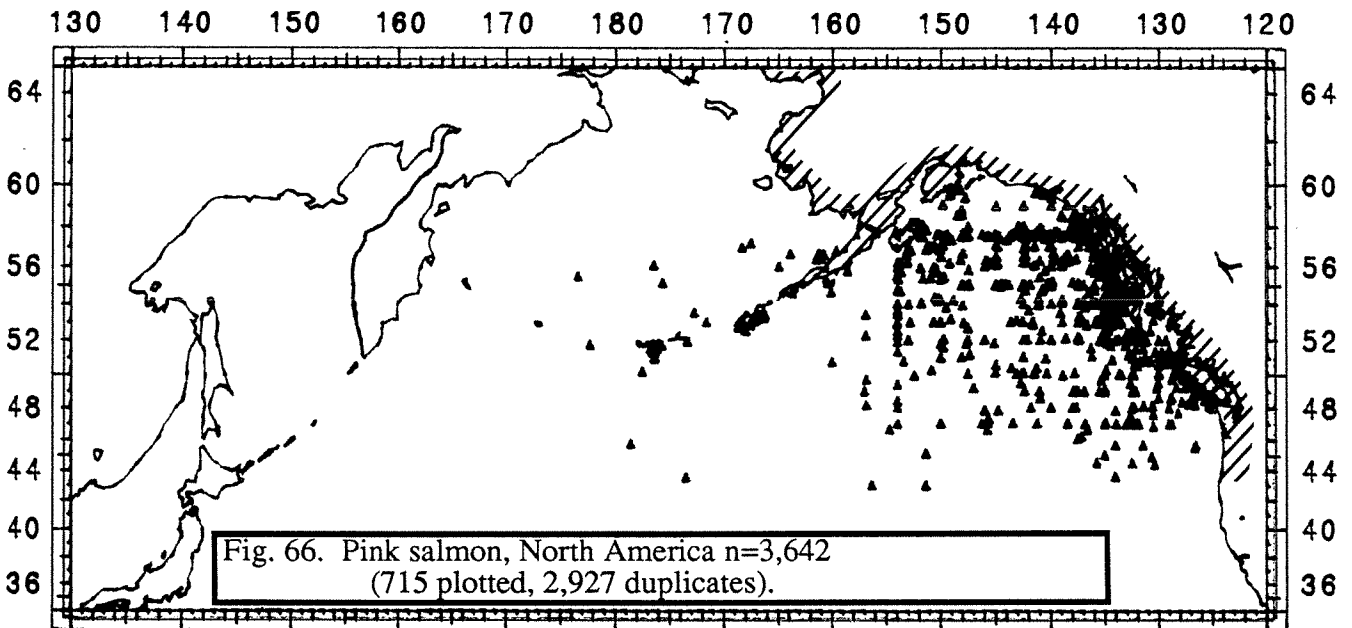
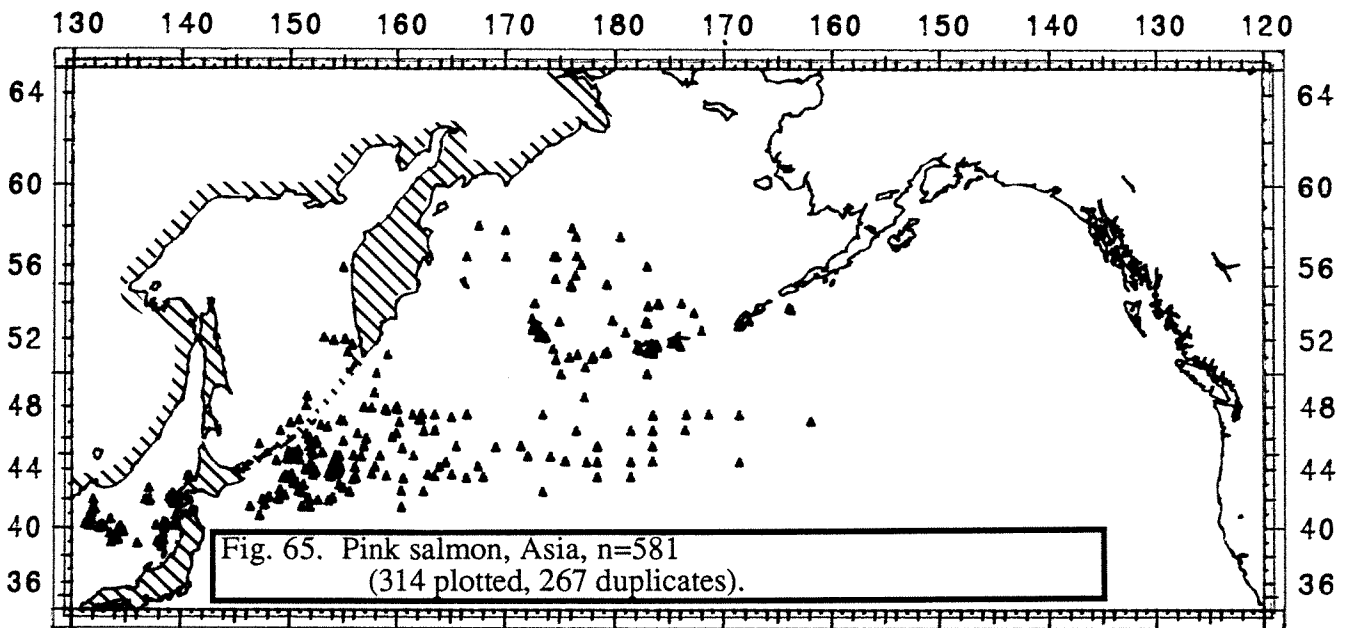


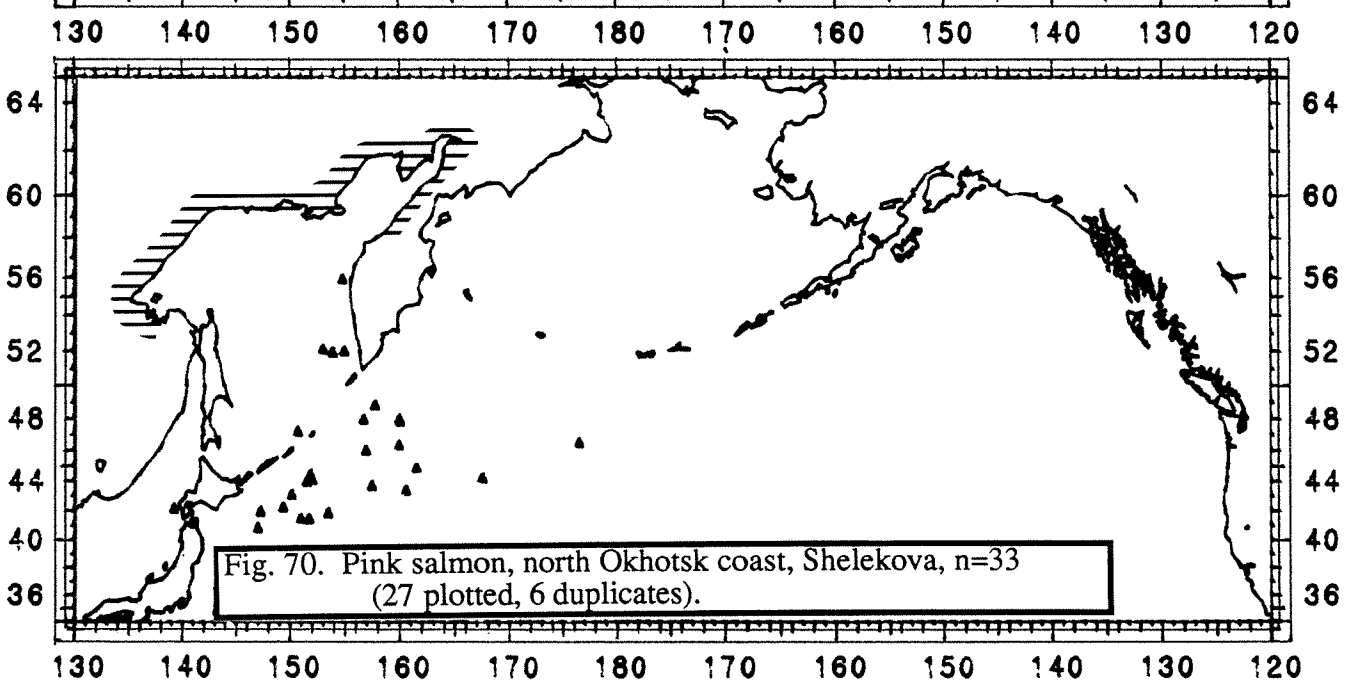
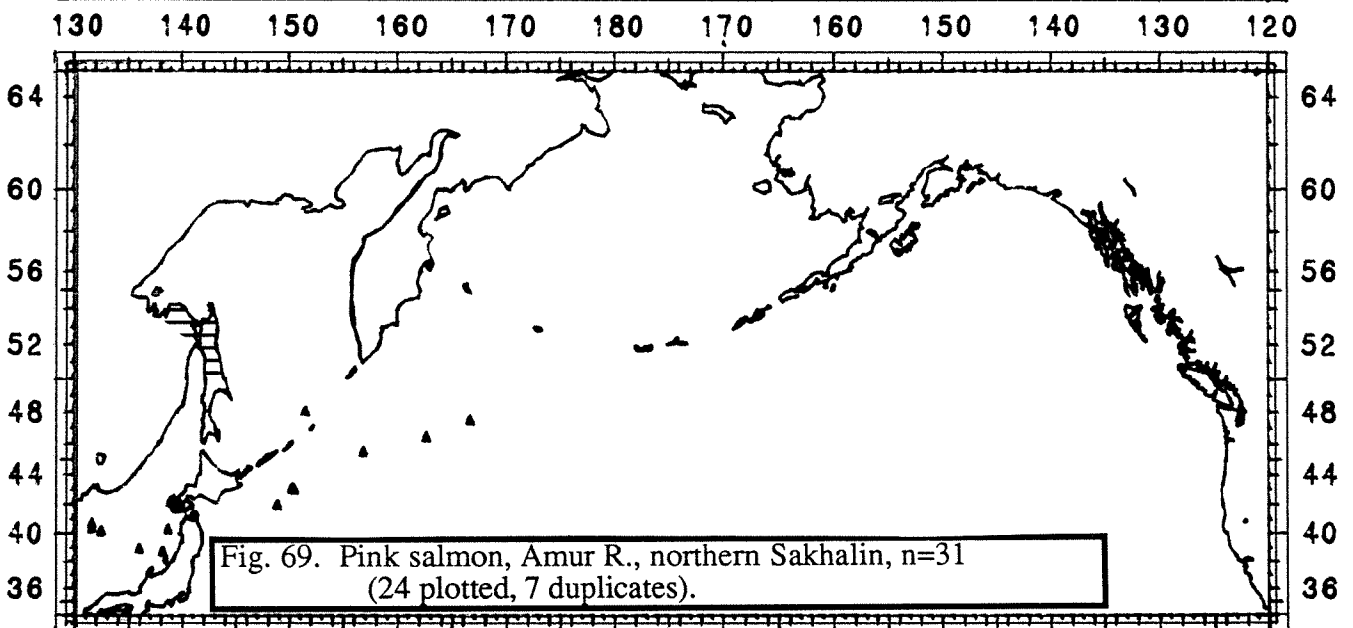
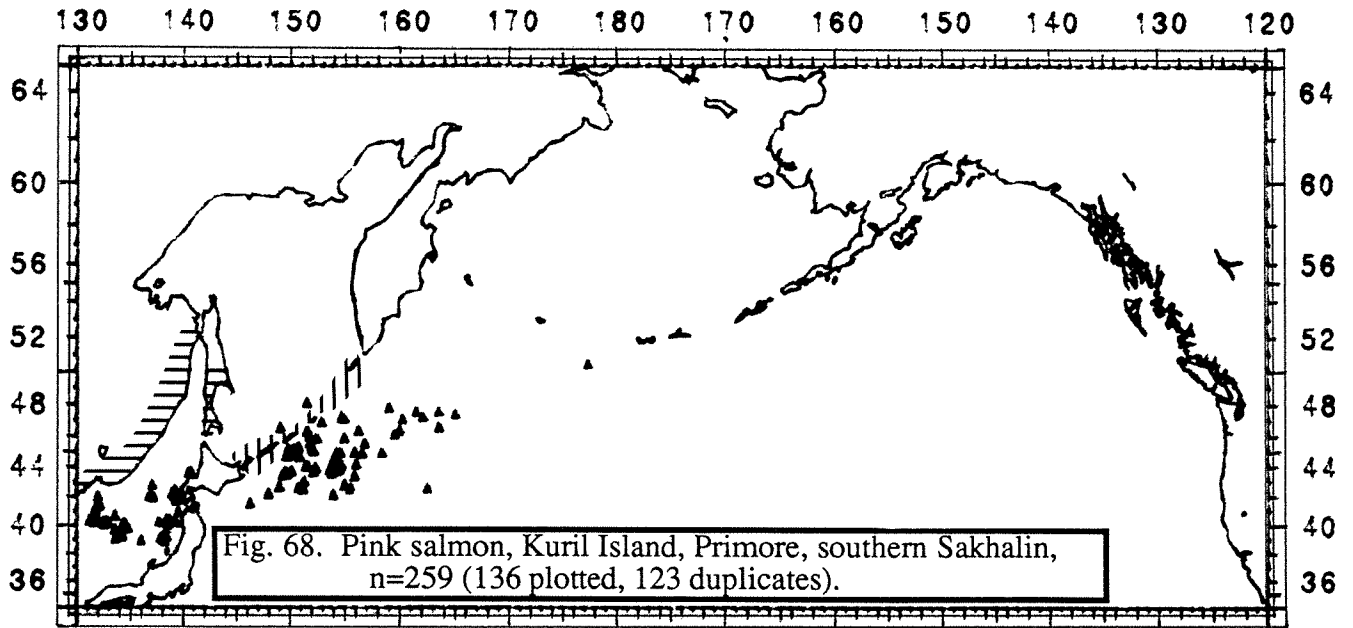


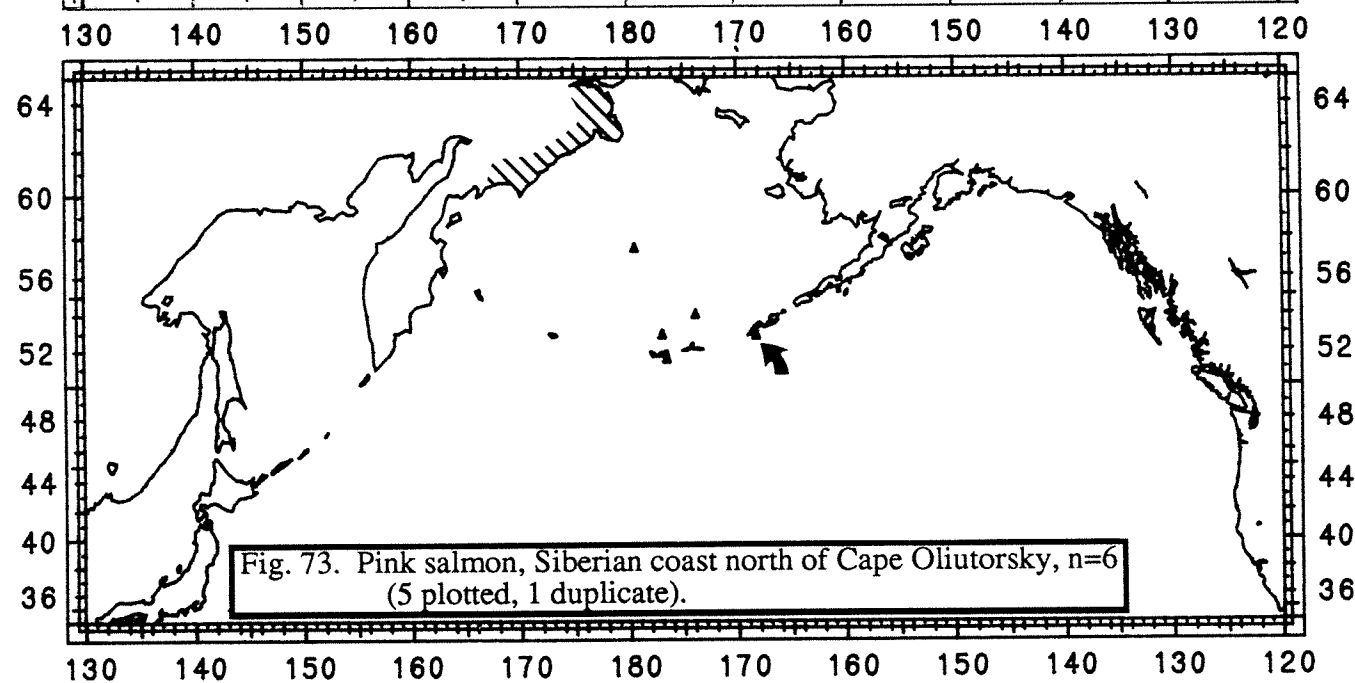
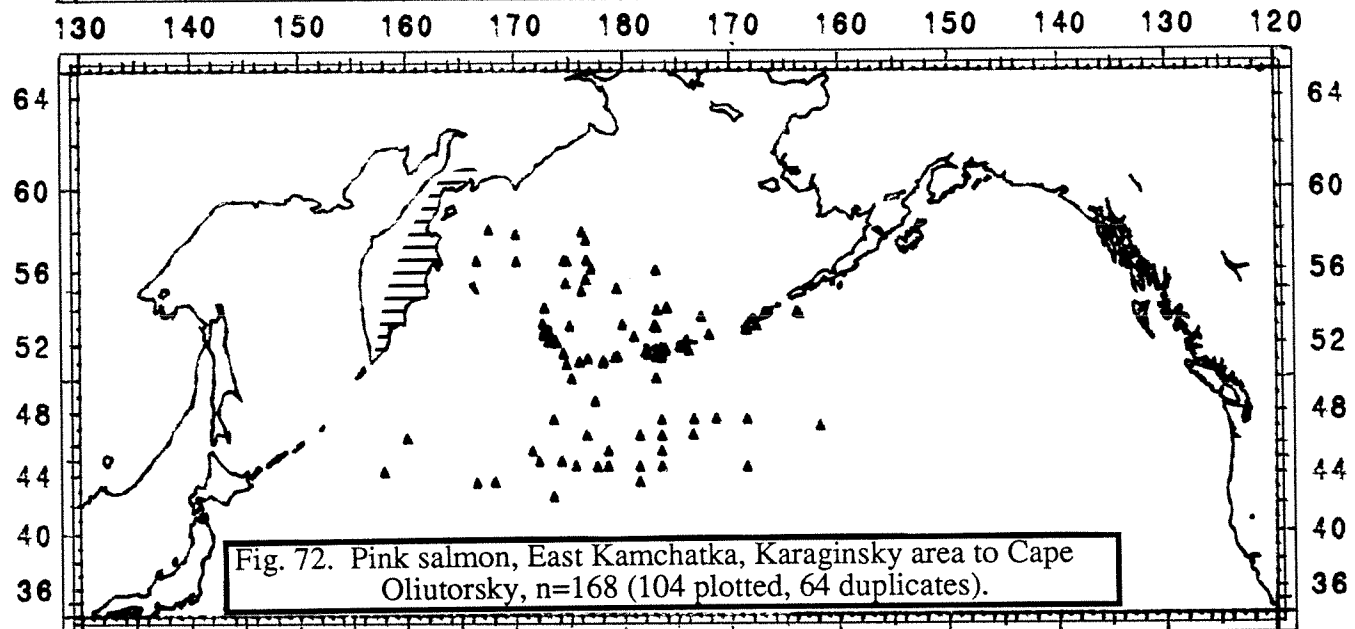
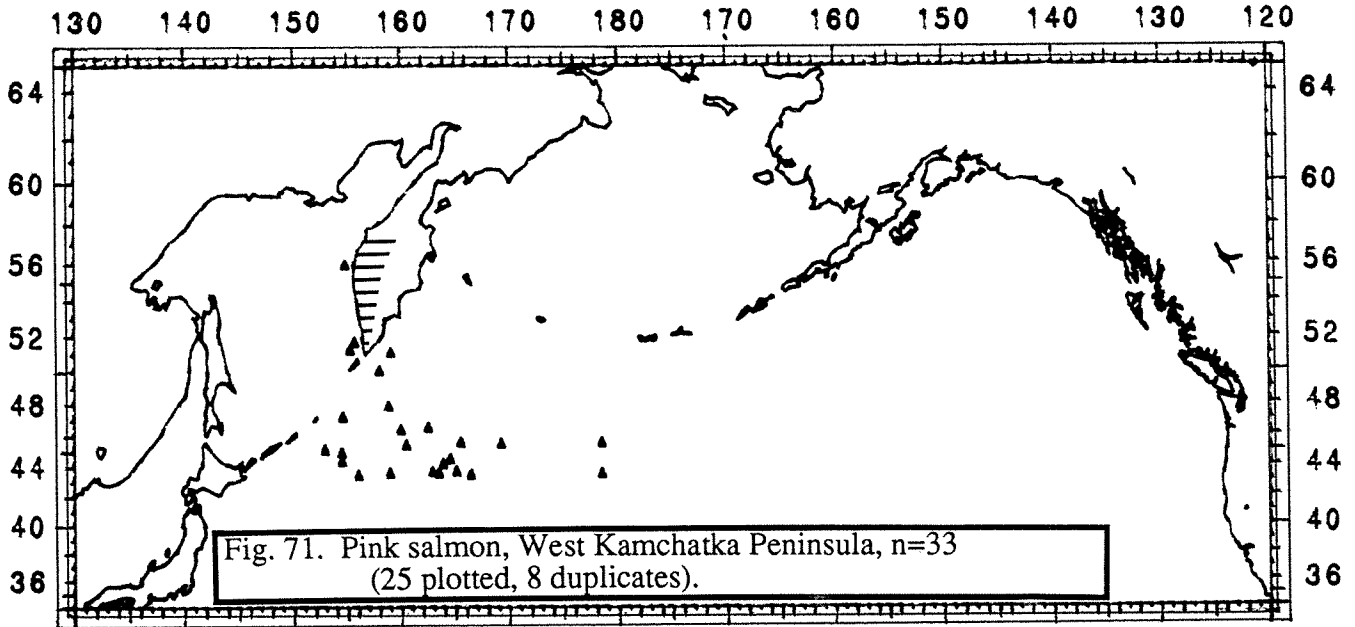


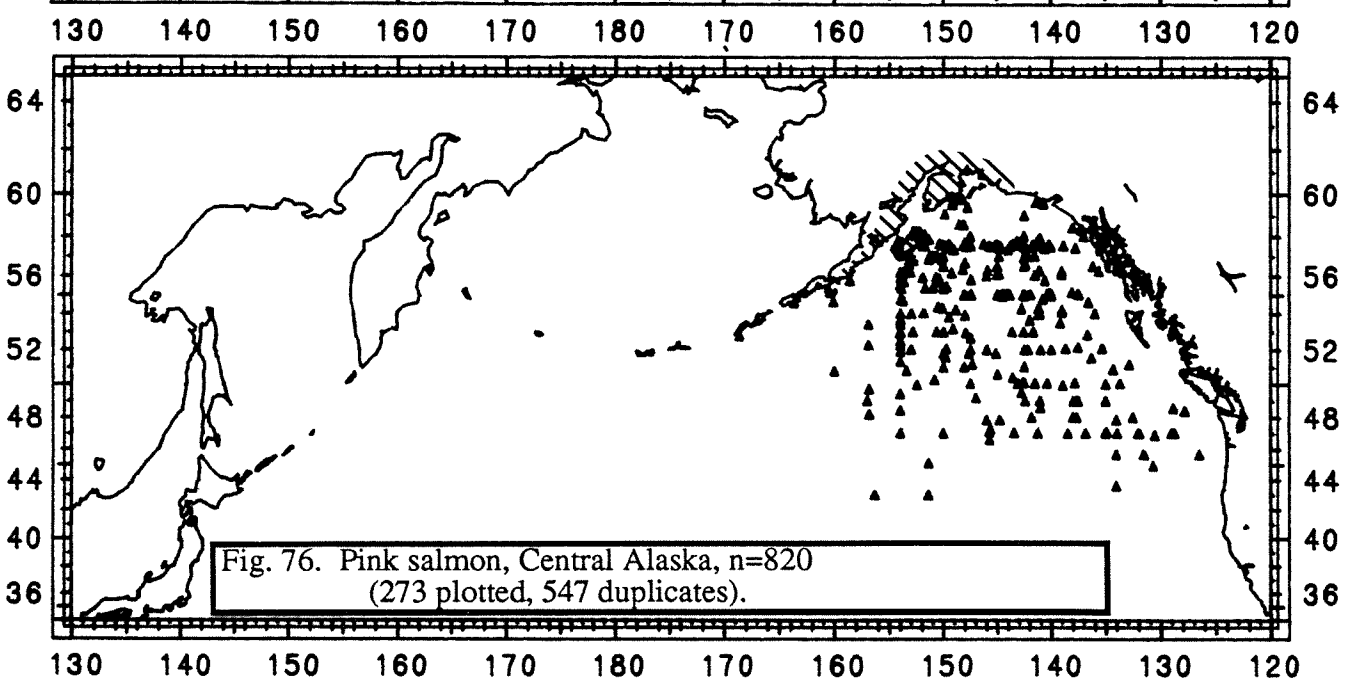
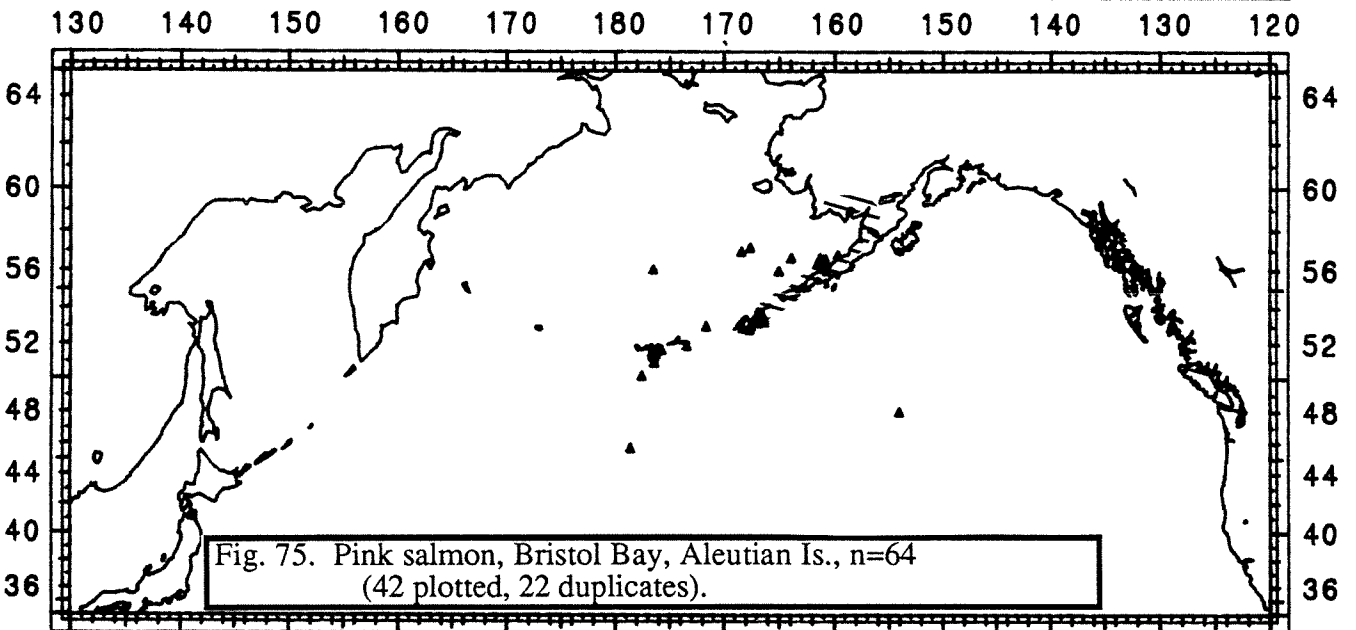
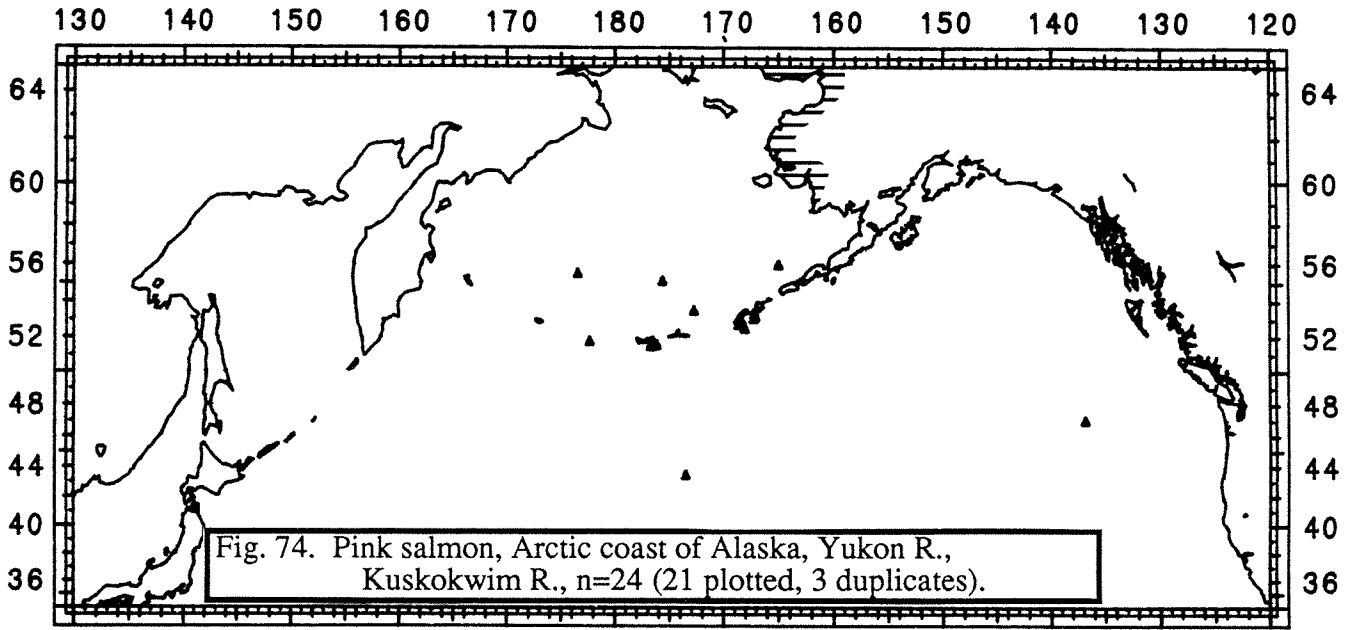


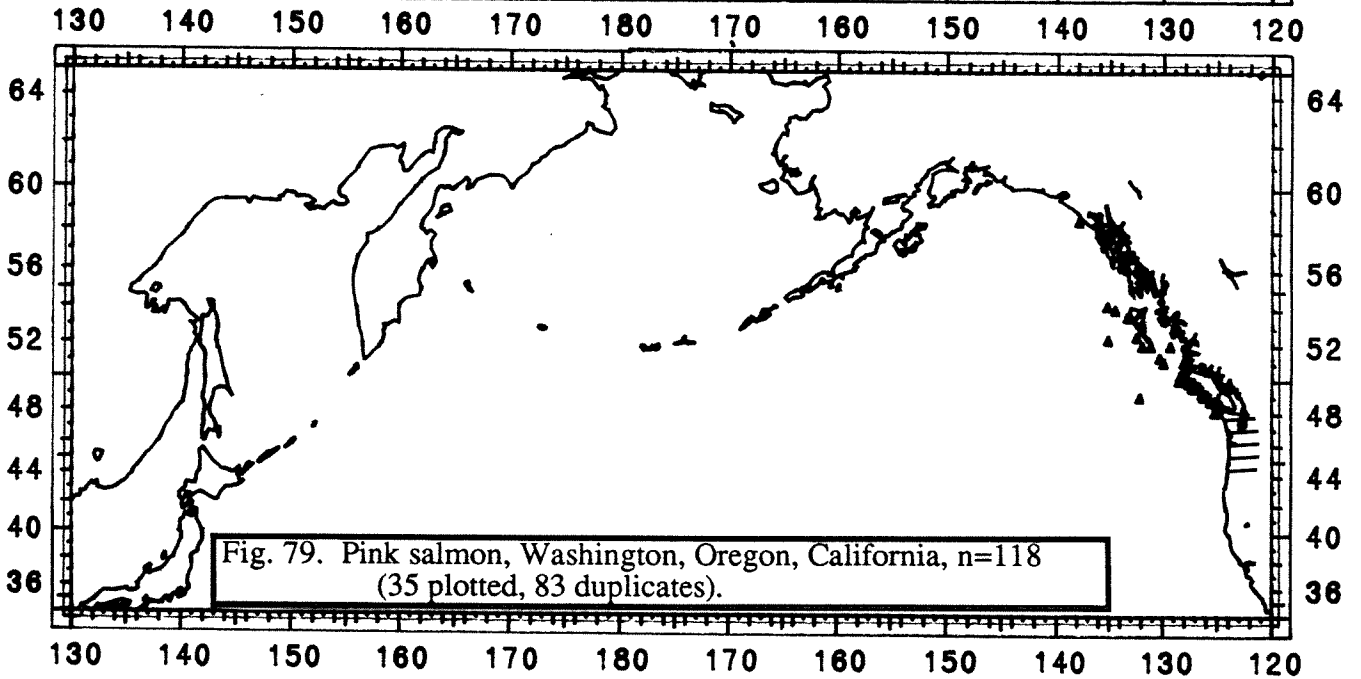
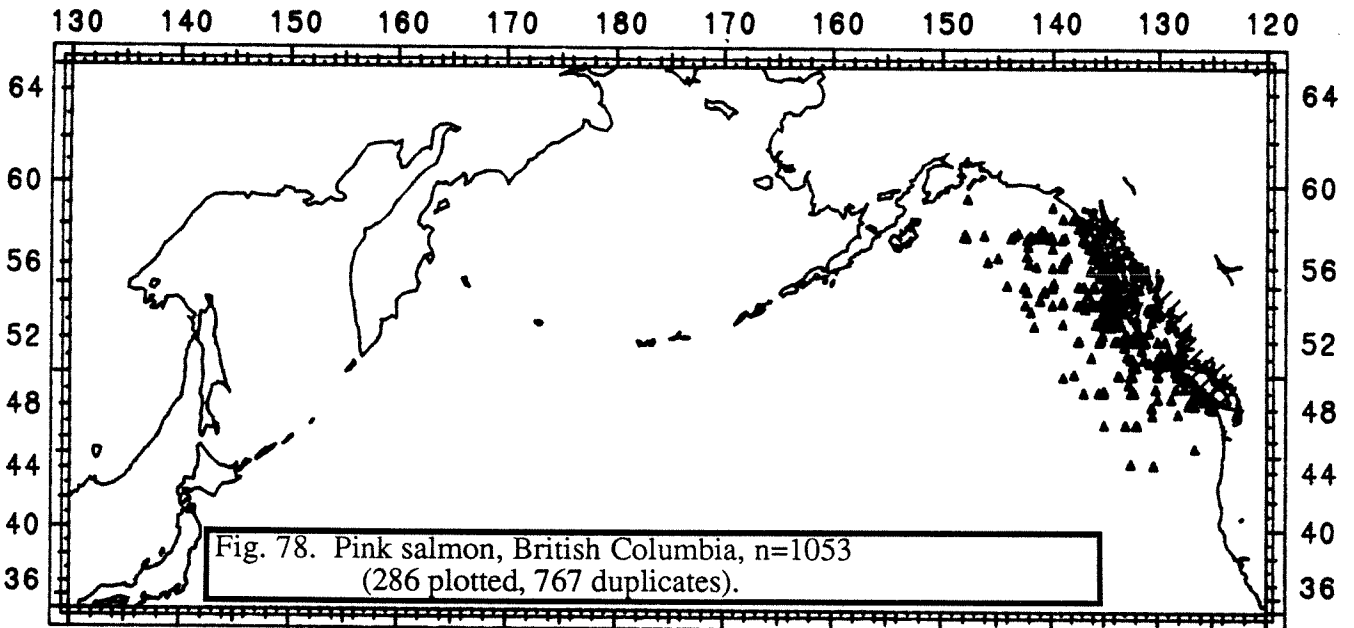
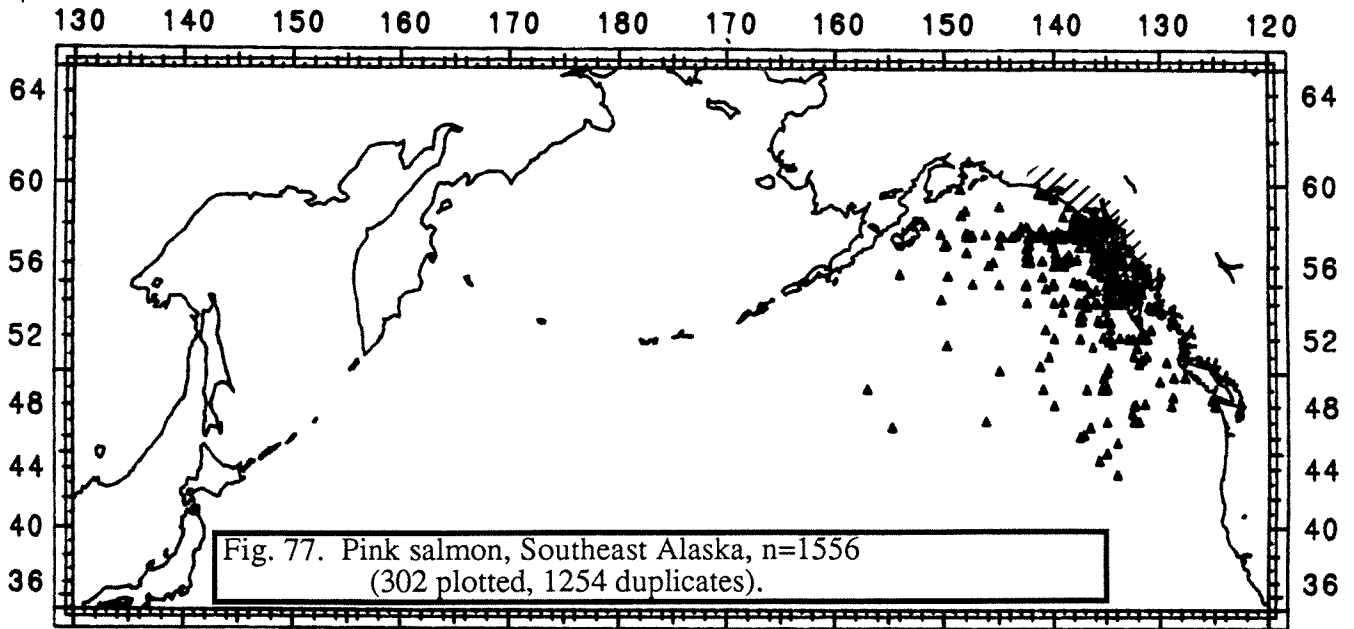


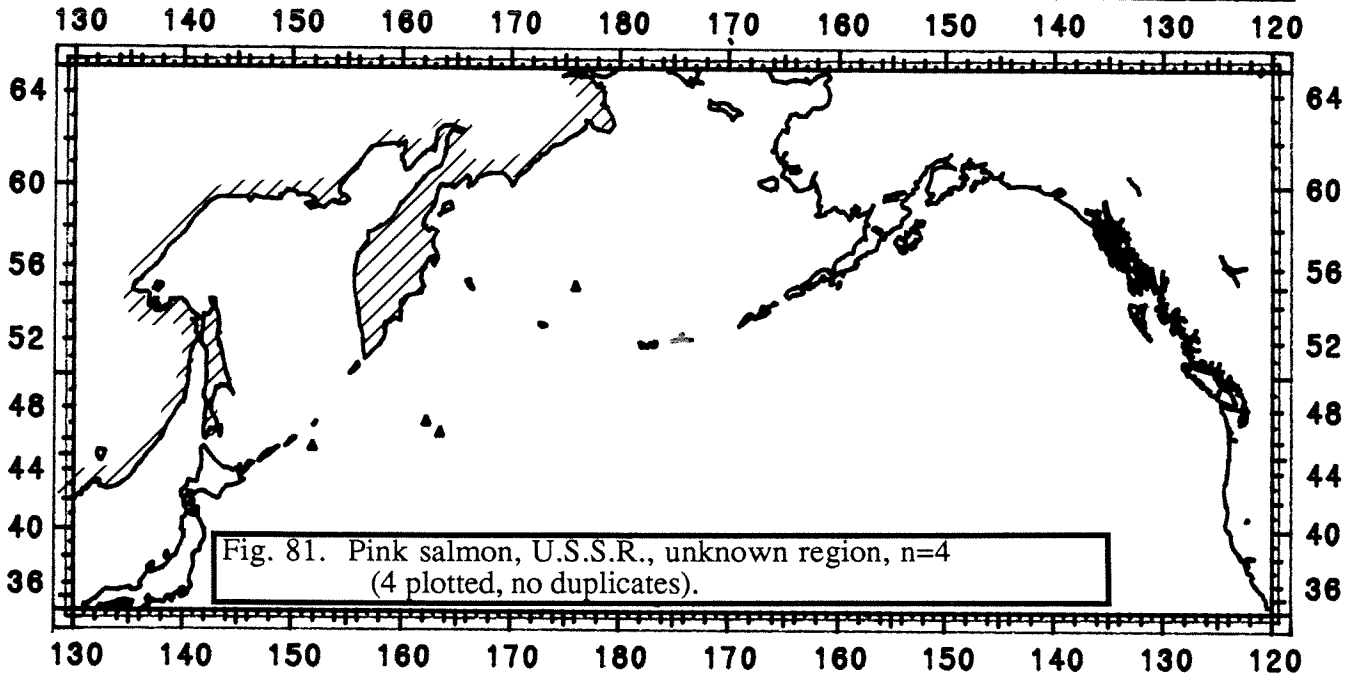
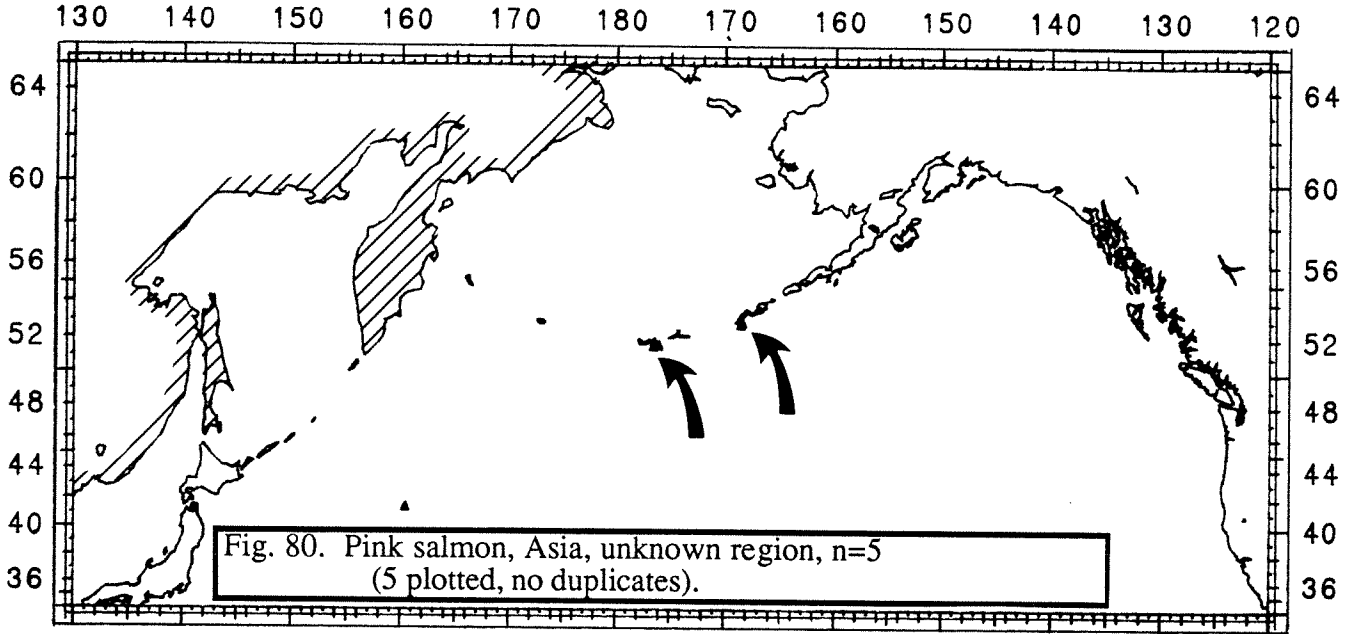


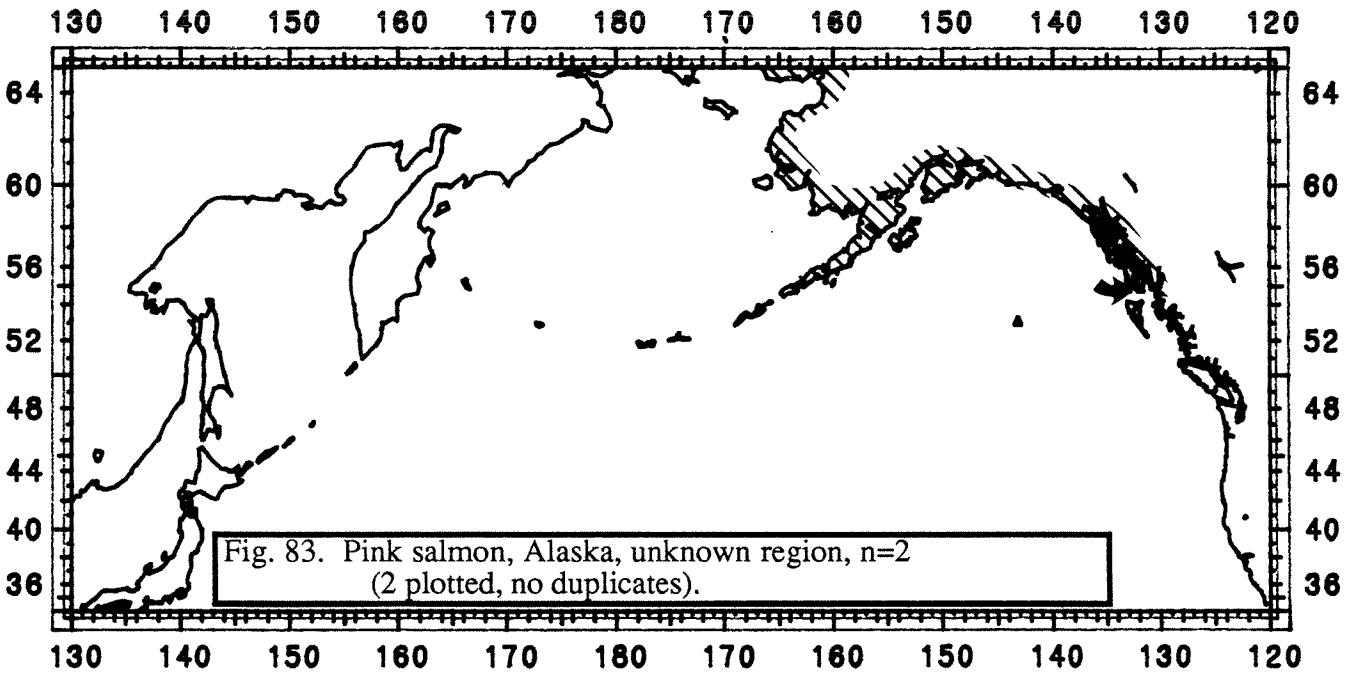
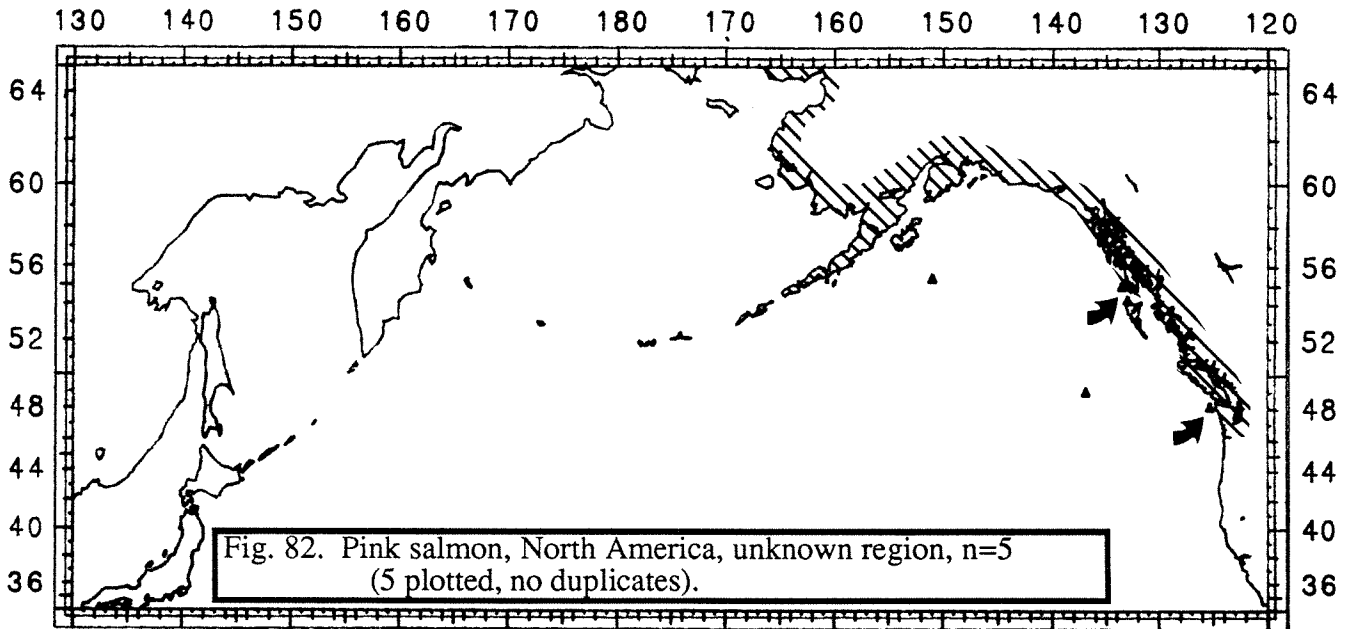


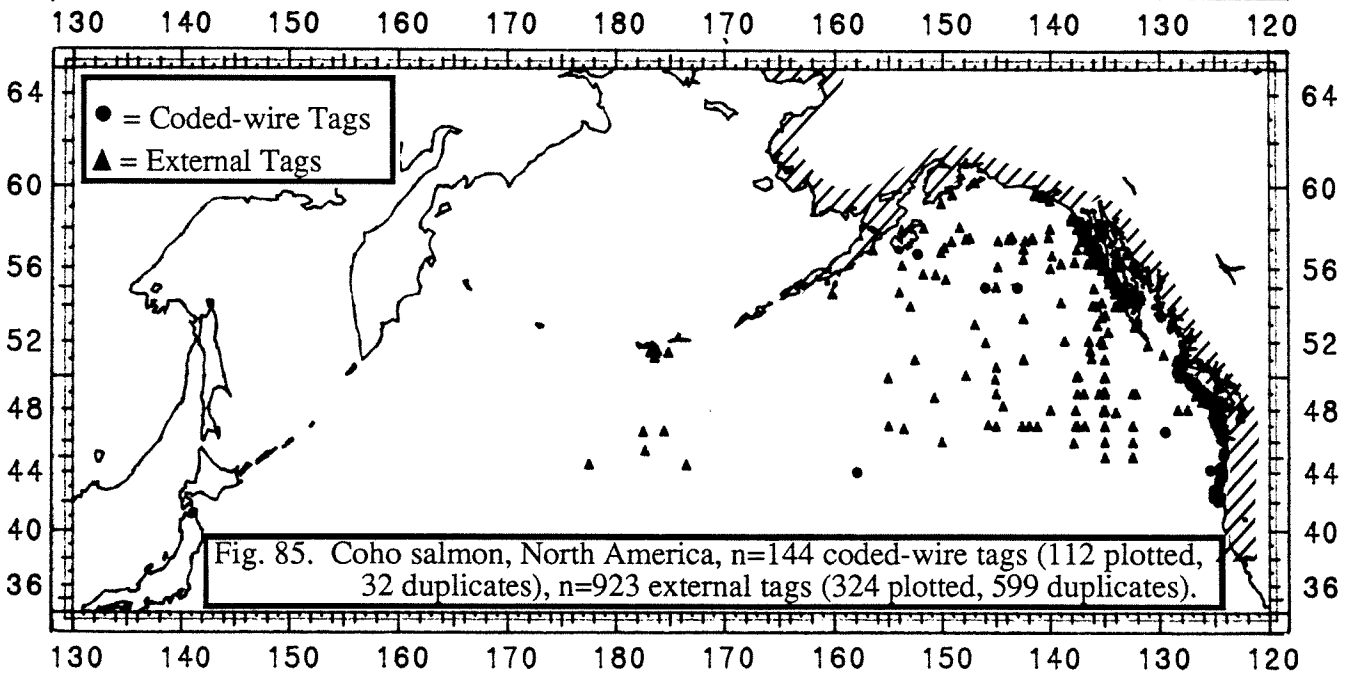
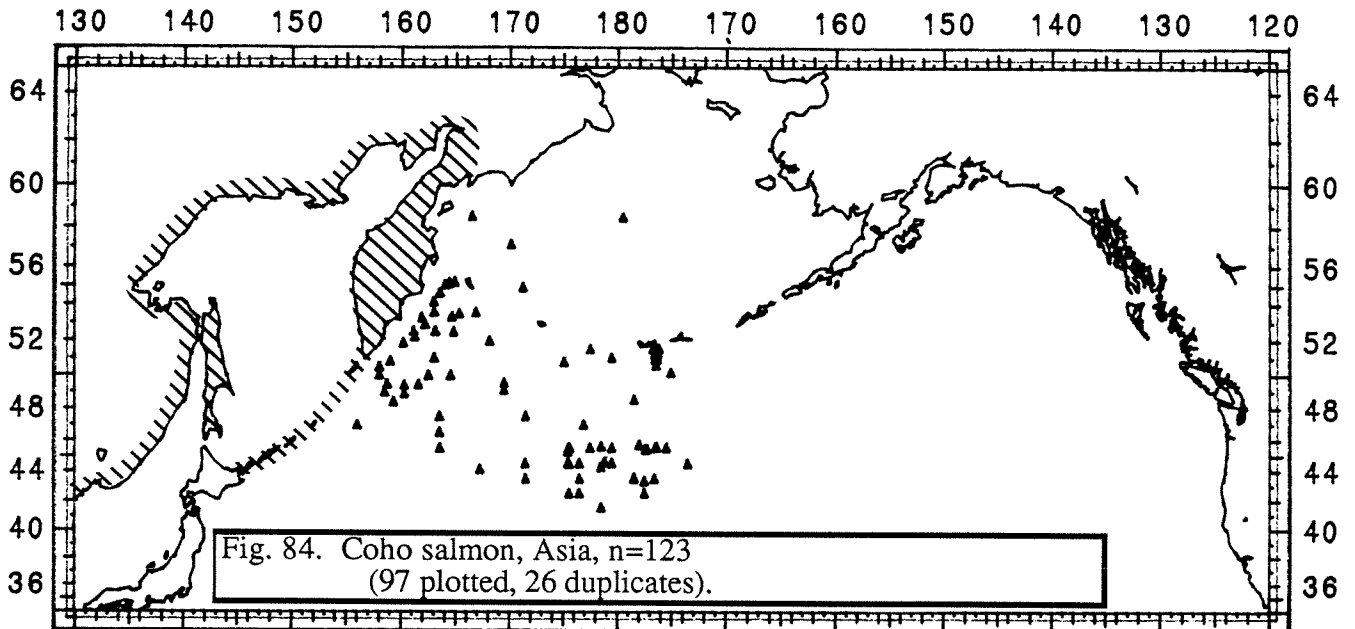


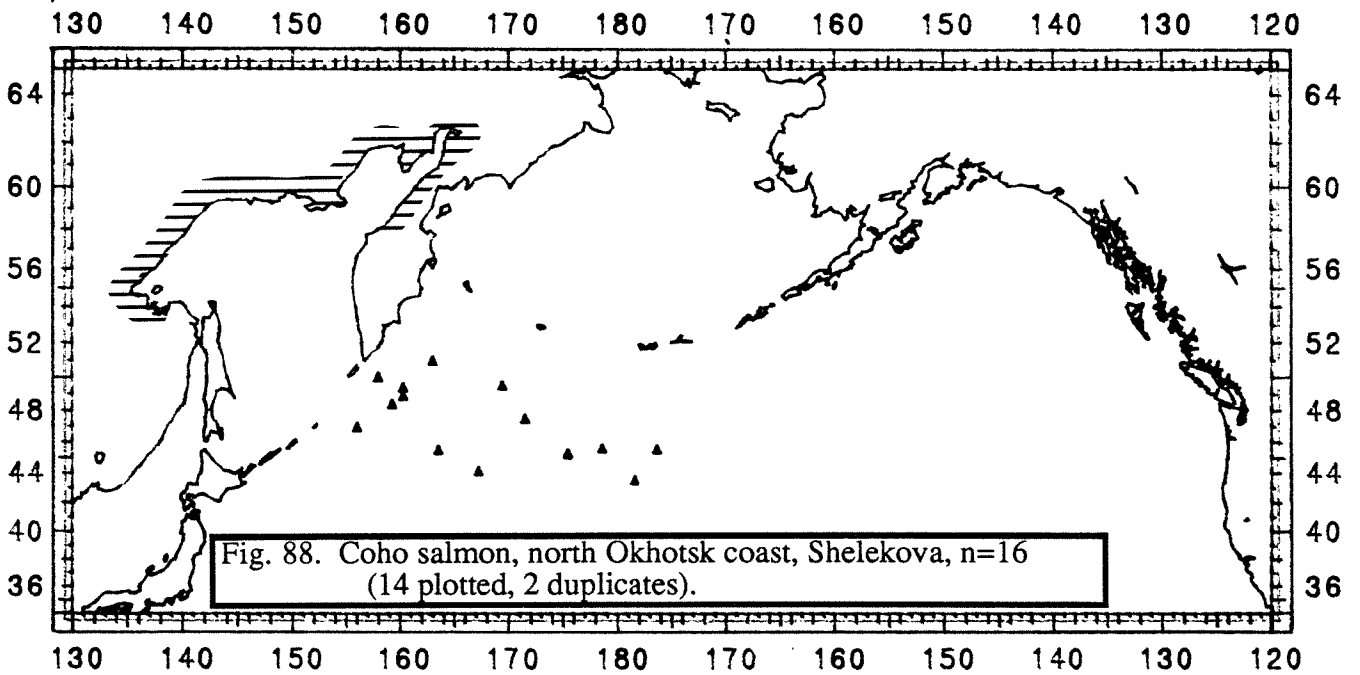
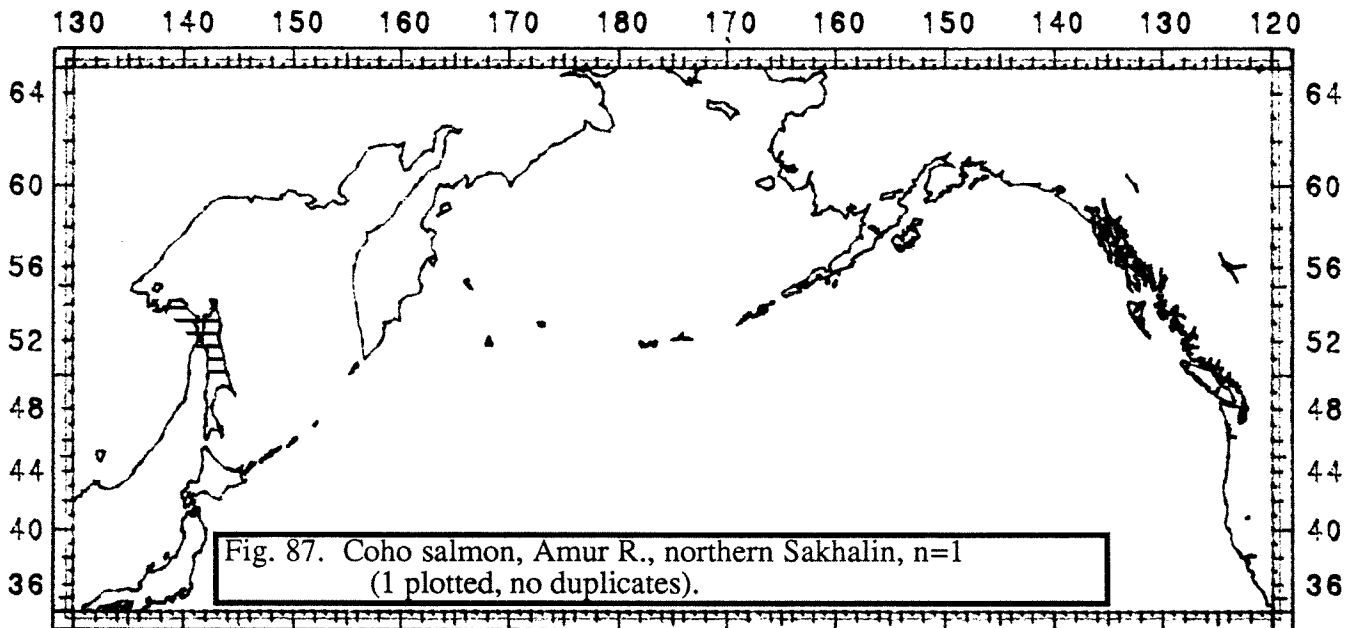
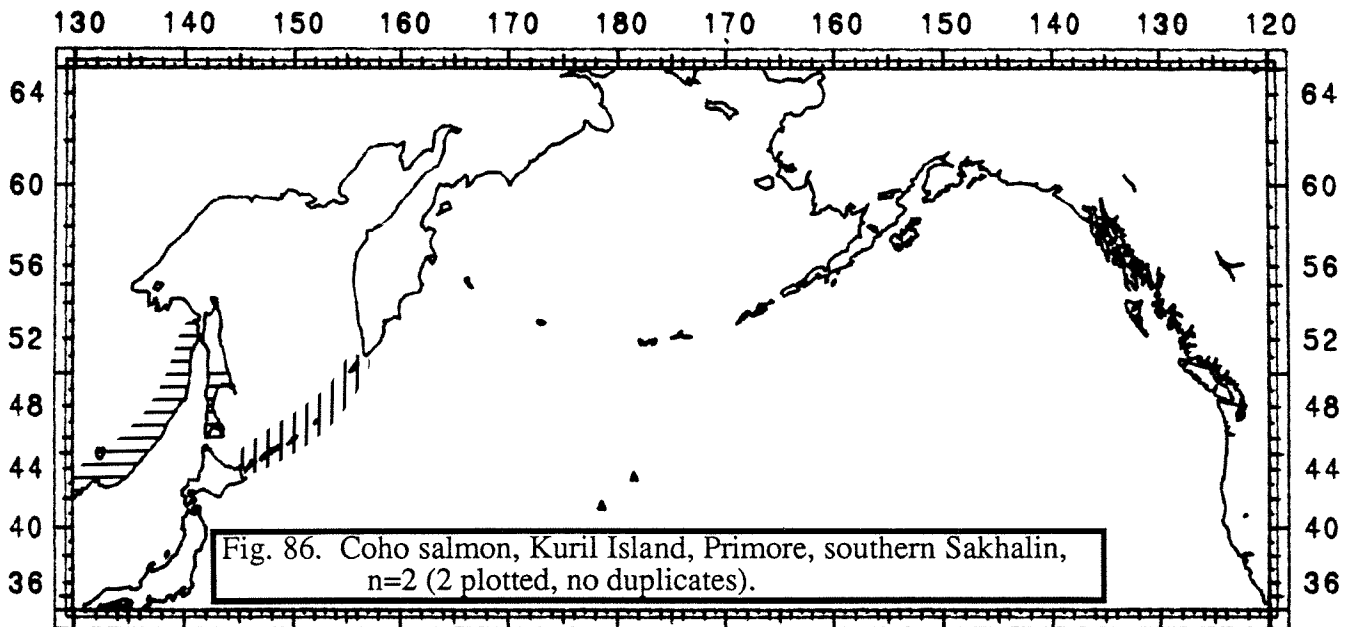


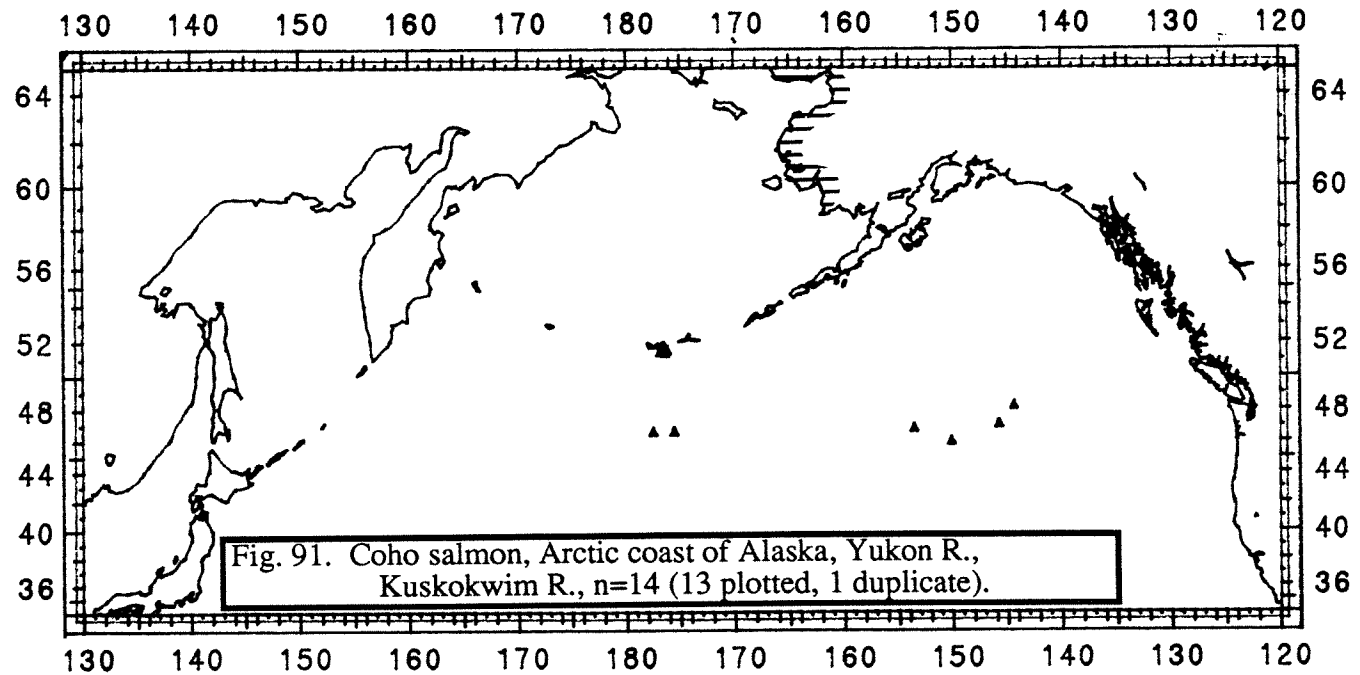
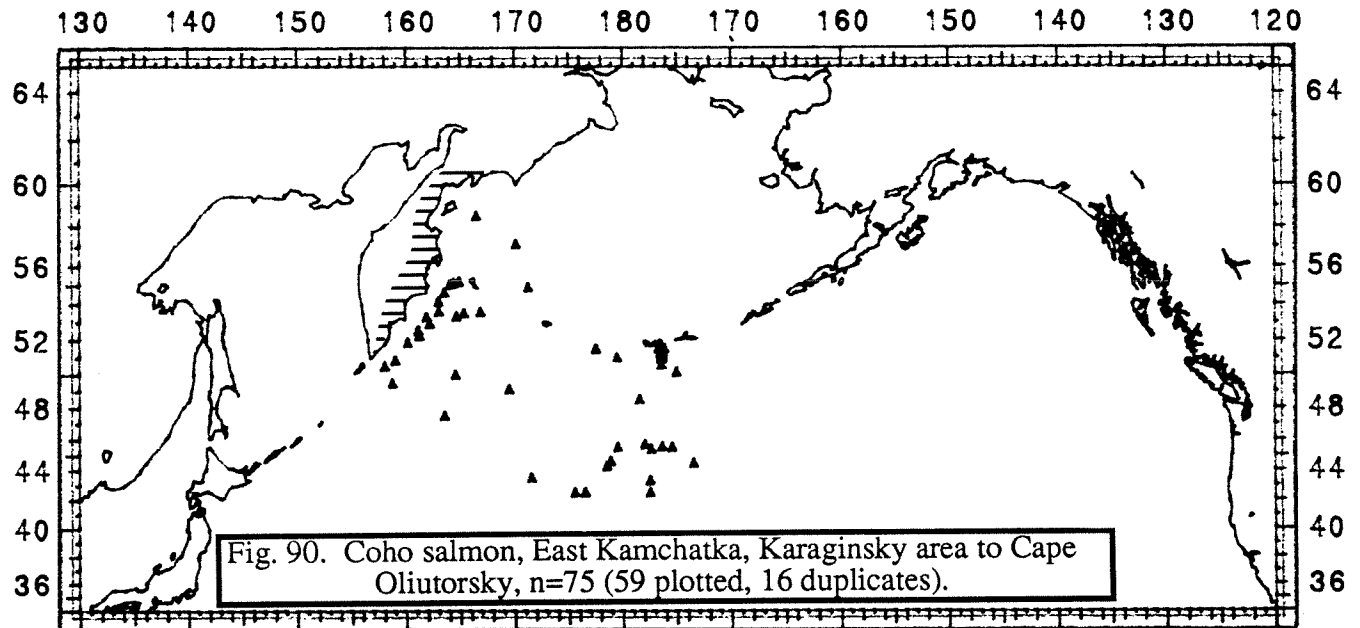
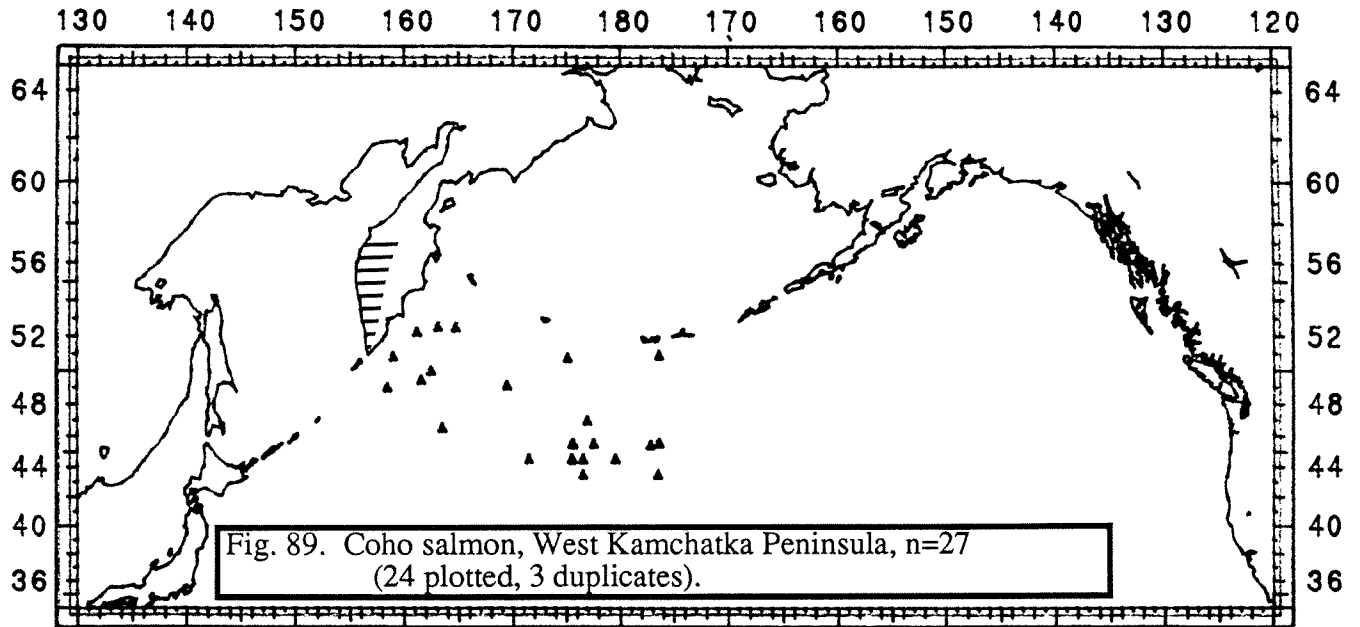


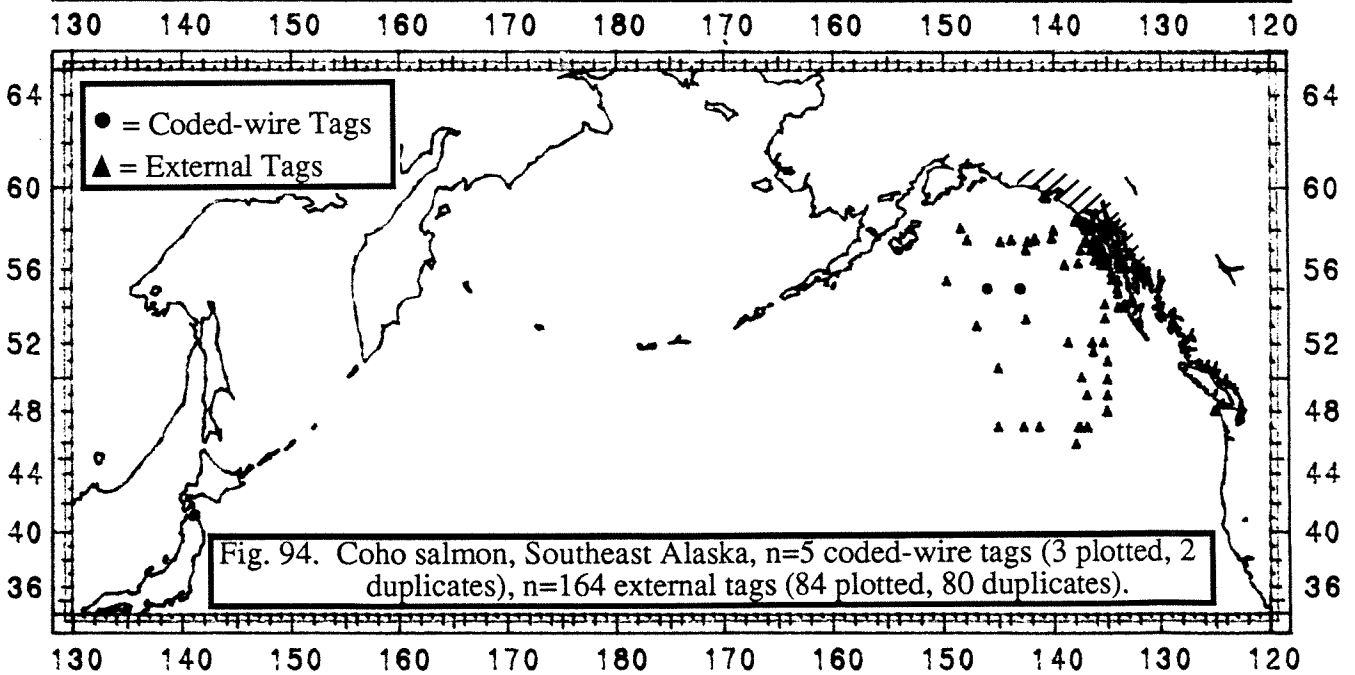
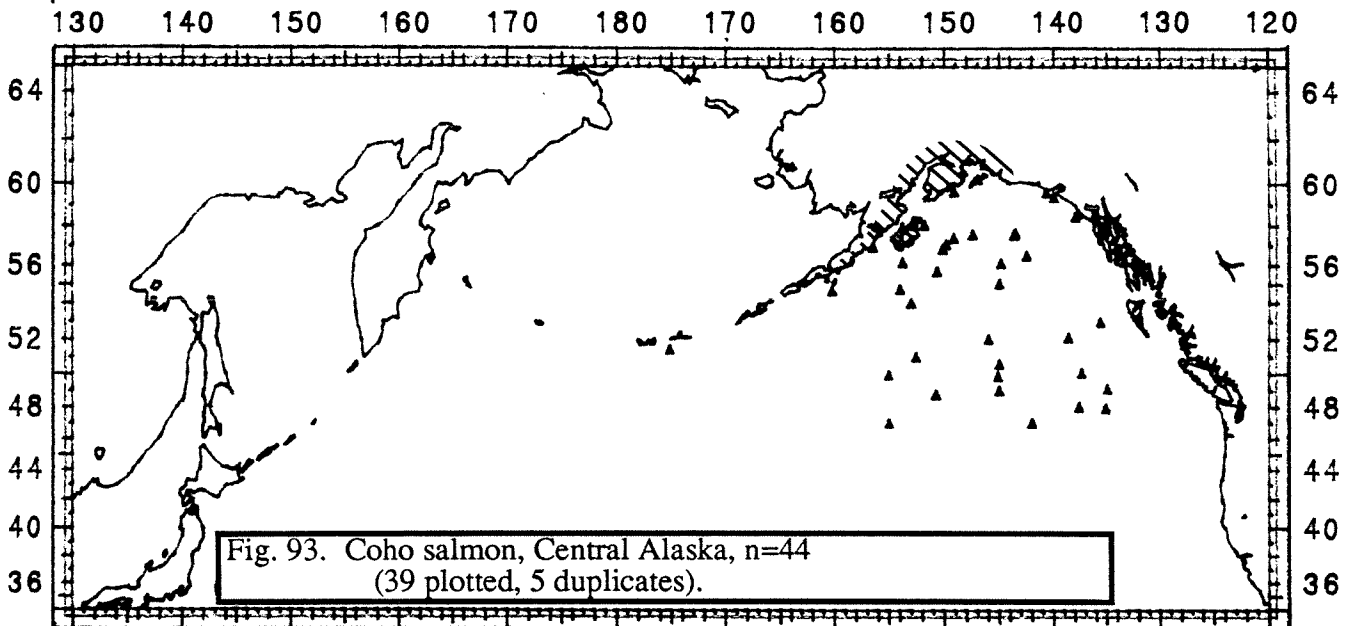
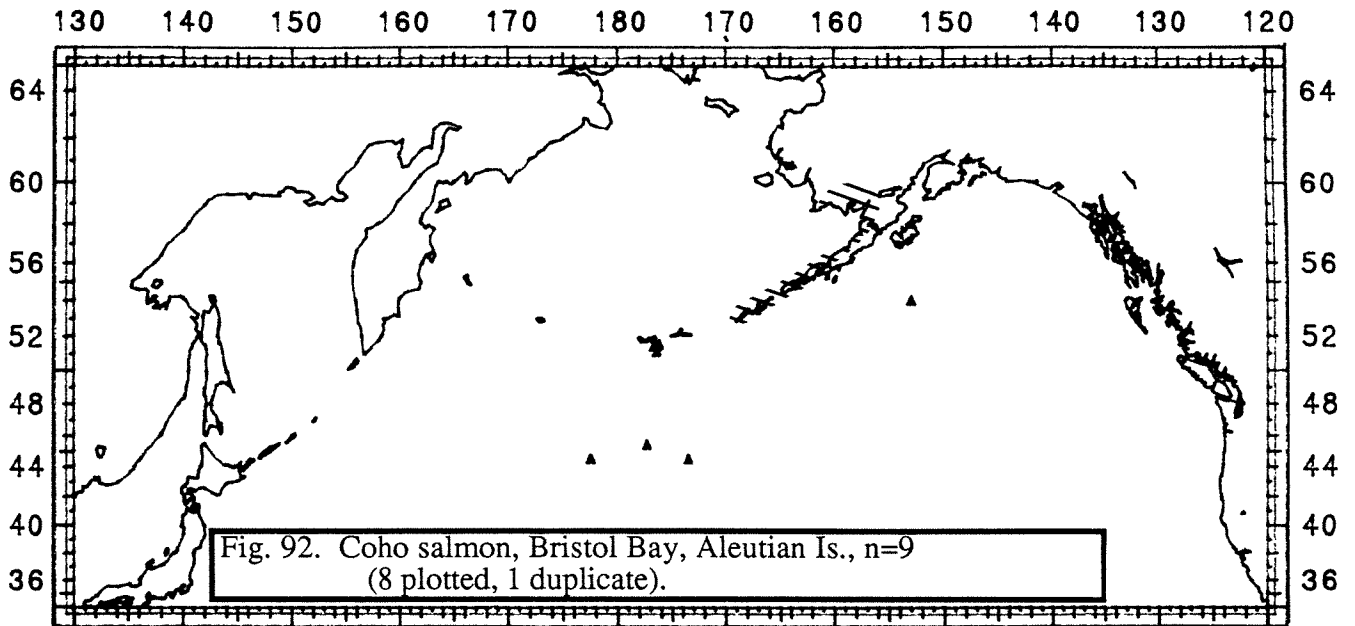


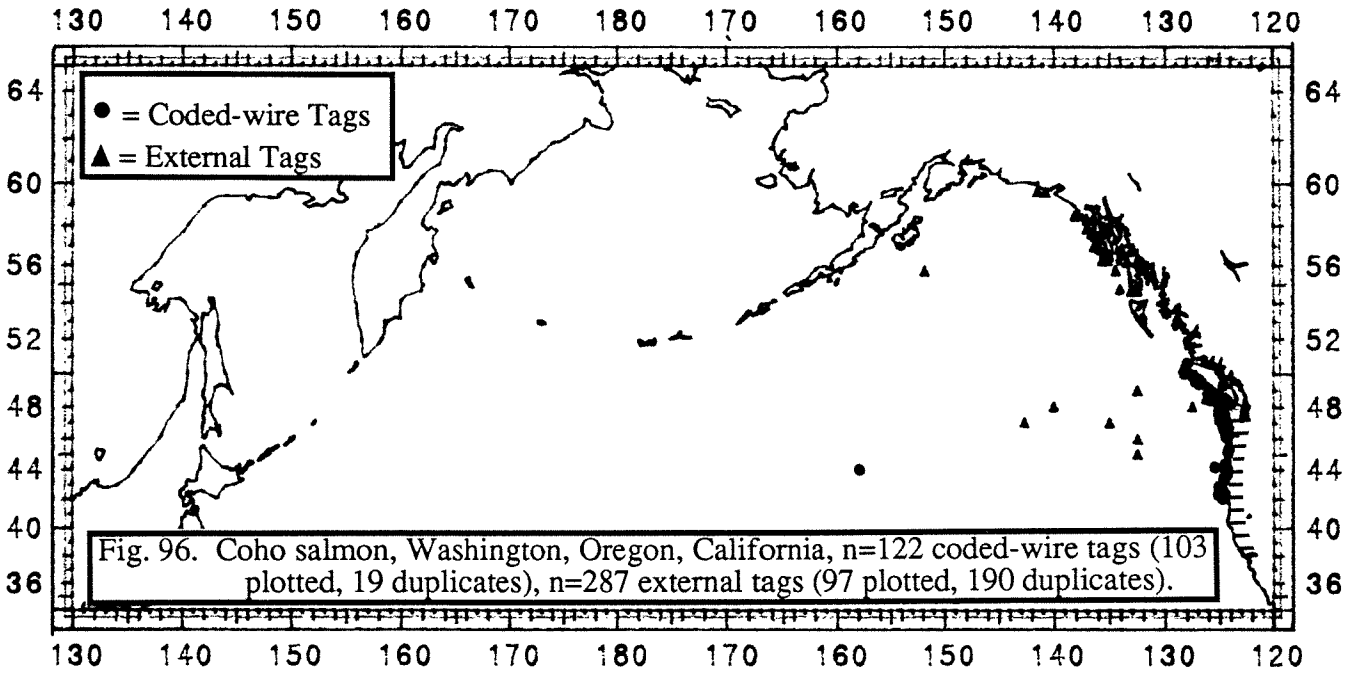
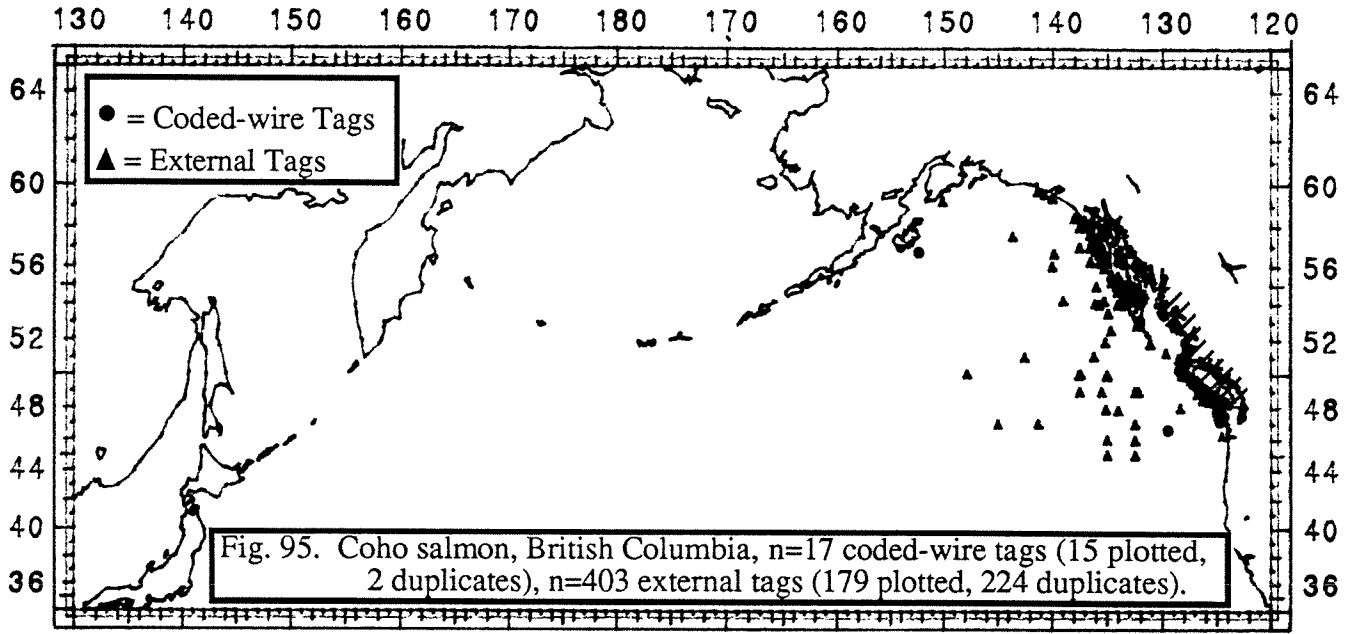


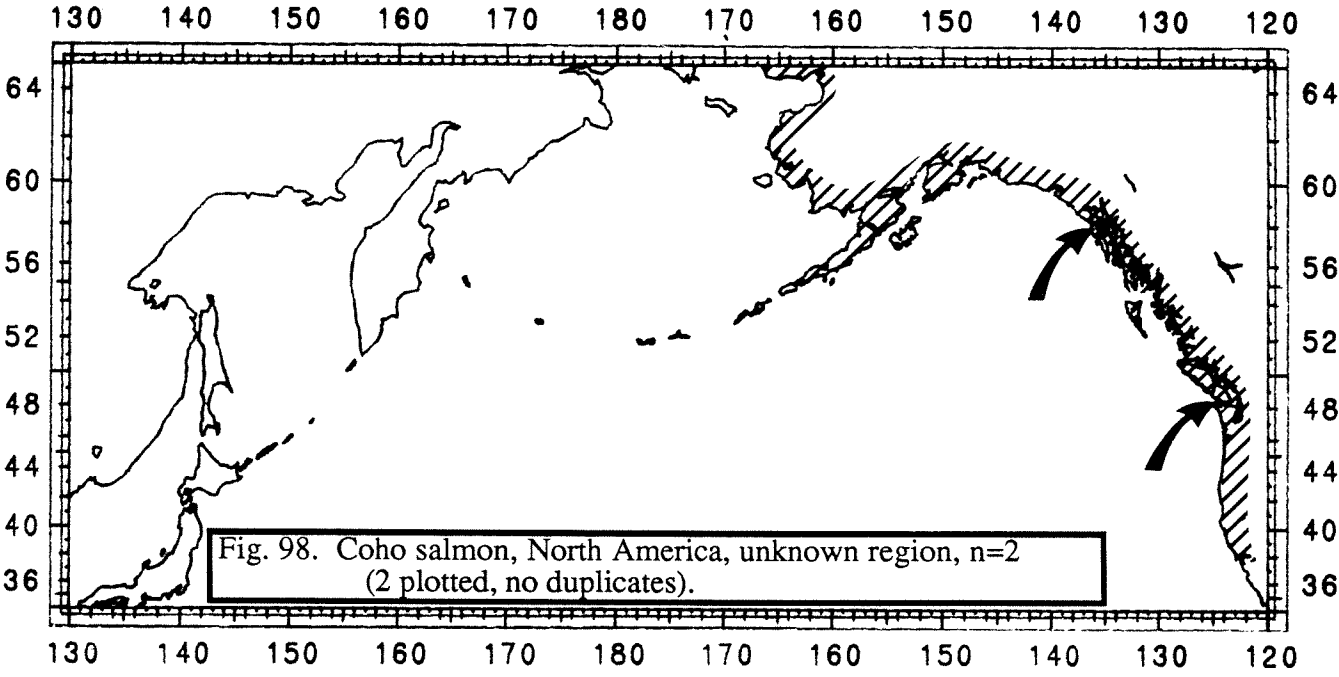
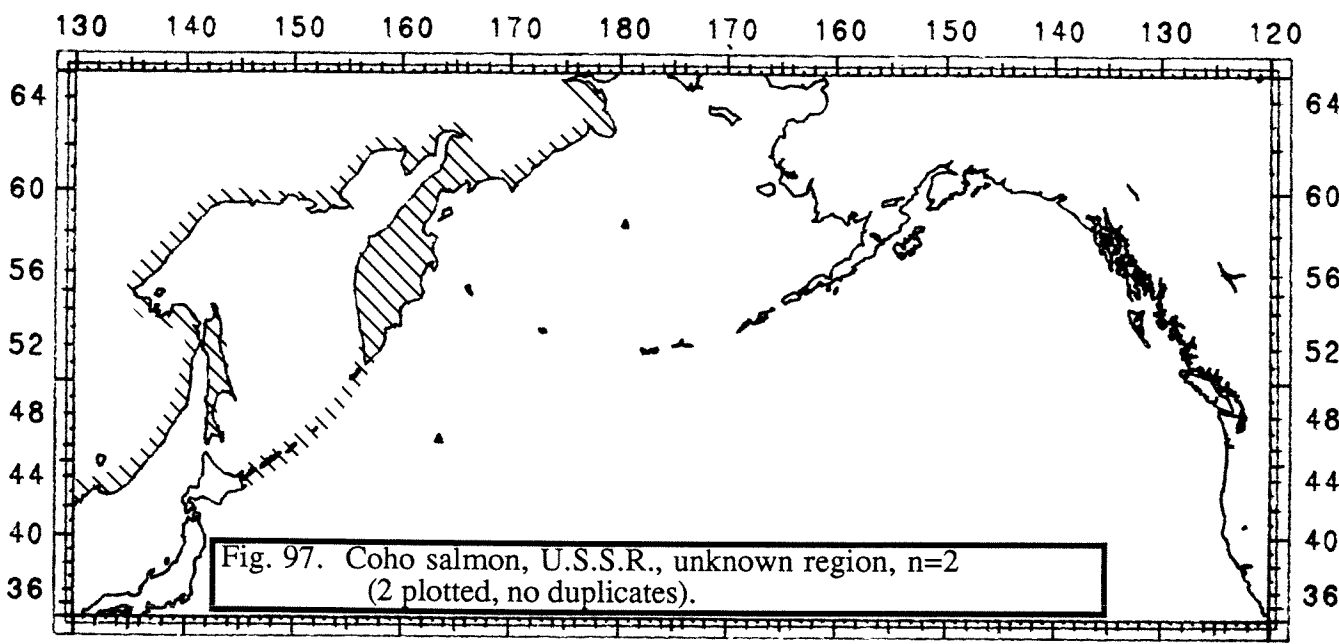


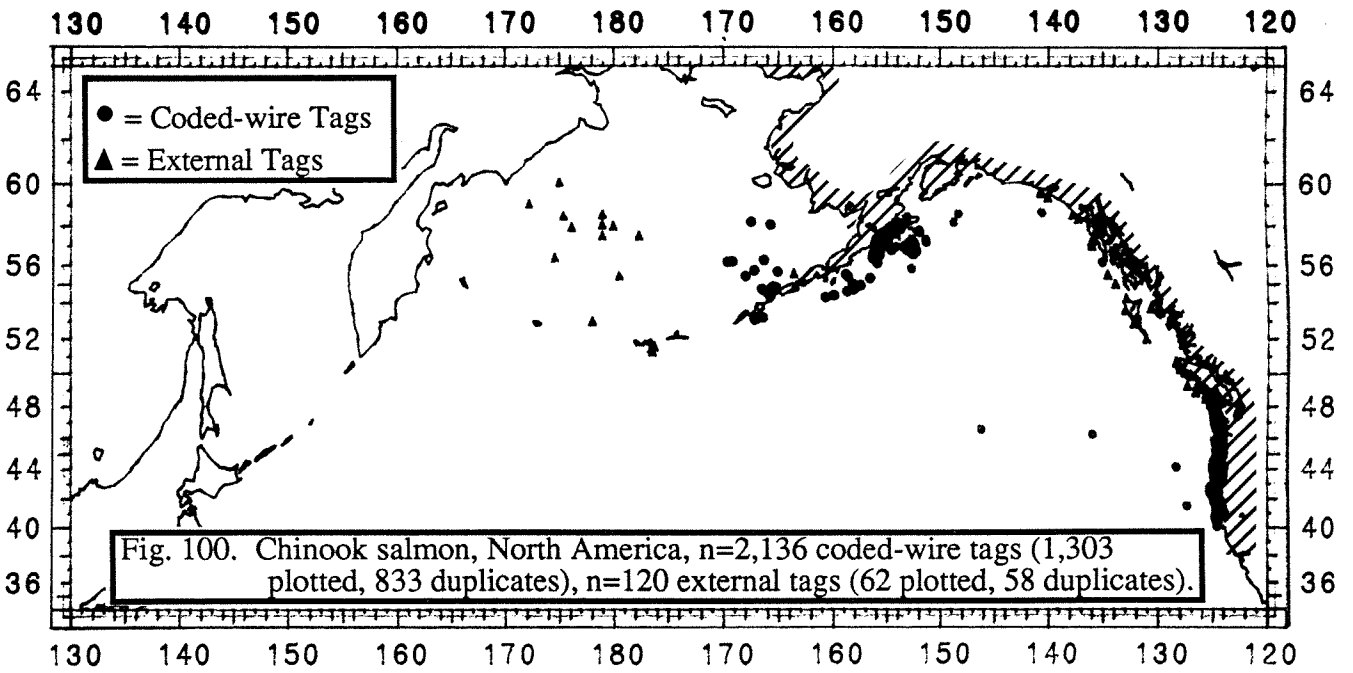
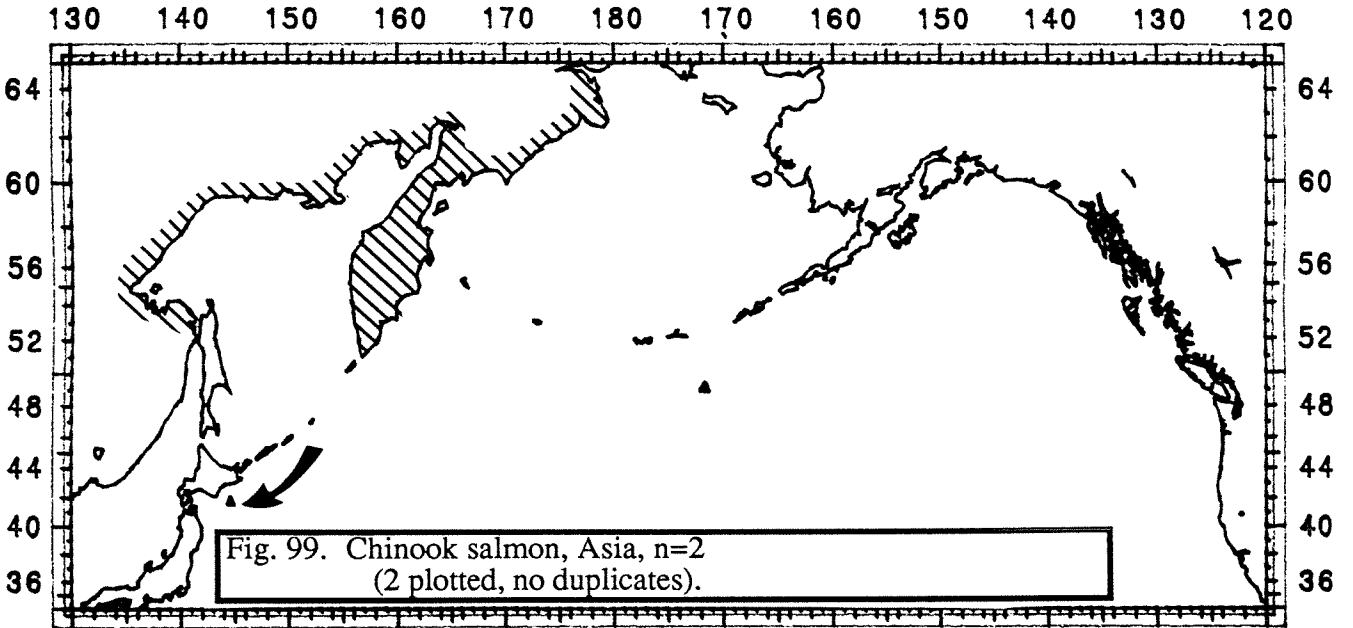


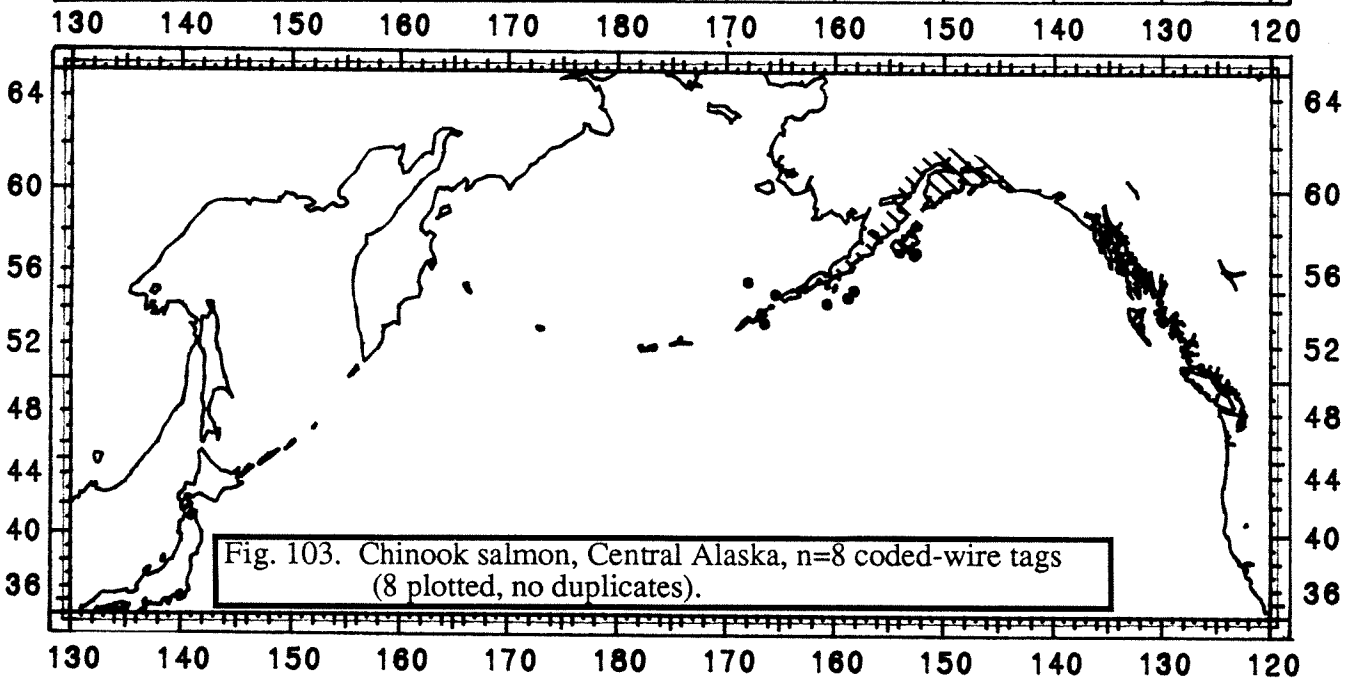
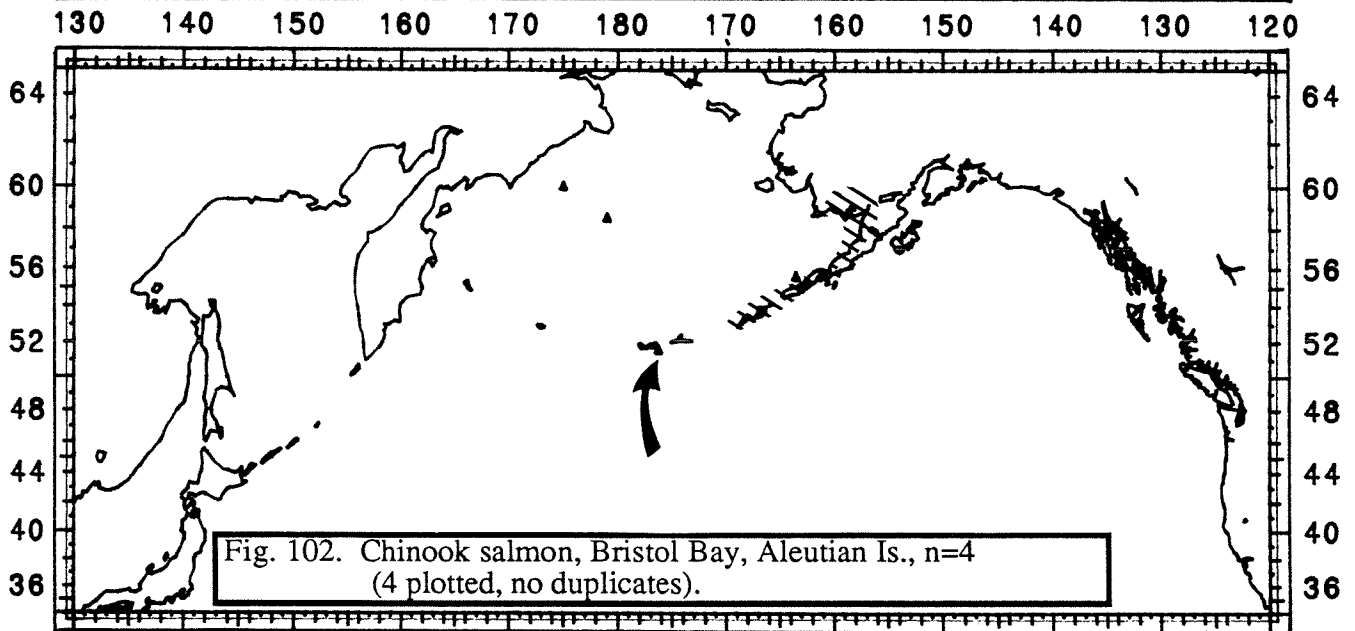
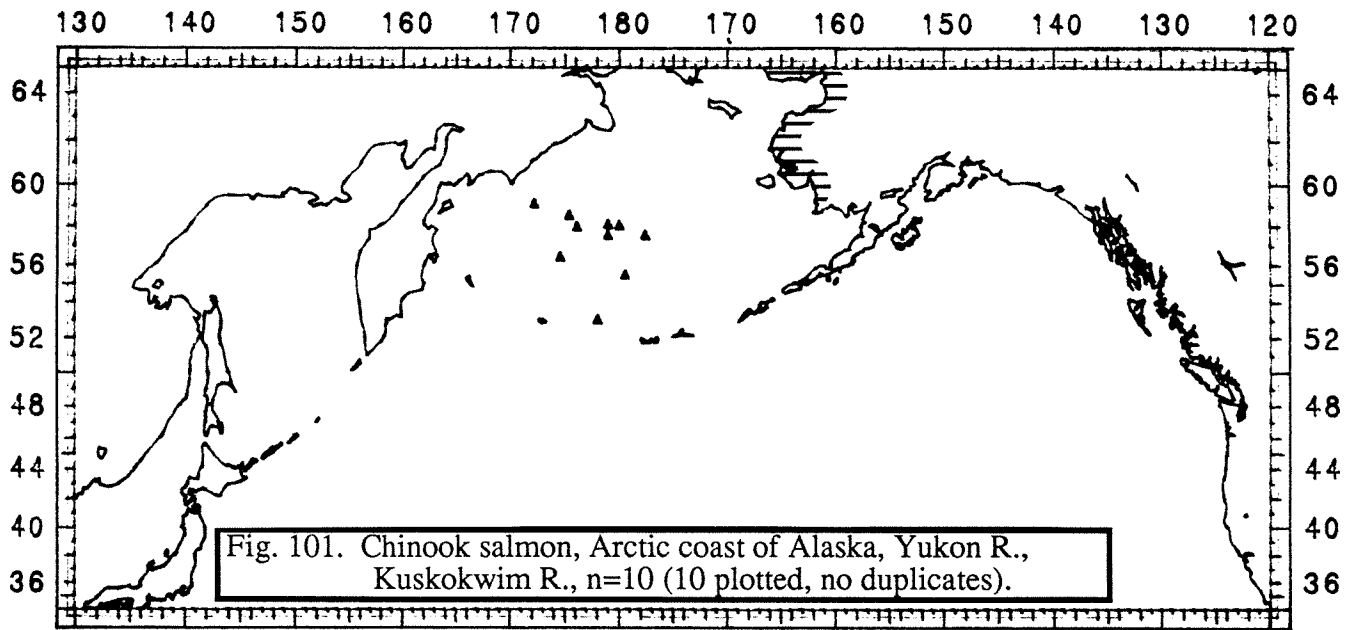


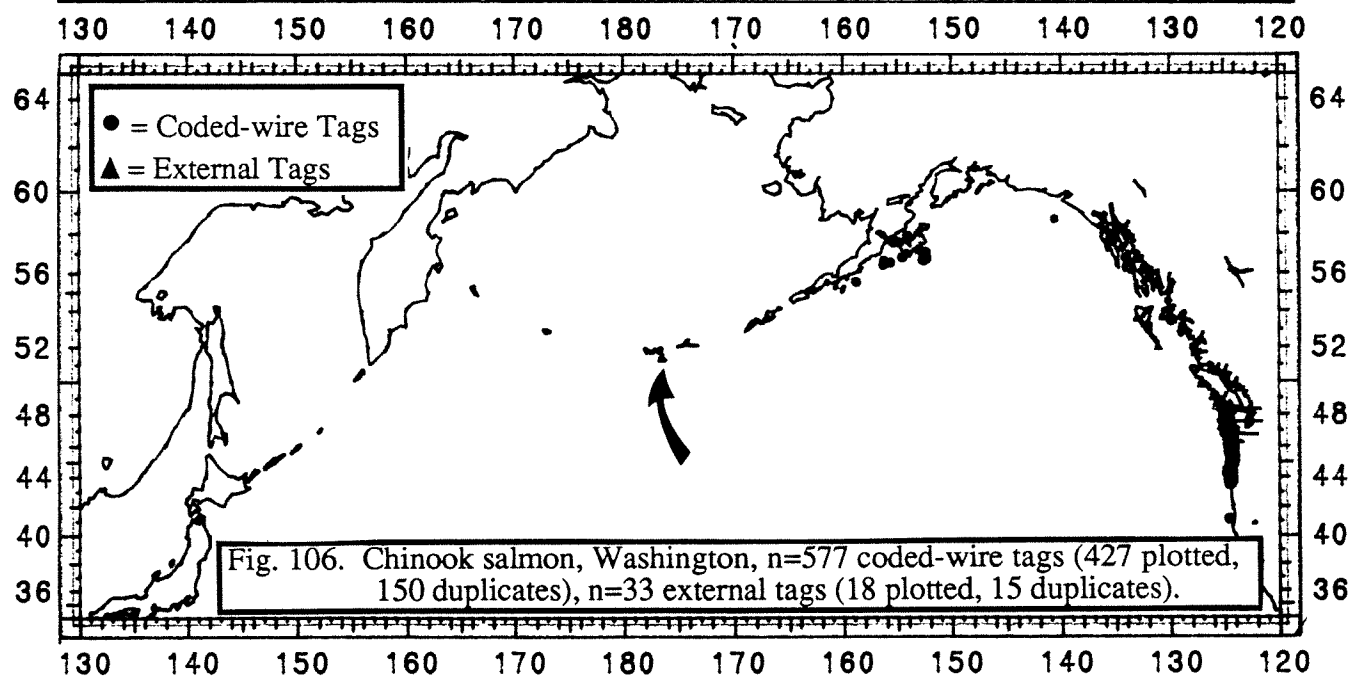
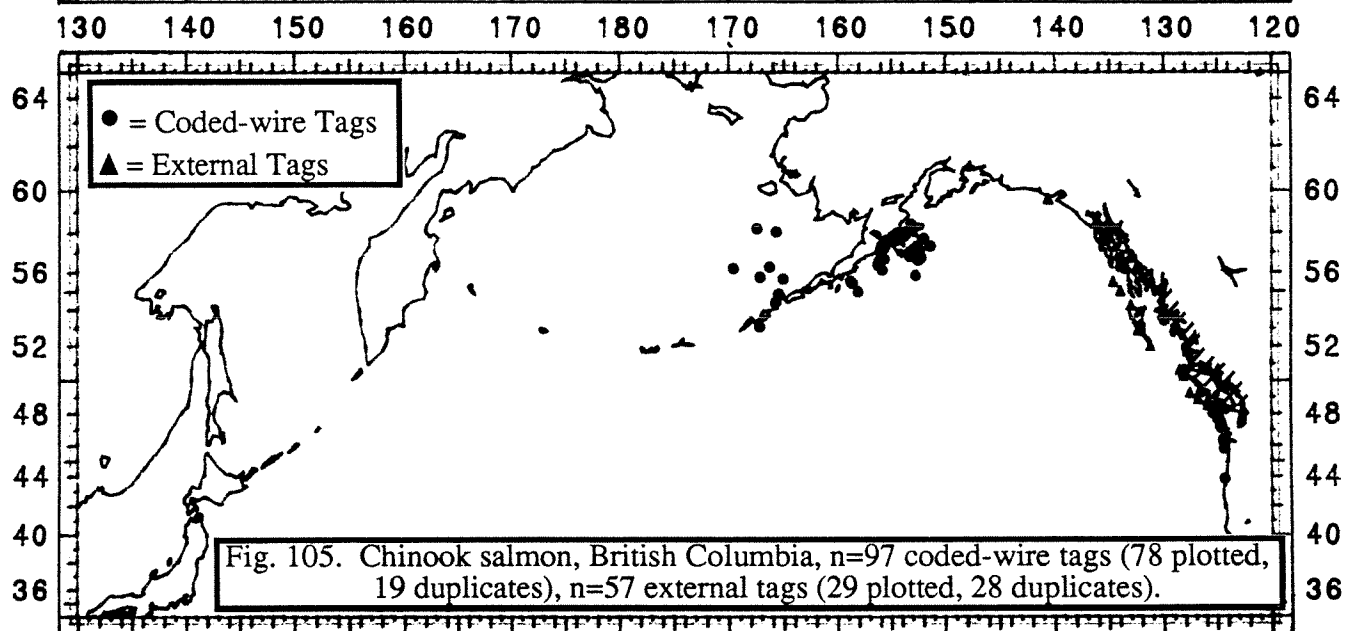
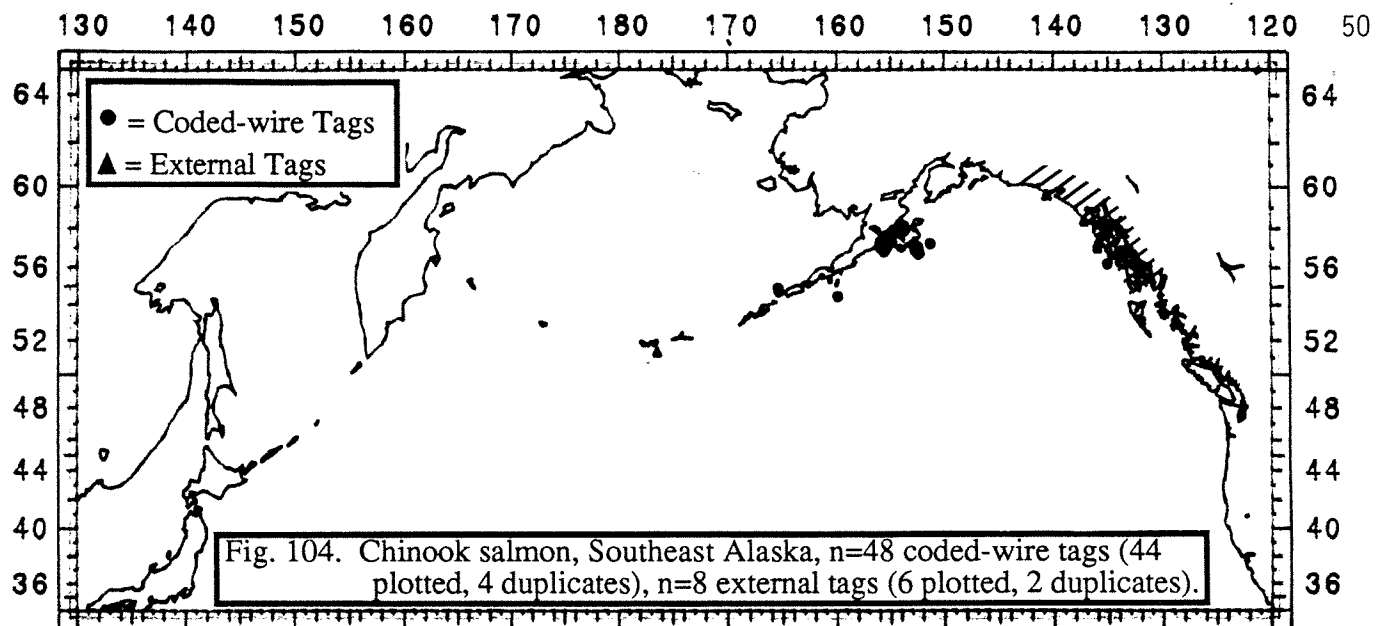


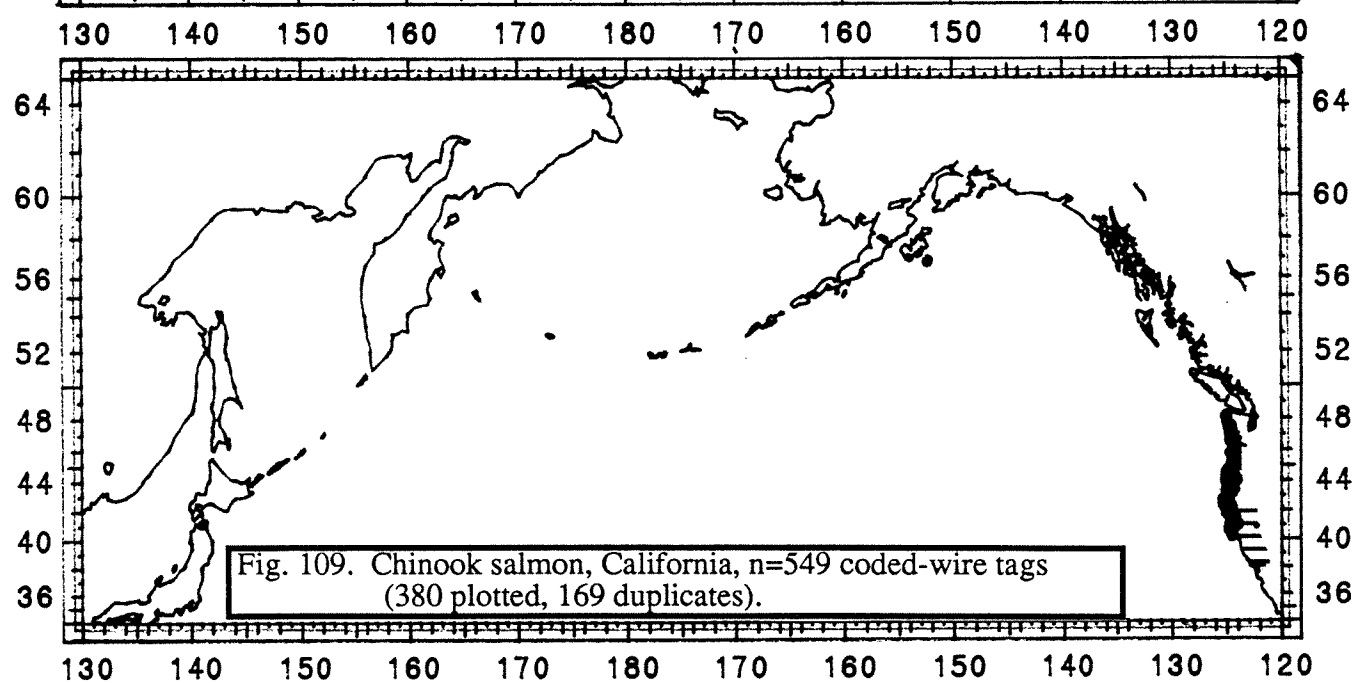
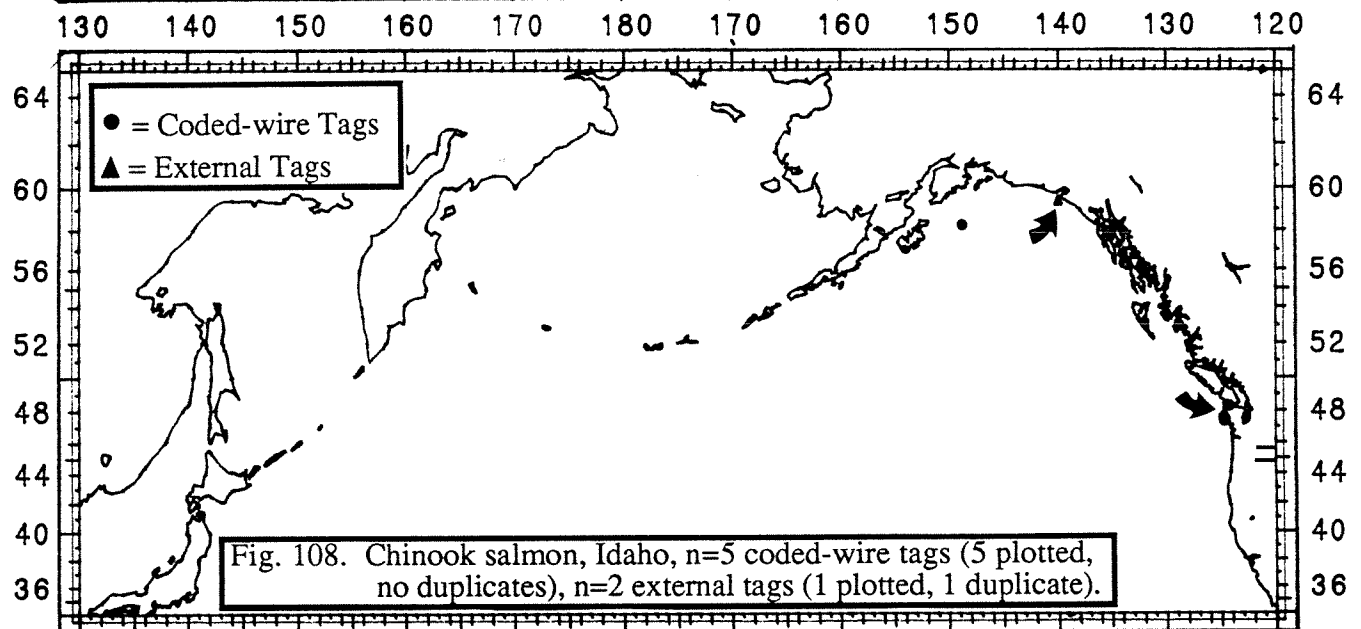
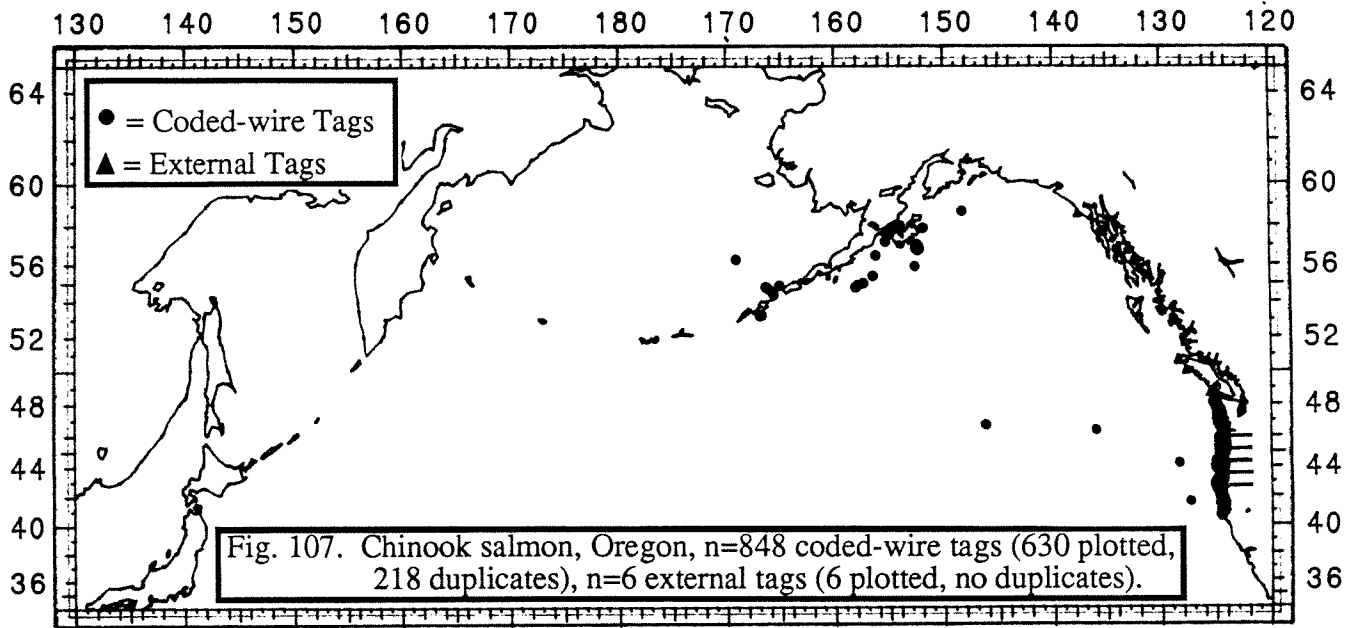


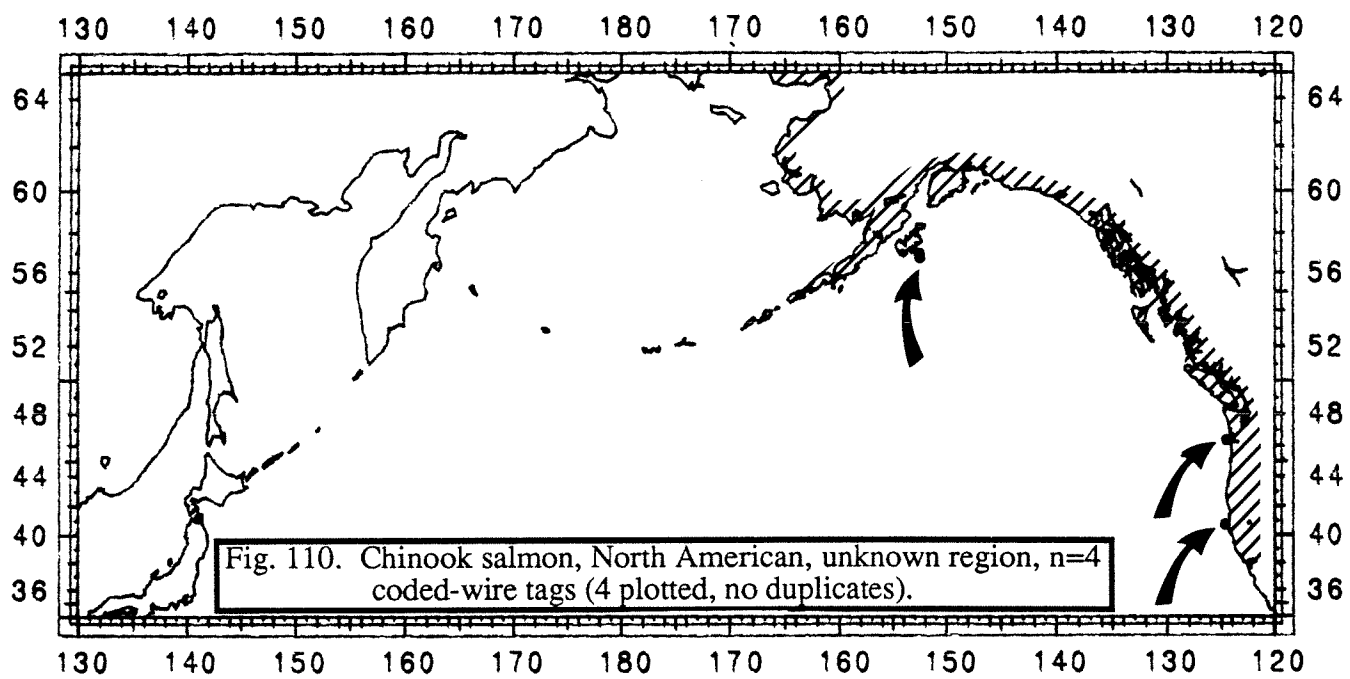


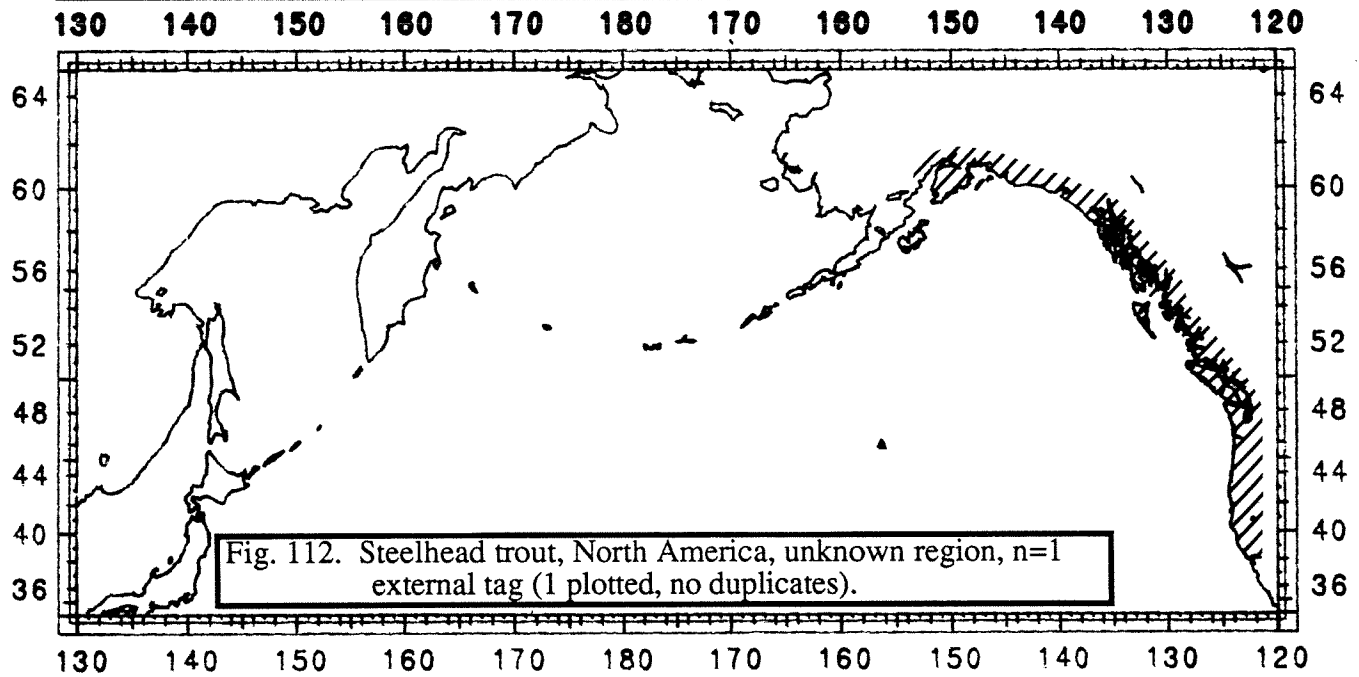
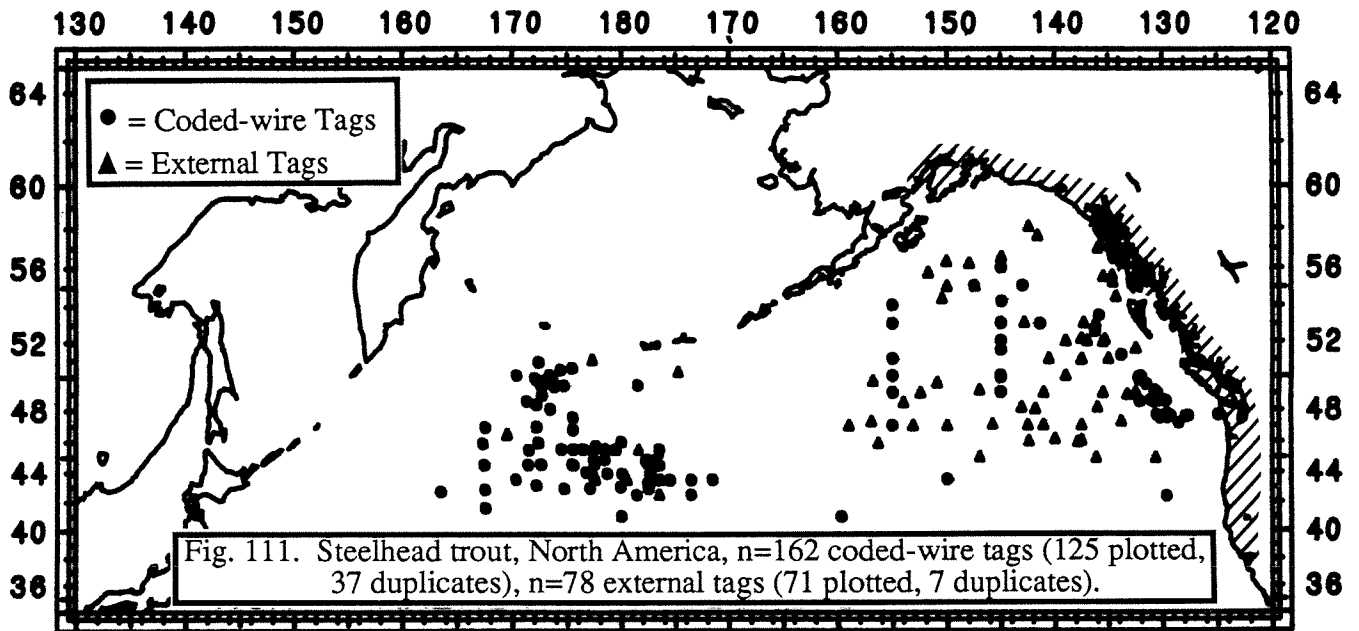


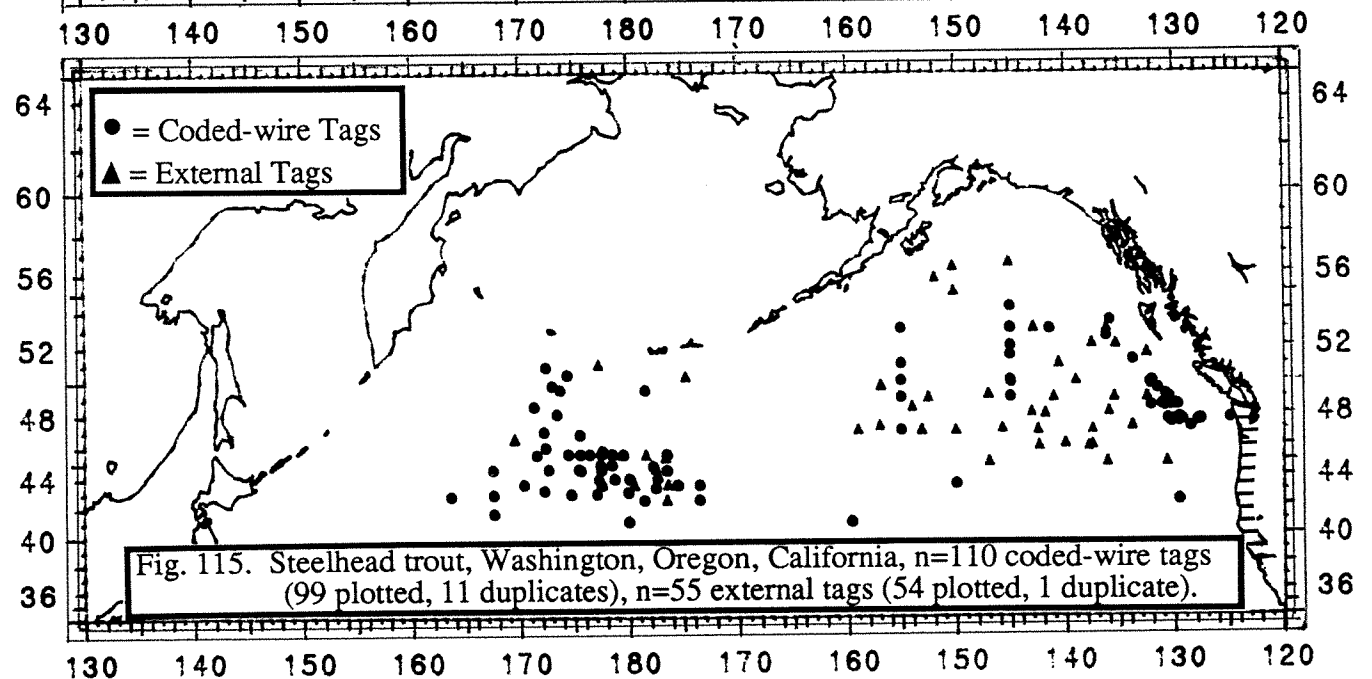
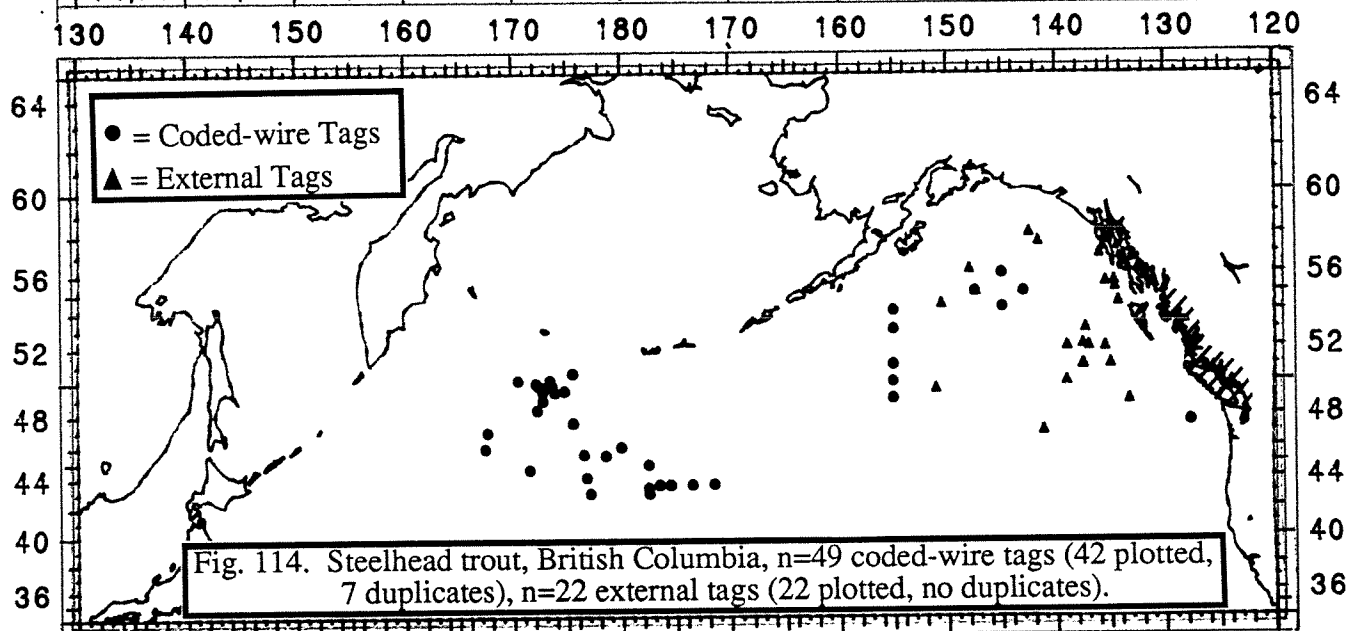
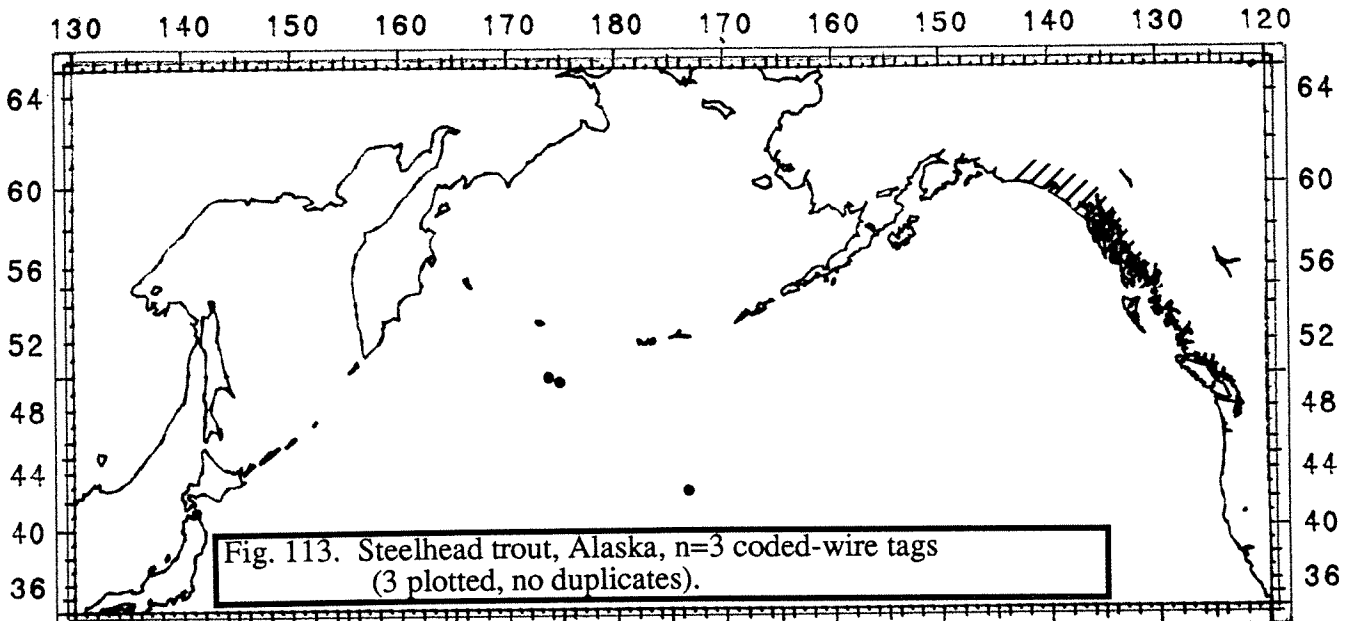


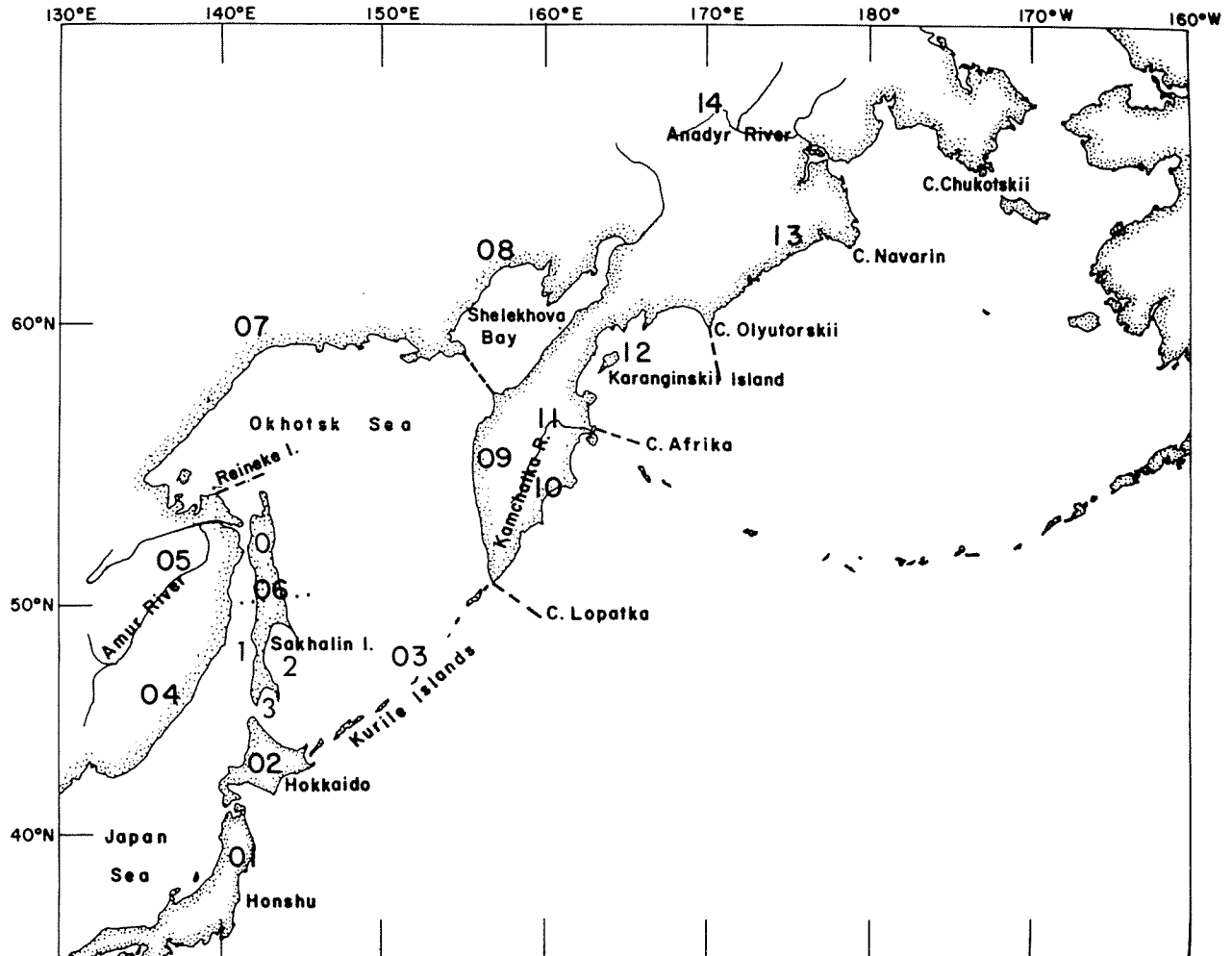




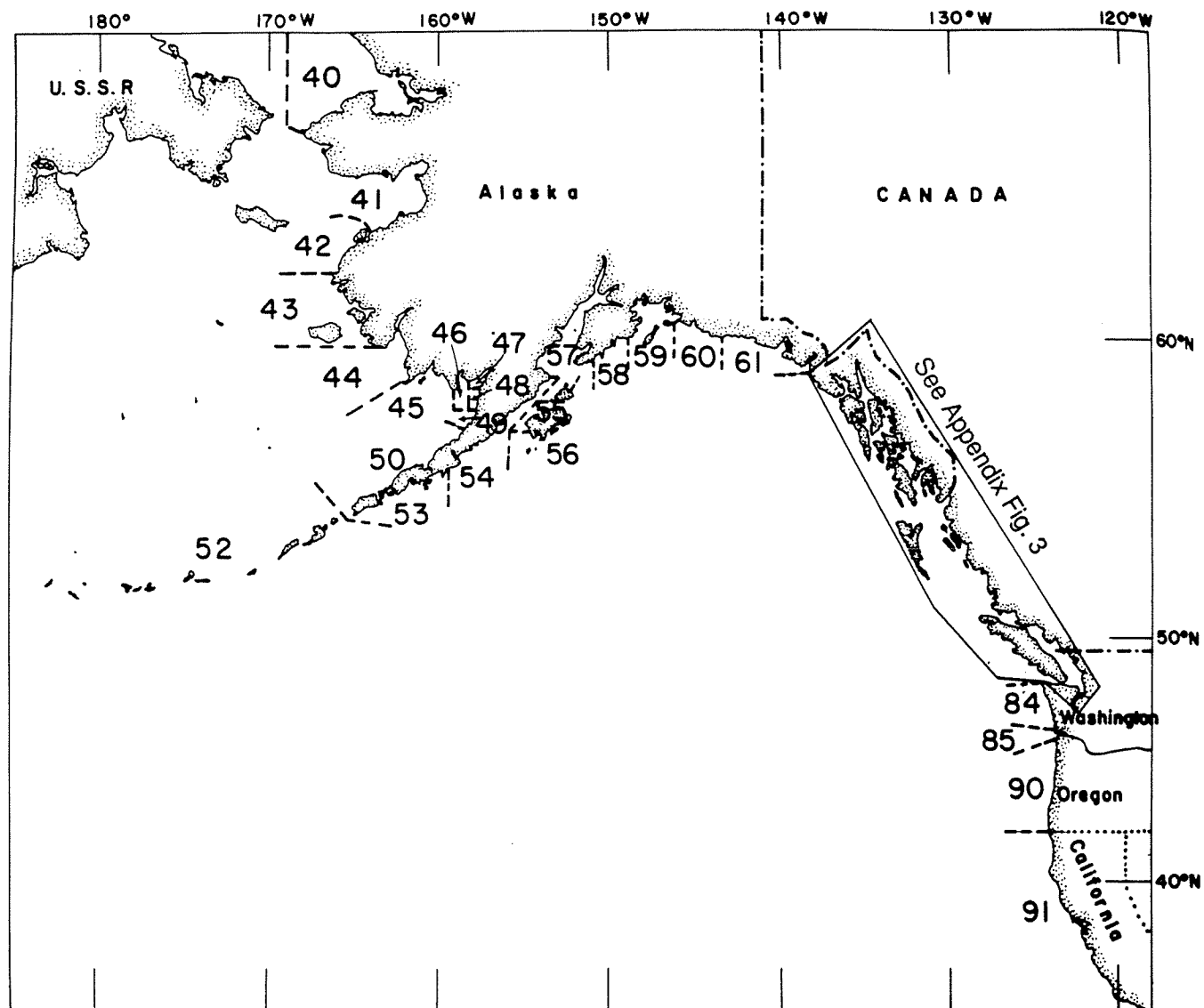




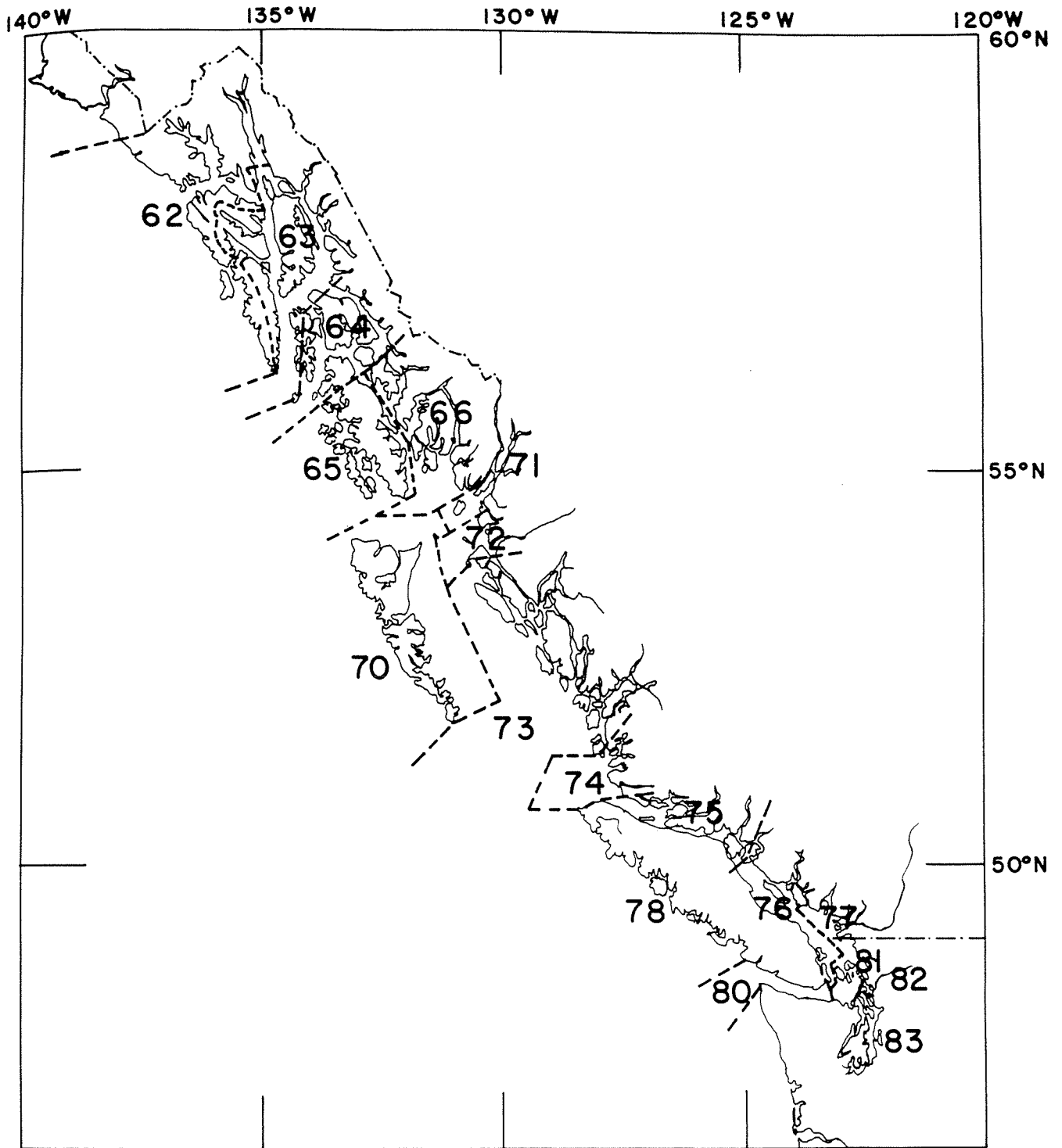




Appendix Fig. 1. General areas and INPFC codes for Asia (from French et al. 1975).



Appendix Fig. 2. General areas and INPFC codes for North America (inset enlarged in Fig. 3) (from French et al. 1975).



Appendix Fig. 3. General areas and INPFC codes for Southeast Alaska, British Columbia, and Puget Sound (from French et al. 1975).