FRI-UW-9810
September 1998

Migrations, Abundance, and Origins of Salmonids in Offshore Waters of the North Pacific – 1998

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Annual Report
High-Seas Salmon Research Project

National Marine Fisheries Service
Contract No. 50ABNF700003

ANNUAL REPORT

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Abstract

This report summarizes research on high seas salmonids conducted in FY98 (October 1997-September 1998) by the Fisheries Research Institute (FRI), University of Washington, under contract to the U.S. National Marine Fisheries Service (NMFS). The research was conducted in two major areas: (1) stock origin studies (including scale pattern analysis and tagging) and (2) ocean ecology, carrying capacity, climate change, and stock assessment.

FRI scientists participated in two NMFS salmon research cruises in the Aleutian Islands and Gulf of Alaska, a wintertime cruise aboard a Japanese salmon research vessel in the western and central North Pacific and Bering Sea, and two summertime cruises on Japanese salmon research vessels with operations in the central North Pacific, Bering Sea, and Gulf of Alaska. Fifty-five temperature-recording archival tags were placed on salmonids, and thus far, four tags were returned. Data revealed that temperatures encountered by the fish were higher at night, and that temperatures were more variable during the daytime. Disk tags were attached to 963 salmonids on Japanese cruises and seven salmon on a NMFS cruise. Seventeen Japan-U.S. tags were returned (14 chum, 1 pink, and 1 coho salmon, and 1 steelhead) in the last year. Ninety coded-wire tag recoveries of chinook salmon caught by U.S. commercial groundfish fisheries included the first information on summer distribution of Yukon River chinook in the offshore waters of the eastern Bering shelf, the second recovery of Washington chinook in the Bering Sea, and recoveries off the Washington coast of Snake River hatchery fish, which are representatives of wild fall chinook listed under the U.S. Endangered Species Act.

The results of several stock identification and scale studies are summarized. A study of age 0.3 chum salmon in the 1994 Bering Sea pollock B-season bycatch was published. A sockeye salmon scale aging test involving salmon scientists from Russia, Japan, Canada and the U.S. indicates a high degree of consistency in ocean ages but substantial variation in freshwater ages. A study of timing of scale annulus formation in chinook salmon revealed that annulus formation varied by freshwater age or behavioral type. Historical results of high seas tag, scale pattern, and parasite stock identification research were summarized to show overlap in ocean ranges of Russian and North American sockeye, coho, and chinook and to identify gaps in information on stock origins.

Summaries are presented of research cruise data, food habits, bioenergetics, and carrying capacity modeling. Research gillnet catch, age, weight, and length data, and stomach contents data from cooperative Japan-U.S. cruises were summarized by oceanographic region. A 24-hour food habits study in the Bering Sea showed peak feeding activity by sockeye and pink salmon immediately after sunset and by chum salmon in mid- to late afternoon. Models of digestion and consumption rates were sensitive to estimated start and end times of feeding. More intensive sampling is needed at dawn and dusk, when salmon switch prey types. Bioenergetic modeling of pink salmon in the Gulf of Alaska indicated that salmon can continually increase their growth

rates, by eating an increasing proportion of squid as salmon body weight increases. An index of squid abundance based on salmon food habits data was developed. Carrying capacity model simulations indicated that as the size of central Alaskan pink salmon decreases with increasing abundance, squid might change from being prey of salmon to a competitor. Simulations also revealed that a build-up of salmon predators after an "upward" regime shift (e. g., post-1976) might have severe consequences during a "downward" regime shift because high populations of predators could rapidly reduce declining salmon biomass.

Other research topics summarized in this report include: origin and catches of Dolly Varden in offshore waters; scale growth studies in the Gulf of Alaska; Russian sockeye scale time series and carbon isotopes; and seasonal levels of insulin-like growth factor-I. Results from these studies will be reported later. Research coordination with the Auke Bay Laboratory and participation of FRI personnel in NPAFC meetings and activities is also summarized.

Introduction

Since 1955, the U. S. Government has contracted the Fisheries Research Institute (FRI), University of Washington, to conduct research on issues related to Pacific salmon and steelhead (*Oncorhynchus* spp.) in the North Pacific Ocean and to participate in the deliberations of the International North Pacific Fisheries Commission (INPFC, 1955-1992) and the North Pacific Anadromous Fish Commission (NPAFC, 1993-present). This report summarizes research on high seas salmonids conducted in FY98 (October 1997-September 1998) by FRI under contract to the Auke Bay Laboratory (ABL), U. S. National Marine Fisheries Service (50ABNF700003). The research was conducted in two major areas: (1) stock origin studies (including scale pattern analysis and tagging) and (2) ocean ecology, carrying capacity, climate change, and stock assessment (including cooperative international cruises, food habits and bioenergetics, growth studies, models of carrying capacity, and coordination with ABL research). In addition this report summarizes the participation of FRI personnel in NPAFC meetings and activities.

I. International Cooperative High Seas Salmon Research

A. Stock Origin Studies for Research, Management, and Enforcement

1. HIGH SEAS TAGGING PROGRAM

In cooperation with ABL, FRI initiated a new program in 1998 of placing temperature-recording archival tags on salmonids. FRI also assumed responsibility for reporting high seas research vessel and domestic trawl fishery recoveries of coded-wire tags to NPAFC, in addition to regular tag release and recovery activities.

Temperature-recording archival tags

Fifty-five temperature-recording archival tags were placed on Pacific salmonids in the North Pacific Ocean and Bering Sea during three research cruises (Walker et al. 1998a). In May six sockeye (*O. nerka*) and one coho salmon (*O. kisutch*) were tagged in the Gulf of Alaska and eastern North Pacific. Twelve steelhead trout (*O. mykiss*) were tagged in June in the central North Pacific, and 23 chum salmon (*O. keta*) were tagged in July in the Bering Sea. Thirteen salmonids (4 sockeye, 1 chum, 4 pink (*O. gorbuscha*), 3 coho, and 1 steelhead) were tagged on transects along 165°W and 145°W in late June and early July. Four tags have been returned to date.

Tag 189 - Pink salmon. A pink salmon, tagged at 56°N, 145°W in the Gulf of Alaska on 3 July 1998, was caught by coastal seine at Cape Izhut, Afognak Island, on 24 July after 21 days at liberty (4,063 temperature data points at 7.5 minute intervals; Fig. 1). Great circle distance was 501 km from the tagging location, which indicates a minimum travel speed of 23.9 km/day. The data on temperatures encountered by the fish show two clear phases (Fig. 1). During the first phase, the fish remains at relatively constant temperatures of 10-11°C during both day and night for five days (July 3-7). This may represent a period of recovery from tagging trauma, where the fish remains in or near surface waters, with few dives. The second phase shows fairly constant, higher temperatures at night, and cooler but more variable temperatures during the day, with moves between cooler and warmer waters. This may represent a normal pattern of moving to surface waters at night, possibly feeding, and diving to deeper, cooler waters during the day, but with frequent rises to warmer waters. Within this second phase, three periods can be discerned. At first (July 8-11), the fish is in 11-12°C waters at night and in cooler waters for most of the day. We think the fish is still in waters of the Dilute Domain (Alaskan Gyre). Next (July 12-18), nighttime temperatures are slightly higher and daytime data cover a wider range of temperatures. This is probably when the fish is crossing the warmer waters of the Alaska Current. Finally (July 19-23), temperatures at night are cooler again and the daytime temperature range is narrower. The fish was probably in waters on the coastal side of the Alaska Current, where surface waters are cooler, but warmer temperatures and the thermocline are found slightly deeper.

Tag 52 - Coho salmon. A coho salmon, tagged at 56°N, 145°W in the Gulf of Alaska on 3 July 1998, was caught by drift gillnet in Togiak Bay on 24 August after 52 days at liberty (5,857 data points at 15 minute intervals; Fig. 2). Combined great circle distances (via Unimak Pass) are 1,858 km from the tagging location, which indicates a minimum travel speed of 35.7 km/day. The data on temperatures encountered by the fish show three clear phases (Fig. 2). Like the pink salmon, the coho seems to undergo a five-day recovery from tagging trauma, remaining at relatively constant temperatures day and night. The second phase (July 8-August 5) shows moves between cooler and warmer waters, with night temperatures only slightly more constant than days. In the last phase (August 6-24), the fish stops most of its sharp movements between warm and cool temperatures. At this point the fish may have stopped feeding or whatever behavior necessitated the dives and started travelling to its spawning river. During these last three weeks, many days show a mid-day temperature peak approximately 0.5-3°C warmer than the early and late portions of the day, and nighttime temperatures show gradual cooling. The fish is probably swimming steadily near the surface, and the small rises and falls reflect the diurnal pattern of daytime warming of surface waters and cooling at night.

Tag 198 - Steelhead trout. A steelhead trout, tagged at 50°N, 145°W in the Gulf of Alaska on 9 July 1998, was caught by drift gillnet inside Softuk Bar, Copper River Delta on 14 August after 36 days at liberty (6,909 data points at 7.5 min. intervals; Fig. 3). Great circle distance was 931 km from the tagging location, which indicates a minimum travel speed of 25.9 km/day. The steelhead data also show a possible recovery phase of relatively constant day/night temperatures (Fig. 3). The fish then began a diel pattern of fairly constant, higher temperatures at night, and more variable temperatures during the day. Unlike the pink salmon data, the daytime temperatures are frequently as high or higher than night temperatures. Within this second phase, three periods can be discerned. At first (July 13-28), the fish is in 11°C waters at night and waters ranging from 7 to 12°C during the day. We think this is when the fish was still in the Subarctic Current and the Ridge/Dilute Domains of the Alaskan Gyre. Next (July 28-August 9), nighttime temperatures are higher, probably the warmer waters of the Alaska Current. In the final period (August 11-14), there is no clear pattern; the fish is probably in waters on the coastal side of the Alaska Current. During the entire time at liberty, many days show a mid-day temperature peak approximately 1°C warmer than the early and late portions of daylight hours. Steelhead are surface-oriented, and the warmer mid-day peaks may be diurnal solar heating of surface waters. A surprising feature of the data is frequent movement between warmer and cooler waters. Since steelhead have been assumed to be surface-oriented, such frequent dives (probably down to about 50 m) were not expected.

Tag 259 - Chum salmon. A chum salmon, tagged at 52°30'N, 179°30'W in the central Aleutians on 3 July 1998, was caught by setnet at the mouth of the Tokachi River, Pacific coast of Hokkaido (42°39'N, 143°31'W), on 4 September after 63 days at liberty (6,011 data points at 15 min. intervals; Fig. 4). Great circle distance was 2,942 km from the tagging location, which indicates a minimum travel speed of 46.7 km/day. We have just received these data, and have not yet analyzed them in detail. The initial 23 days (3-25 July) are puzzling, with very few moves between warmer and cooler water. This could be a very prolonged recovery from tagging trauma, or perhaps it is "normal" behavior in the Bering Sea, similar to that displayed by the coho salmon in the latter part of its migration. The subsequent data show a pattern of moves between warmer and cooler water. Like the pink salmon and steelhead, the chum is in warmer waters with fewer dives at night.

The fish tagged in the Gulf of Alaska (coho, pink, and steelhead) were at warmer average temperatures than the chum salmon (Table 1). The chum salmon was also found at a wider range of temperatures (Tables 1 and 2). This is probably mainly an effect of the different oceanographic areas traveled by the fish, but may also be due to species differences. Except for the coho salmon, fish generally were found at slightly higher temperatures at night, with a lower variability (smaller temperature range and less movement between temperatures). Percentage of time spent at different temperatures may be useful for bioenergetics studies (Table 2).

High seas tagging

Scientists aboard the F/V *Great Pacific* in the Gulf of Alaska and eastern North Pacific conducted tagging operations on viable salmonids caught by trawl (Fig. 5; Carlson et al. 1998). Fish were tagged with FRI Petersen disk-tags. These tagging experiments resulted in the release of six sockeye and one coho salmon. A temperature data archival tag was placed on each of these salmonids.

Tagging operations on viable salmonids caught by longlines were conducted by scientists aboard the R/V *Wakatake maru* along a transect in the central North Pacific and Bering Sea (43°00'N to 58°30'N at 179°30'W and at 56°30'N between 177°30'W and 177°30'E; Fig. 5; Ueno et al. 1998). Fish were double-tagged with FAJ (Fisheries Agency of Japan) and FRI Petersen disk-tags. These tagging experiments resulted in the release of 884 salmonids, including 23 sockeye, 809 chum, 8 pink, 21 coho, 10 chinook salmon (*O. tshawytscha*), and 13 steelhead trout. Temperature data archival tags were attached to 12 of the steelhead and 23 of the chum salmon tagged with disk tags.

In 1998 aboard the T/S *Oshoro maru* ten salmon (11 in 1997) in the central North Pacific Ocean, 41 salmon along the 165°W transect, and 28 salmonids (28 salmon in 1997) along the 145°W transect were tagged and released (Fig. 5; Walker et al. 1998b). Temperature data archival tags were attached to one salmon released along the 165°W transect and to 12 salmonids released along the 145°W transect.

High seas tag recoveries

From 1 September 1997 through 15 September 1998, seventeen Japan-U.S. tags were returned (14 chum, 1 pink, and 1 coho salmon, and 1 steelhead; Myers et al. 1998a; Table 3). These tagged salmon were released in 1997 and 1998 during cooperative Japan-US tagging operations aboard the *Wakatake maru* and *Oshoro maru* in the central Aleutian Islands, Bering Sea, and Gulf of Alaska in June and July. The steelhead and pink and coho salmon were released in the central Gulf of Alaska in July 1998 and recovered in Alaska; all carried temperature data archival tags. The pink salmon was recovered off Afognak Island after three weeks, the steelhead was recovered at the Copper River Delta after five weeks, and the coho was recovered in Togiak Bay after seven weeks. The steelhead was the first Alaskan recovery of a steelhead tagged on the high seas. The coho recovery extended the known range of western Alaskan coho in the Gulf of Alaska northeastward by 550 km. Twelve maturing chum salmon released in July 1997 in the central Aleutian Islands and Bering Sea were recovered in Hokkaido and Honshu from September to November 1997. Two maturing chum carrying different types of archival tags were released in early July 1998 in the central Aleutian Islands and Bering Sea and recovered approximately two months later in Hokkaido.

Processing center for tag recoveries

FRI is the North American processing center for recovery of high seas salmonid tags. This activity requires advertising for tag returns, returning tags and recovery information to appropriate agencies, returning information on tag recoveries and a reward to fishermen and processors who return high seas tags, and reporting new tag recoveries in a document for NPAFC (Myers et al. 1997a, 1998a).

In the spring, we advertised for return of high seas salmon tags by mailing approximately 1400 informational packets to addresses in Alaska, British Columbia, Washington, Oregon, and California. These packets were sent to federal, state, and tribal fisheries research and management agencies, fishermen's organizations, salmon buyers and processors, and post offices. The informational packet included a letter explaining the tagging program and the importance of returning tags, a poster advertising for tag returns (Fig. 6), and a business-reply envelope that includes a form for recording recovery information (tag number, date, location, fishing gear) and salmon biological data (species, sex, body weight, and how to collect scales).

Since 1991, we have offered a cap as a reward for people who return high seas tags. The reward caps are embroidered with the profile of a tagged salmon and the words "International High Seas Tagging" to emphasize the cooperative nature of the high seas tagging program of NPAFC-member countries.

Snout collection for potential recovery of coded-wire tags

Snouts were collected by the *Wakatake maru* from fin-clipped salmonids because these fish may contain a coded-wire tag (Table 4). Twenty-four steelhead trout with clipped fins were caught between 43°00'N and 47°30'N. Clipped fins included adipose, left ventral, left pelvic, and right pectoral fins. Snouts were salted and sent to ABL for recovery of coded-wire tags. None of the snouts has been examined for tags as yet.

Aboard the *Oshoro maru*, snouts were collected from 46 salmonids lacking adipose fins (35 steelhead and 6 coho, 2 sockeye, 2 chum, and 1 chinook salmon; Table 5). Snouts were salted or frozen and sent to ABL for recovery of coded-wire tags. None of the snouts has been examined for tags as yet.

Maintenance and updating of tag release and recovery databases

The high seas salmon tag release and recovery databases were updated with data provided at the 1997 NPAFC annual meeting. Japan reported double-tagging operations conducted with the United States. The release database was updated with 41 operations in which 818 fish were tagged and released. Eighteen fish were added to the tag recovery database (12 recoveries from Japan, 1 recovery from Russia, 1 recovery from Washington, 4 high seas recoveries). The updated databases are available to all national sections. Preliminary information from documents prepared for the 1998 NPAFC annual meeting indicates 963 fish were tagged in 44 operations. New tag release and recovery information will be added to the databases in the next year of the contract.

Maintenance and updating of high seas and observer coded-wire tag recovery databases

In 1998 FRI assumed responsibility for reporting recoveries of coded-wire tags by high seas research vessels and the domestic trawl-fishery observer program. This activity requires obtaining information from ABL on recovery data and tag codes, entering it into the coded-wire tag recovery database, and reporting new tag recoveries in a document for NPAFC. The coded-wire tag recovery database was updated with trawl observer data provided by ABL. No data were available from high seas research vessels at the time the report was completed (Myers et al. 1998b).

Information reported to NPAFC includes previously unreported release and recovery data for 90 coded-wire tagged chinook salmon recovered in 1996 (21 recoveries), 1997 (57), and 1998 (12; Table 6). All reported recoveries were made by U.S. observers on commercial groundfish vessels operating in the U.S. Exclusive Economic Zone in the Bering Sea (62 recoveries), Gulf of Alaska (2), northeastern Pacific Ocean (22), and unknown locations (4). The fish originated from releases in the Yukon Territory (1 recovery), Alaska (27), British Columbia (40), Washington

(11), Oregon (8), and California (3). Notable recoveries include: (1) the first information on summer (June) distribution of Yukon River chinook salmon in the offshore waters of the eastern Bering shelf, (2) the second reported recovery of a Washington-origin chinook salmon in the Bering Sea, and (3) three recoveries off the Washington coast in 1996 of Snake River, Washington, hatchery fish, which are representatives of wild fall chinook salmon listed under the U.S. Endangered Species Act (Myers et al. 1998b). Recoveries of CWT salmonids from high seas research vessel operations in 1998 will be reported later.

2. Scale Pattern Analyses

Origins of 1994 chum salmon bycatch

The final results of a scale pattern study to estimate origins of chum salmon caught incidentally in the 1994 eastern Bering Sea walleye pollock trawl fishery were published (Patton et al. 1998). Approximately 74,500 chum salmon were intercepted in the 1994 U.S. walleye pollock (*Theragra chalcogramma*) B-season fishery in the eastern Bering Sea and Aleutian Islands. Using scale pattern analysis, we estimated the stock composition of age-0.3 chum salmon (fish that had spent three winters in the ocean) from this incidental catch. A conditional maximum-likelihood discrimination model, assessed through a series of simulation runs using hypothetical stock mixtures, was 83.3-92.3% accurate. Our fleet-wide, unweighted proportion estimates closely resembled the results of a concurrent stock composition study based on allelic frequencies of the 1994 chum salmon bycatch. Interception estimates weighted by time, which depend on the accuracy of National Marine Fisheries Service week-stratified bycatch estimates, indicated that about 50% of the incidentally-caught chum salmon originated from Asia (Russia and Japan), 18% from western and central Alaska, and 32% from southeast Alaska, British Columbia, and Washington. The western and central Alaskan proportion increased over the course of the B-season fishery, although the numbers intercepted remained stable. A comparison of our regional interception estimates with estimated run sizes indicates that bycatch in the 1994 B-season walleye pollock fishery did not greatly affect returns to western Alaskan chum salmon fisheries.

NPAFC sockeye salmon scale aging test

The most accurate results from stock identification of salmon using scale pattern analysis are obtained when both baseline and mixture samples are composed of fish of the same age class and brood year. For accurate stock identification results, therefore, consistency in scale age determinations in both the baseline and mixture samples is critical. For baseline samples, however, resource agency scale experts may have used additional knowledge of stock-specific life history traits to assist in determining age from scales. At the March 1997 NPAFC research planning meeting in Vancouver, B.C., the Working Group on Stock Identification and Growth discussed the need to test inter-laboratory variation in scale age and growth data. A comparison of sockeye salmon scale age determinations by 9 laboratories indicates a high degree of consistency in ocean ages, but substantial variation in freshwater ages (Fig. 7; Myers 1998a).

3. OTHER STUDIES OF STOCK ORIGINS

Ocean ranges of Russian and North American sockeye, coho, and chinook salmon

The results of high seas tag, scale pattern, and parasite stock identification research were summarized to provide a general overview of overlap in ocean ranges of Russian and North American sockeye, coho, and chinook salmon and to identify gaps in information on stock origins of salmon in offshore waters (Figs. 8-10). The sockeye tag data show a broad overlap in the ocean ranges of Russian and North American sockeye salmon in the Bering Sea and North Pacific Ocean between 160°E and 165°W (Fig. 8). Scale pattern data extend the range of North American sockeye salmon throughout the area south of 46°N, between 160°E-170°E. The scale pattern results are based on samples collected during a period of low abundance of Bristol Bay sockeye salmon (1972-1976). During periods of high abundance, the overlap in ocean ranges of Russian and North American sockeye may be much greater than is indicated by the data in Figure 8.

A broad region of overlap in the ranges of Russian and North American coho salmon occurs in the North Pacific Ocean south of 52°N, between 160°E and 170°W (Fig. 9). The tag and scale pattern information for this area apply only to maturing (ocean age-.1) coho salmon in summer (May-August). There is a large gap in coho salmon stock information for the area between 175°W and 160°W, although research vessel catch data show that maturing coho salmon range throughout this area in summer. Scale pattern data extend the known range of North American coho salmon into the area south of 46°N and west of 170°E, but information from tagging or other direct evidence is needed to validate these results.

The combined results of tag, scale, and parasite data indicate extensive overlap in the ocean ranges of Russian and North American chinook salmon, across the Bering Sea south of 62°N, between 165°E and 175°W, and in the North Pacific Ocean from 160°E to 145°W (Fig. 10). The parasite data is viewed as indirect evidence (not proof of origin) for Russian salmon because the indicator species (*Myxobolus arcticus*) is known to occur in some North American chinook salmon stocks. The scale and parasite data pertain primarily to immature, ocean age-.2 and age-.3 chinook salmon, which are the predominant age groups of chinook salmon in offshore waters. There is a significant gap in information on stock origins of chinook salmon in the eastern North Pacific Ocean south of 50°N, between 130°W-170°W.

Origins of Dolly Varden caught in the offshore waters of the central Bering Sea

Small numbers of Dolly Varden (*Salvelinus malma*) have been caught annually in July in the offshore waters of the central Bering Sea during fishing operations of the *Wakatake maru*. In the past, FRI has sent round samples to a Canadian char specialist for confirmation of species identification. In 1998, 86 Dolly Varden were caught in the central Bering Sea, five times more fish than catches from the previous seven years combined. To take advantage of this rare opportunity, a variety of data and tissue samples for genetic studies and age determination were collected on board. These samples and additional round samples collected on the spring cruise of the *Great Pacific* will be sent to Canada for analysis. Data on the catches and origins of Dolly Varden in these catches will be reported later.

Identification of scales from illegal driftnet fishing

FRI evaluated and confirmed species identification and age determinations made by an ABL scientist of 400 scales taken from two vessels illegally fishing driftnets for salmon south of the western Aleutian Islands. All scales, collected by the U.S. Coast Guard from surfaces and gear of the vessels, were of chum and sockeye salmon, mostly three-ocean fish (-.3). The species mix was consistent with the area where the vessels were intercepted. Lack of growth beyond the last annulus at the edge of the scale indicated the fish were caught in spring. The age composition was typical of larger, maturing fish.

B. Ocean Ecology, Carrying Capacity, Climate Change, and Stock Assessment

1. SALMON RESEARCH VESSEL CRUISES

Kaiyo maru

One FRI scientist (N. Davis) participated in the cooperative Japan-Russia-U.S. salmon research cruise on board the *Kaiyo maru* from 3 February to 2 March, 1998 in the western (165°E) and central (180°) North Pacific Ocean and Bering Sea (180°) (Fig. 5.; Davis 1998, Ishida et al. 1998). This was the third overwintering salmonid survey conducted on board the *Kaiyo maru,* and this cruise was the first wintertime salmon research cruise in the central Bering Sea since 1963. Research objectives were to collect samples and data on salmon distribution and biology in February; collect data on salmon habitats such as environmental temperatures, primary production, and conditions for salmon feeding that might contribute to wintertime salmon growth reduction and mortality; and determine what differences might exist between mid-winter and summer seasons in salmon habitat conditions, especially with respect to primary production and production of salmon prey organisms. Salmon were caught at 14 of 19 trawl stations. The total catch of salmon during the survey was 2,381 fish (49 sockeye, 1,433 chum, 843 pink, 24 coho, and 32 chinook). No steelhead were caught (Table 7). The majority of the catch (66%) occurred at one station in the western North Pacific Ocean, where there were relatively large catches of chum and pink salmon. The combined results of the December 1992, January 1996, and February 1998 surveys indicate that salmon in their first ocean winter are distributed well offshore, and that in the western North Pacific Ocean, chum and pink salmon are more abundant in offshore waters in February than in December or January. Most of the salmon catch in February 1998 was distributed in a narrow band from 42°-45°N in the western North Pacific Ocean (at 165°E), where sea surface temperatures (at 5 m) were 3.9°-5.1°C, and from 43°-46°N in the central North Pacific Ocean (at 180°), where sea surface temperatures were 5.7-6.8°C. Chinook salmon was the only species caught in the Bering Sea.

Wakatake maru

One FRI scientist (N. Davis) participated in the cooperative Japan-U.S. salmon research cruise on board the *Wakatake maru* from 9 June to 25 July 1998 (Fig 5; Ueno et al. 1998). Research cruise activities included collection of data on oceanography, primary production, zooplankton, salmonids, and other fishes. Results of oceanographic sampling indicated that the average sea surface temperature (SST) in the central North Pacific was 9.1°C (0.4° cooler in 1998 than in this region in 1997) and the average SST in July in the Bering Sea was 8.2°C (1.1°C cooler than in 1997). A total of 8,635 salmonids was caught by longline and gillnet. In the North Pacific Ocean, coho salmon was the most abundant salmon (57% of the salmonid catch), followed by chum (25%), steelhead (8%), sockeye (5%), pink (3%), and chinook salmon (2%). One masu salmon (*O. masou*) was collected at 46°00'N, 180°00', which may be the eastern-most recorded catch of this species. In the Bering Sea, chum salmon was the most abundant salmon (84% of the salmonid catch), followed by sockeye (9%), chinook (5%), pink (1%), and Dolly Varden (1%).

Oshoro maru

Two FRI scientists (R. Walker and K. Aydin) participated in the cooperative Japan-U.S. salmon research cruise on board the T/S *Oshoro maru* from 30 June to 13 July 1997 (Fig. 5, Table 8; Walker et al. 1998b). Salmon surveys conducted aboard the *Oshoro maru* along 180° longitude in the central North Pacific Ocean in June since 1978 have provided a valuable time series of fisheries and oceanographic data. This was the fifth consecutive year of cooperative Japan-U.S. sampling for salmon along a 145°W-longitude transect in the central Gulf of Alaska in early July, and the first year of a new transect along 165°W. The primary objective of the 1998 cooperative research was to continue the collection of oceanographic and biological data along the 180°, 165°W, and 145°W transects. In 1998, mid-June SSTs at gillnet fishing stations were about the same as in 1997 at 43° and 45°N and 1.3°C cooler (5.9°C) at 47°N along the 180° transect. Late-June mean SSTs were about 8.4°C at four gillnet stations on the 165°W transect, and early July mean SSTs (10.2°C) were 2.2°C cooler along the 145°W transect than in 1997. This represents a return to cooler conditions found from 1991 to 1996 at 145°W (mean 9.8°C). The Subarctic Current was further north (53°N) than in previous years. Catches by gillnet totaled 3,165 salmonids, including 256 salmonids (225 in 1997) in the central North Pacific Ocean (180° transect), 645 salmonids along the 165°W transect, and 2,264 salmonids (1,811 in 1997) in the Gulf of Alaska.

Salmonid abundance, maturity, age, and size in the central North Pacific Ocean, Bering Sea, and Gulf of Alaska

Wintertime trawl catches by operations conducted by the *Kaiyo maru* indicated that salmon were most abundant in the catches in the western North Pacific (165° E), where ocean age .1 chum and pink salmon were the major component of the catch (58% and 40%; Table 9; Davis 1998). A few sockeye (predominantly ocean age .2) and chinook salmon (all ocean age .1) were also caught. In the Bering Sea, 12 chinook salmon (mostly ocean age .1)were caught. More intensive wintertime sampling in the Bering Sea is required before conclusions can be made about salmon distributions in the Bering Sea at this time of year. In the central North Pacific at 180°, chum and pink salmon were abundant and composed 85% of the catch. Sockeye and coho salmon were each 6% of the catch in this area, and chinook salmon was 2% of the catch. The pink salmon were all ocean age .1, and the sockeye were a mixture of ocean ages .1 and .2. In contrast to the western North Pacific, catches in the central North Pacific included more older (ocean age .2) chum (90%) and chinook salmon (25%; Table 9).

Summertime catches by the research vessel *Wakatake maru* indicated that sockeye salmon were less abundant in the Bering Sea in 1998 than in the past two years (Table 10). Fifty-six percent of the sockeye caught in the Bering Sea were ocean age .1, an increase in the proportion over last year (Table 11). Chum salmon, however, were more abundant in the Bering Sea in 1998 than in 1997, and in 1998 the age composition included older fish (.2 and .3) and a smaller proportion of ocean age .1 than in 1997 (Table 12). In 1997, pink salmon were more abundant than any other year from 1991 to 1998. The 1998 Bering Sea pink salmon catch per unit of effort was 1% of the value in the previous year, continuing a strong pattern of high abundance in odd years and low abundance in even years (Table 10). In 1998 the size of pink salmon caught in the Bering Sea was smaller (length and weight) than in the previous seven years despite their low relative abundance (Table 13). Bering Sea chinook salmon, primarily ocean age .1, were more abundant in 1998 than in the previous seven years (Table 14). In 1998 coho salmon caught in the Subarctic Current were more abundant and larger (mean length and weight) than they had been since 1991 (Tables 10 and 15). Steelhead were more abundant in the Subarctic Current area in 1998 than in the past two years, and these fish comprised a larger proportion of younger (ocean age .1) fish than in 1997 (Table 16).

The *Oshoro maru* salmon research cruise in the central North Pacific (180°, 39°-50°N) is in mid-June, approximately one week earlier than the *Wakatake maru* cruise (Table 17; Walker et al. 1998b). In 1998, as in 1997, sockeye salmon (1 in 1997, 4 in 1998) were caught at 45°N, 180° in the Transition Domain, a region where sockeye salmon had not been found in previous (1994-1996) surveys. The abundance of pink salmon was substantially lower than in 1997 (near levels in 1996) in both the Transition Domain and Subarctic Current. The abundances of coho and chum salmon were substantially higher in the Transition Domain than in 1997, while coho abundance remained low in the Subarctic Current. Along the 165°W transect in late June, salmonids were caught by research gillnet in the Ridge Domain (50°N) and the Subarctic Current (45°30'-48°30'N). Sockeye, chum, and pink salmon were abundant in both areas. Coho salmon were absent in the Ridge Domain and abundant in the Subarctic Current.

Along the 145°W transect in early July, salmonids were caught by research gillnet in the Subarctic Current (49°-53°N) and the Dilute Domain (54°N-56°N). The relative abundance of sockeye salmon in catches in the Dilute Domain area of the 145°W transect was lower than the 1997 peak but near the 1994-97 average (Table 17). Sockeye salmon in the catch were predominantly maturing, ocean age .2 fish (Table 18). The abundance of chum salmon (predominantly immature, ocean ages .1 and .2) in this area continued a four-year decline (Tables 17 and 18). Chum salmon catches in the Subarctic Current were higher than the previous two years, and those of sockeye were the highest observed. The abundance of both pink and coho salmon in the Dilute Domain in 1998 rebounded to levels nearing or exceeding the peaks of the previous four years. The few chinook salmon caught along 145°W are predominantly immature, and steelhead are predominantly juvenile, ocean age .0 fish (Table 19). Fork lengths, body weights, and condition factors of salmonids in the 1994-98 *Oshoro maru* research gillnet (C-gear) catches are summarized by species, age group and oceanic area (Tables 20-22). Preliminary statistical analyses of these biological data indicate that variation between stations within one year is as high as variation between years or between oceanic areas.

2. Food Habits

Diel variation in feeding habits of sockeye, chum, and pink salmon

Stomach contents of sockeye (n=215), chum (n=94), and pink (n=333) salmon collected over a 24-hour period in the central Bering Sea (57°30'N, 178°30'N, 11-12 July 1997) were analyzed to determine diel changes in prey composition and stomach content weight (Fig. 11, Davis et al. 1998a). Salmon were caught in eight gillnet sets (2-hour soak time) spaced at equal time intervals throughout the day. Sockeye (mostly immature ocean age.2) and maturing pink salmon fed on the same types of prey, including fish, squid, euphausiids, copepods, and crab larvae. Chum salmon (immature and maturing ocean ages .2 and .3) also fed on fish, squid, euphausiids, and copepods; however, their diet was more diverse, including gelatinous zooplankton (medusae, ctenophores, and salps), appendicularians, and pteropods. Sockeye salmon fed throughout the day, with a peak of feeding activity just after sunset when the predominant prey groups were copepods and euphausiids. The proportion of stomach contents in a fresh state of digestion was higher during the sunset to early morning hours. Mean prey weight and the proportion of fresh prey in sockeye salmon stomach contents decreased from mid- to late afternoon. During daylight fish and crab larvae were important prey of sockeye salmon. Pink salmon fed throughout the day, and, like sockeye salmon, had a peak in feeding activity immediately after sunset, as shown by the high prey weight and high proportion of fresh prey in their stomachs from nighttime until just after sunrise (Fig 11). Euphausiids and copepods were important prey of pink salmon during the night. There was a second peak in pink salmon feeding activity in the afternoon. In the afternoon pink salmon preyed on fish, crab larvae, and squid. Pink salmon fed on fish during all time periods. Chum salmon fed throughout the day, and prey weights were higher in chum salmon than in sockeye and pink salmon in every time interval (Fig. 11). Chum salmon exhibited a peak in feeding activity in the mid- to late afternoon (1500-1700) when fish was a major component of the diet. The proportion of fish decreased from evening through nighttime and then gradually increased again from morning to afternoon. Their diet was most diverse during the night, when they fed on a mixture of squid, euphausiids, copepods, gelatinous zooplankton, appendicularians, and unidentified material. Chum salmon fed on gelatinous zooplankton during the day and night.

Estimates of digestion rate and prey consumption

Based on diurnal sampling of stomach contents weight, estimates were made of digestion and consumption rates for sockeye, chum, and pink salmon (Davis et al. 1998a). The models used require estimation of four parameters: start time of feeding, end time of feeding, consumption rate, and digestion rate. Start and end times (and hence consumption and digestion rates) were estimated separately for different prey items because prey items vary throughout the day. Diel consumption for sockeye salmon was estimated by adjusting the summed consumption rate for individual prey items by feeding diversity for sockeye (Table 23). Consumption rates for other species will be reported later.

Sensitivity analysis of the results indicates that digestion and consumption rates are sensitive to estimated start and end times of feeding. Future experiments should include more intensive sampling at dawn and dusk, when salmon switch their types of prey.

Food habits

Shipboard analyses were conducted on stomach contents of salmon caught during the 28 April to 25 May 1998 cruise of the F/V *Great Pacific*. Stomach contents data were summarized by salmon species, region, and major prey category (Table 24). The major prey of sockeye salmon were pteropods and fish in coastal waters and squid and amphipods in offshore waters. The stomach contents of chum salmon were often too well digested to identify to major prey categories. When contents could be identified, major prey of chum salmon included gelatinous zooplankton (offshore, western and central Gulf of Alaska), pteropods (coastal, central Gulf of Alaska), and euphausiids (coastal, Unalaska Island; offshore, Central Gulf of Alaska). Amphipods and pteropods were the major prey of adult pink salmon in offshore waters (central Gulf of Alaska). Adult coho salmon fed on squid in offshore waters (central Gulf of Alaska) and fish and crab larvae in coastal waters (Washington). Chinook salmon caught in coastal areas fed primarily on fish, squid, euphausiids, and crab larvae.

Five years of sampling along a 145°W transect by the *Oshoro maru* in the central Gulf of Alaska have shown some striking differences in the food habits of salmonids in Ridge/Dilute Domain versus Subarctic Current areas (Tables 25–26). In the Subarctic Current, squid, primarily *Berryteuthis anonychus*, has been the dominant prey of all species except chum salmon, which had a much more diverse diet (primarily euphausiids, amphipods, pteropods, and gelatinous zooplankton). This corroborates the results of earlier studies, and highlights the importance of *B. anonychus* in the diets of salmon in the Subarctic Current area of the Gulf of Alaska. In the Dilute Domain, prey composition of stomach contents of sockeye, chum, and pink salmon was more diverse and the mean stomach content index (SCI; prey weight*100/body weight) was often lower than in the Subarctic Current. Coho, chinook, and steelhead tend to specialize in feeding on squid and fish, regardless of oceanic area. The first year of sampling along a 165°W transect showed some differences in salmonid food habits in the Subarctic Current compared with feeding in that same oceanographic region along 145°W (Table 27). Squid were still an important food item for all species except chum salmon, but not the dominant prey for sockeye or pink salmon, which also ate many amphipods, or steelhead, which fed primarily on fish. Food habits of sockeye, pink, and chum salmon in the Ridge Domain were similar to those found in that domain and the Dilute Domain along 145°W.

Results of shipboard examination of salmonid stomach contents on the *Wakatake maru* indicated that sockeye and pink salmon were feeding on fish, squid, euphausiids, copepods, hyperiid amphipods, ostracods, crab larvae, and pteropods (Ueno et al. 1998). The stomachs of Dolly Varden contained many of the same prey items as the pink salmon, including fish, squid, euphausiids, copepods, and hyperiid amphipods. The stomachs of chum salmon contained gelatinous zooplankton, fish, squid, euphausiids, copepods, hyperiid amphipods, pteropods, polychaetes, and appendicularia. The stomachs of coho and chinook salmon, and steelhead contained fish, squid, euphausiids, and copepods. Three-spine sticklebacks (*Gasterosteus aculeatus*) were found in the stomach contents of coho salmon and steelhead. Juvenile sculpins were found in chinook salmon stomach contents. Other coho salmon prey included phoronomid amphipods, ostracods, and pteropods. Chinook salmon and steelhead also fed on hyperiid amphipods. Other steelhead stomach contents included crab zoea and floating debris.

An analysis of feeding habits of chum salmon caught in the central Bering Sea (1991-1997) by age group indicated that ocean age .1 fish eat more amphipods than older fish (Table 28; Ishida and Davis 1998). Older chum salmon (ocean age .2 to .5) eat more gelatinous zooplankton, euphausiids and "other" prey, primarily appendicularia, ostracods, heteropods and mysids. Mean prey weight is greater in mature fish than in immature fish of the same age, ranging from 40% more for maturing ocean age .2 fish to 25% more for maturing ocean age .4 fish (Table 28). However, mean SCI is inversely related to ocean age.

3. Growth Studies

Time of scale annulus formation in chinook salmon

A large database (5,066 fish) of information on time of formation of the last ocean annulus on scales collected from coded-wire tagged chinook salmon recovered in Washington State coastal waters from 1988 to 1993 was analyzed (Hyun et al. 1998). Variation in the time of annulus formation by year, recovery age, behavioral type, recovery season, recovery area, and stock was investigated. The most important finding was that time of annulus formation varied by freshwater age or behavioral type. Chinook salmon that migrated to the ocean in their first year (freshwater age 0.) completed formation of the last ocean annulus in March, and chinook salmon that migrated to the ocean in their second year (freshwater age 1.) completed annulus formation in April (Fig. 12, Table 29). We hypothesize that inter- and intra-specific differences in time of annulus formation on salmon scales reflect differences in growth rates, regulated by feeding conditions.

Scale growth studies

Studies were conducted of growth on scales collected from salmon caught during high seas research cruises in the Gulf of Alaska. This is an extension of an earlier study of scale growth of pink and chum salmon south of the central Aleutian Islands (Walker et al. 1998c). Measurements were made of scales of chum and sockeye salmon caught by Japanese research vessels from 1982 to 1997 and examined for stomach contents. Measurements were taken to the end of each annular mark and at the edge of the scale, and to every circulus on the scale. Scale measurements (particularly growth at the edge of the scale) were then compared to indices of stomach fullness and other measures of condition and growth. Edge growth of scales from 1993-97 for ocean age .2 chum and sockeye shows no correlation with prey weight or SCI. Edge growth of scales from 1983-85/1993-95/1997 shows no correlation with stomach fullness indices. Early growth (first and second ocean years) on sockeye salmon scales shows no trend with time, but edge growth (third ocean year and edge growth variables) was less in the 1990s samples than in 1980s samples. Chum salmon scale edge growth was also slightly lower in the 1990s. In the next contract period, measurements will also be made of scales collected in the Gulf of Alaska in earlier years by U.S. and Japanese research cruises and from pink salmon for the entire period.

Russian sockeye scale time series, carbon and nitrogen isotopes, and salmon growth

In 1995, a joint study by Dr. Thomas Brown at the Lawrence Livermore National Laboratory in California, Dr. Robert Francis (School of Fisheries, UW), and Dr. Paul Quay (School of Oceanography, UW) was initiated to explore the potential for using salmon scales from different stocks in the North Pacific to reconstruct the ^{14}C and ^{13}C levels of the surface waters of the subarctic North Pacific over the last century. Preliminary measurements of 1951, 1960, and 1980 Kuril Lake sockeye salmon scales from the FRI archives were encouraging, and in April 1997 a request was sent to KamchatNIRO to provide additional samples. In response, KamchatNIRO provided FRI with an extensive time series of sockeye salmon scales from the Ozernaya River (1929, 1937-38, 1941-43, 1945, 1949, 1960-62, 1964, 1966-67, 1969, 1971, 1973, 1975-78, and 1987), Kamchatka River (1928-29, 1932, 1939, 1941-42, 1944-45, 1947-49, 1965, 1975-82, 1984-86, 1988-90), and Bolshaya River (1941, 1951-52, 1955-59, 1961, 1964-65, 1967, 1971, 1976, 1978, 1986, 1988-90). We are presently cataloging and archiving these samples for use in future salmon scale growth studies. This year a summer student intern measured a subset of the Ozernaya River samples to compare carbon and nitrogen isotope levels and scale growth. The results of this analysis will be reported later.

Growth hormone studies

The first study of blood plasma levels of insulin-like growth factor-I (IGF-I) in Pacific salmon in offshore waters of the North Pacific Ocean indicated there were significant positive correlations between body weight, liver weight, and IGF-I levels in all species except pink salmon (Myers et al. 1998c). IGF-I may be a useful measure of ocean growth rates of salmon in the North Pacific, but additional data on the significance of high or low levels of IGF-I are needed. In 1998, additional IGF-I samples were collected in February (*Kaiyo maru*) and May (*Great Pacific*) in order to expand the time of the year for which blood samples have been collected. Analysis of blood serum samples collected during cruises of the *Wakatake maru* in 1996, the *Oshoro maru* in 1996 and 1997, the *Great Pacific* in 1997 and 1998, and the *Kaiyo maru* in 1998 will be reported later.

4. Bioenergetics and Carrying Capacity

Bioenergetic modeling

Bioenergetic modeling focused on determining the differences in growth rates in maturing adult salmon in cases where size-dependent prey selection may influence growth. Analyses of food habits data from the 1980s and 1990s (Gulf of Alaska, *Oshoro maru*) indicate that prey composition varies between salmon of differing body weights within a single species. Pink salmon show the most dramatic shift, consuming an increasing proportion of squid as body weight increases (Fig. 13). Growth models that contrasted spring and summer growth of maturing pink salmon were developed for two scenarios: one in which herbivorous zooplankton is the only food available, and a second in which squid availablity increases in proportion to salmon body weight. Temperature profiles for the experiment were based on weekly average SSTs for the Gulf of Alaska (1960s).

The model indicates that by eating an increasing proportion of squid as fish body weight increases, the fish creates a "positive feedback," whereby an increase in the energy density of the diet continually increases growth rate (Fig. 14). Slow growth in the early part the season, due to lower abundance of zooplankton or squid, disrupts this positive feedback. As the season progresses differences in growth are magnified because feeding efficiency decreases with increasing water temperature. Future runs of this model will include data from archival tags to improve realism in modeling salmon thermal habitat, and different model scenarios using recent data on the decadal change in the timing of spring zooplankton blooms at Station P will be investigated.

Carrying capacity modeling

Analysis of food habits data has previously shown the importance of micronekton, especially small gonatid squids, as prey of salmon in the high seas food web of the Gulf of Alaska. In addition, bioenergetic growth models show the importance of micronekton population variation in determining the energy density of available forage and thus in determining the northeastern Pacific Ocean carrying capacity for salmon. However, sampling techniques have not provided a method for measuring squid abundance. Carrying capacity research has thus focused on three areas:

1. A statistical methodology for using salmon food habits data as an abundance index for squid was developed. Tests with simulation models of salmon (coho, sockeye, and pink salmon) foraging indicate that this index corrects for nonlinear preference and foraging effort functions in salmon foraging behavior, albeit with a measurable bias at high squid abundance. Monte Carlo estimation is currently being used to study the variance structure of this index. While this index cannot be calibrated to actual squid biomass in samples without concurrent high seas micronekton sampling, it can be used as a measure of variation in squid abundance by feeding region and time.

2. The squid abundance index and newly-assembled historical data from the 1960s, 1980s, and 1990s, which include data on zooplankton, phytoplankton, and salmon abundance, were combined with the high seas salmon food habits database to

determine sources of interannual variability in the high seas Gulf of Alaska food web. Data is currently being analyzed on local, yearly, and regional scales for evidence of density dependence and trophic cascades (Aydin m.s. 1998a). One important result is the correlation between sea surface temperature and the squid abundance index. Squid abundance decreases dramatically with increasing SST (Figure 15). This decrease occurs independently of latitude or oceanographic region, and it is significant both within and between years. The temperature range of this decrease in squid abundance is well within the thermal limits previously demonstrated for salmon stocks. Work is currently underway to see if salmon distribution shows a tighter correlation with squid than with SST, and if this can offer a bioenergetic explanation for salmon distribution. Whether squid is replaced with zooplankton prey in salmon stomachs varies with latitude and year. The interguild (multi-trophic level) predation of salmon makes it difficult to detect to what extent squid abundance determines salmon abundance, or is controlled by it. Further comparison between the 1960s and 1990s data may clarify this result.

3. Historical records of changing salmon population sizes and individual body weights were used to estimate changes in salmon prey consumption based on size-specific feeding detected in the food habits data. Records of returning central Alaskan (primarily Prince William Sound) pink salmon show that when salmon biomass more than doubles, prey consumption of herbivorous zooplankton almost triples, and squid consumption actually decreases (Fig. 16, Table 30); as fewer salmon grow large enough to consume squid, the salmon trophic level decreases from 2.46 to 2.27. Thus, as salmon numbers increase at the expense of individual size, squid may become competitors rather than prey. Lack of squid production estimates make it difficult to calibrate this effect.

In addition to the above analyses, results were obtained for a trophic model of carrying capacity based on results of three models, including the NPZ model (the nutrient-phytoplankton-zooplankton model), ECOPATH, and ECOSIM (software developed by D. Pauly, C. Walter, and V. Christensen). Results indicate that a buildup of salmon predators, especially salmon sharks, after an "upward" regime shift may have severe consequences during a "downward" regime shift, as higher populations of sharks could rapidly reduce a declining salmon biomass far below pre-1976 levels (Figure 17; Aydin m.s. 1998b). While anecdotal reports indicate a possible increase in salmon shark biomass over the past several years, little information exists on the overall importance of shark predation in determining changes in net salmon production.

Chinook life history models

A numerical life history model was developed to compare the effects of preterminal and terminal fishing intensity on the population dynamics of ocean-type chinook salmon (S. Hyun, unpublished manuscript 1998). Because gonad weight data were not available, length was used as a maturity index. The life history model is a variant of the von Foerster model, where a partial differential equation (PDE) was applied to the dynamics of blood cell populations. The chinook salmon model uses a PDE that relates abundance to fish length (maturity) and time. The model includes the rate of change in egg number with respect to time in order to connect subsequent cohorts. The sigmoid relationship between maturation rate and length was used to develop a maturation profile. Dimensions are removed by scaling. A numerical approach (rather than an analytical one) is used to solve equations with non-constant coefficients. Simulation runs were conducted for four different scenarios: (1) no fishing, (2) preterminal fishing mortality is equal to natural mortality, and no terminal fishing assumed, (3) preterminal fishing mortality is zero and terminal fishing mortality is equal to natural mortality, and (4) fish population response under different maturity schedules (precocity vs. late maturity). The simulation results showed that terminal fishing was more detrimental to ocean-type chinook salmon populations than preterminal fishing. This result can be attributed to the fecundity function in the model because the largest fish have the greatest reproductive potential. The effect of preterminal fishing was greater on late maturing fish than on precocious fish because offshore ocean residence times are shorter for precocious fish. On the basis of these results, maturation proportion is another critical parameter in this model. This model has limitations. Because the model has non-constant coefficients, there is no steady state point. Size selectivity of fishing gear is not incorporated into the model. Real data are needed to validate the model. Further development of this type of model with supporting data would provide results that could be very useful to fishery managers.

5. Research Coordination with ABL

All research by FRI in FY98 was fully coordinated with ABL. This coordination included assistance in the writing and review of research plans and results, participation of two FRI scientists (K. Myers and S. Hyun) onboard an ABL-chartered research vessel (Fig. 5; Carlson et al. 1998), provision of samples, databases, and other ocean salmon research information to ABL, and participation in an annual review by ABL (29-30 September 1998) of the results of FRI's high seas salmon research.

II. NPAFC Participation

K. Myers, R. Walker, and N. Davis participated as scientific advisors for the Committee on Scientific Research and Statistics (CSRS) at the fifth annual meeting of the NPAFC in Victoria, British Columbia, Canada, October 27-31, 1997. Seven documents were submitted or co-authored for this meeting (Carlson et al. 1997; Dahlberg et al. 1997; Mackas et al. 1997; Myers et al. 1997a,b, Nagasawa et al. 1997; Urawa et al. 1997). K. Myers was appointed as the U.S. member of the Science Sub-Committee and 1998 Rapporteur for the CSRS.

K. Myers, R. Walker, and N. Davis participated in the NPAFC Research Planning and Coordinating Meeting held in Vancouver, B.C., Canada, March 24-25, 1998.

K. Myers, R. Walker, N. Davis, K. Aydin, and S. Hyun participated in the NPAFC Workshop on Climate Change and Salmon Production held in Vancouver, Canada, March 26-27, 1998. Two presentations were made or co-authored (Aydin 1998;

Kaeriyama et al. 1998). K. Myers was technical editor of the summary report of the workshop proceedings (Myers 1998b).

K. Myers and C. Schwartz edited and produced three issues of the NPAFC Newsletter (Vol. 1 (2), Vol. 2 (1), and Vol. 2 (2)).

As a member of the Methodology Standardization Working Group, N. Davis is summarizing the methodologies used on ABL research cruises, including the cruise series of the F/V *Great Pacific* in the Gulf of Alaska and the Aleutian Islands (part of the Ocean Carrying Capacity Program), and the inshore monitoring cruise series of the NOAA ship *John N. Cobb* in southeastern Alaska (part of the U.S. GLOBEC program in the northeastern Pacific Ocean).

III. Reports, Documents, and Publications

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Aydin, K.Y. m.s. 1998a. Pacific salmon carrying capacity, ecosystem structure, and density dependent predator-prey interactions on the high seas. Paper accepted at Seventh Annual Meeting of the North Pacific Marine Science Organization (PICES), Fairbanks, October 19-23, 1998. (manuscript in prep.)

Aydin, K.Y. m.s. 1998b. Modelling and measuring the effects of biological feedback on carrying capacity and ecosystem structure in the Alaskan Gyre. Paper presented at First GLOBEC International Open Science Meeting, Paris, March 17-21, 1998. (manuscript in prep.)

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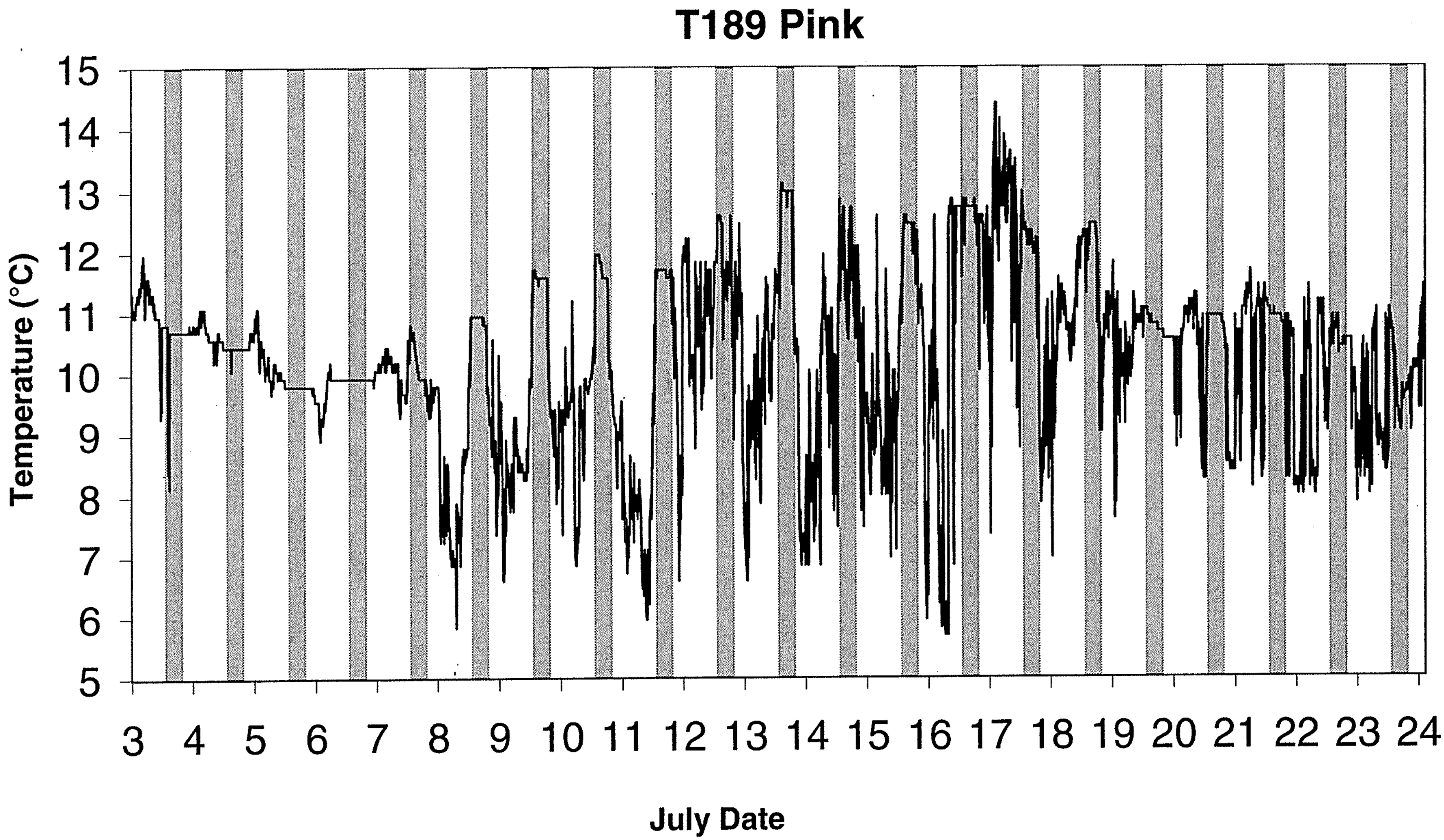


Figure 1. Temperature data from a pink salmon tagged at 56°N, 145°W on 3 July 1998 and recovered on 24 July off Cape Izhut, Afognak Island (58°06'N, 152°20'W). Data points were collected every 7.5 minutes. Shaded bars represent approximate times of local night. X-axis tick marks represent 07:43h local time (GMT -10 hrs), the approximate time of tag release.

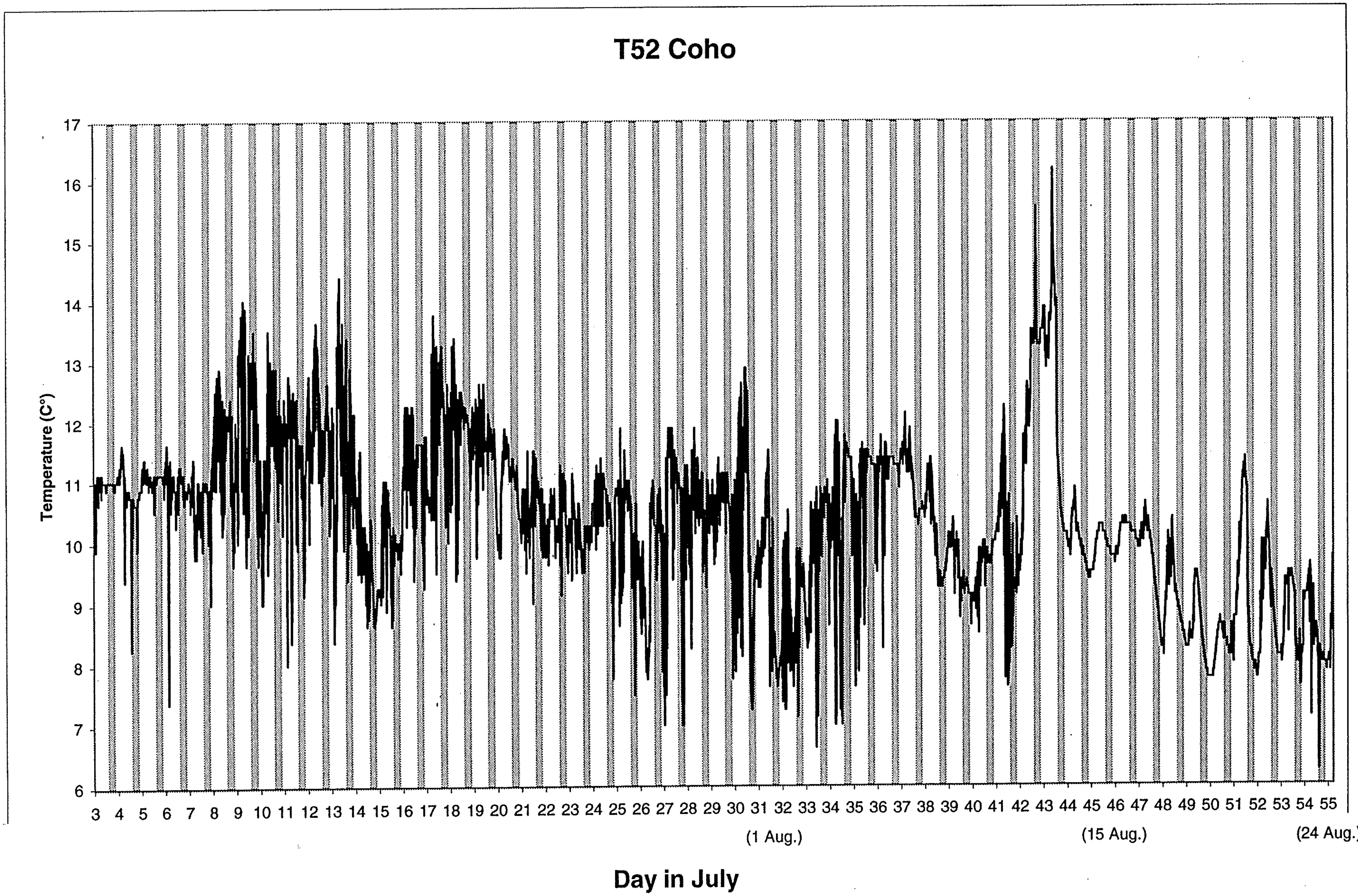


Figure 2. Temperature data from a coho salmon tagged at 56°N, 145°W on 3 July 1998 and recovered on 24 August in Togiak Bay (59°02'N, 160°20'W). Data points were collected every 15 minutes. Shaded bars represent approximate times of local night. X-axis tick marks represent 07:13h local time (GMT -10 hrs), the approximate time of tag release.

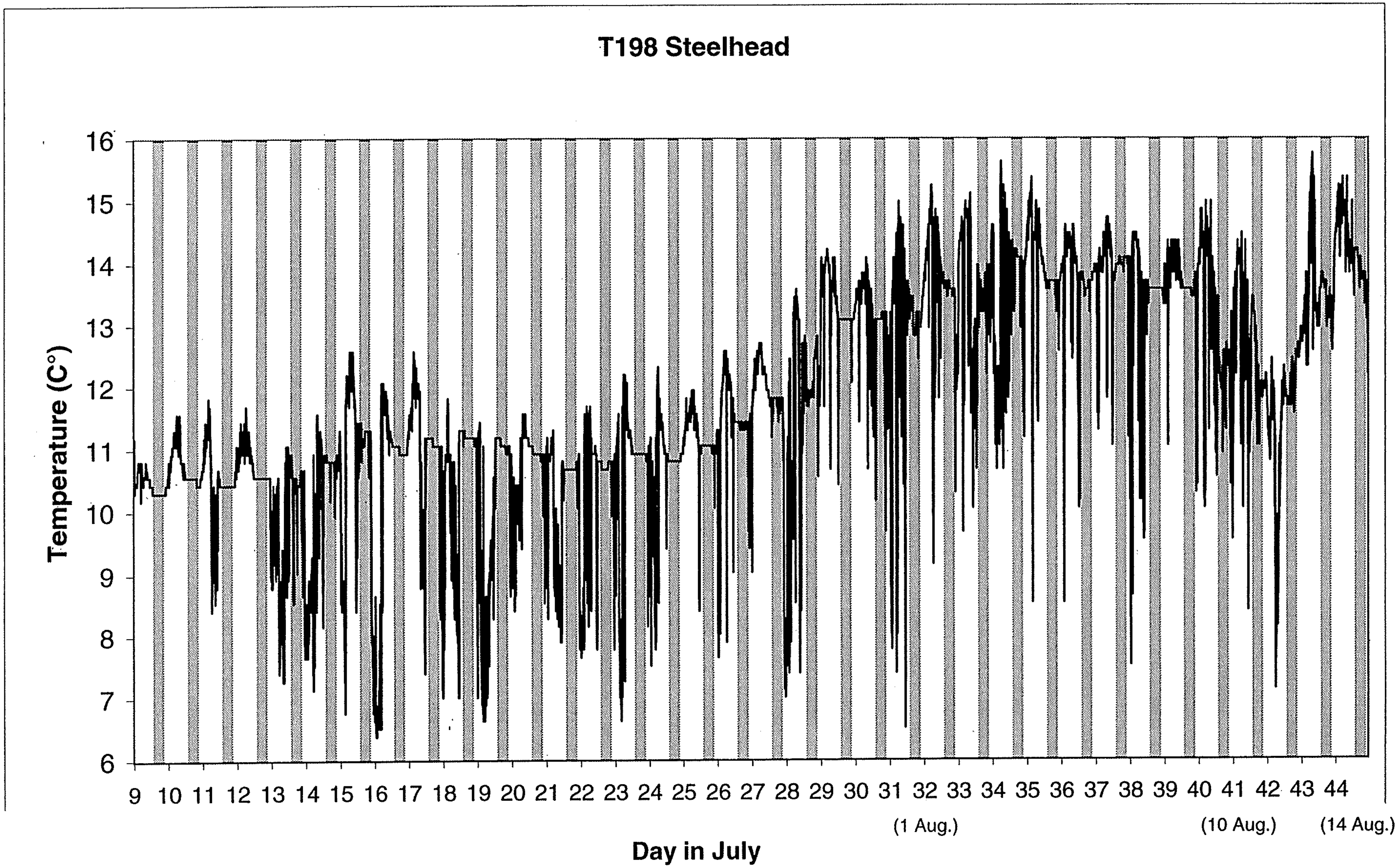


Figure 3. Temperature data from a steelhead trout tagged at 50°N, 145°W on 9 July 1998 and recovered on 14 August inside Softuk Bay, Copper River Delta (60°13'N, 144°40'W). Data points were collected every 7.5 minutes. Shaded bars represent approximate times of local night. X-axis tick marks represent 06:50h local time (GMT -10 hrs), the approximate time of tag release.

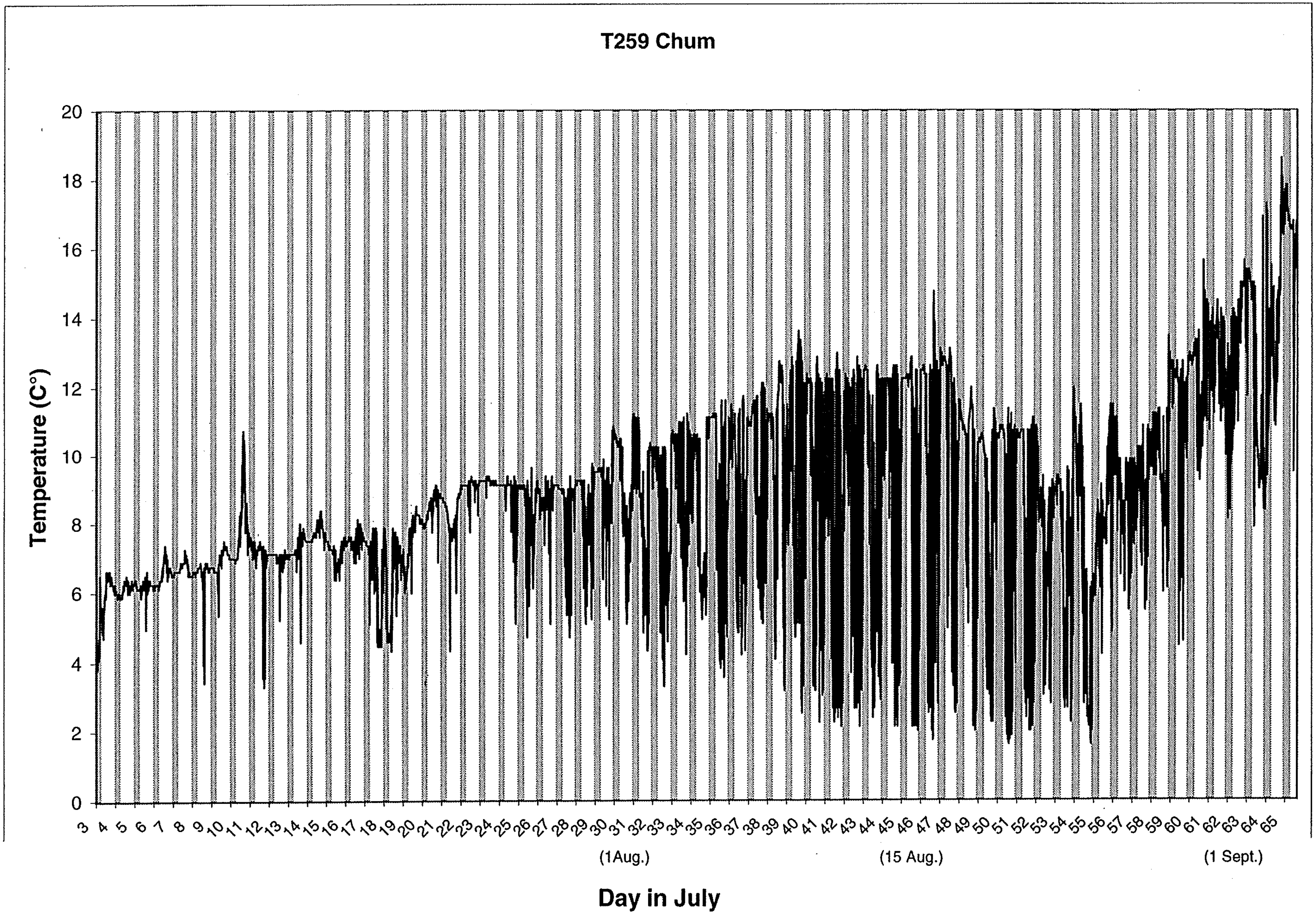


Figure 4. Temperature data from a chum salmon tagged at 52°30'N, 179°30'W on 3 July 1998 and recovered on 4 September at the mouth of the Tokachi River, Hokkaido (42°39'N, 143°31'W). Data points were collected every 15 minutes. Shaded bars represent approximate times of local night. X-axis tick marks represent 21:40h local time (GMT +12 hrs), the approximate time of tag release.

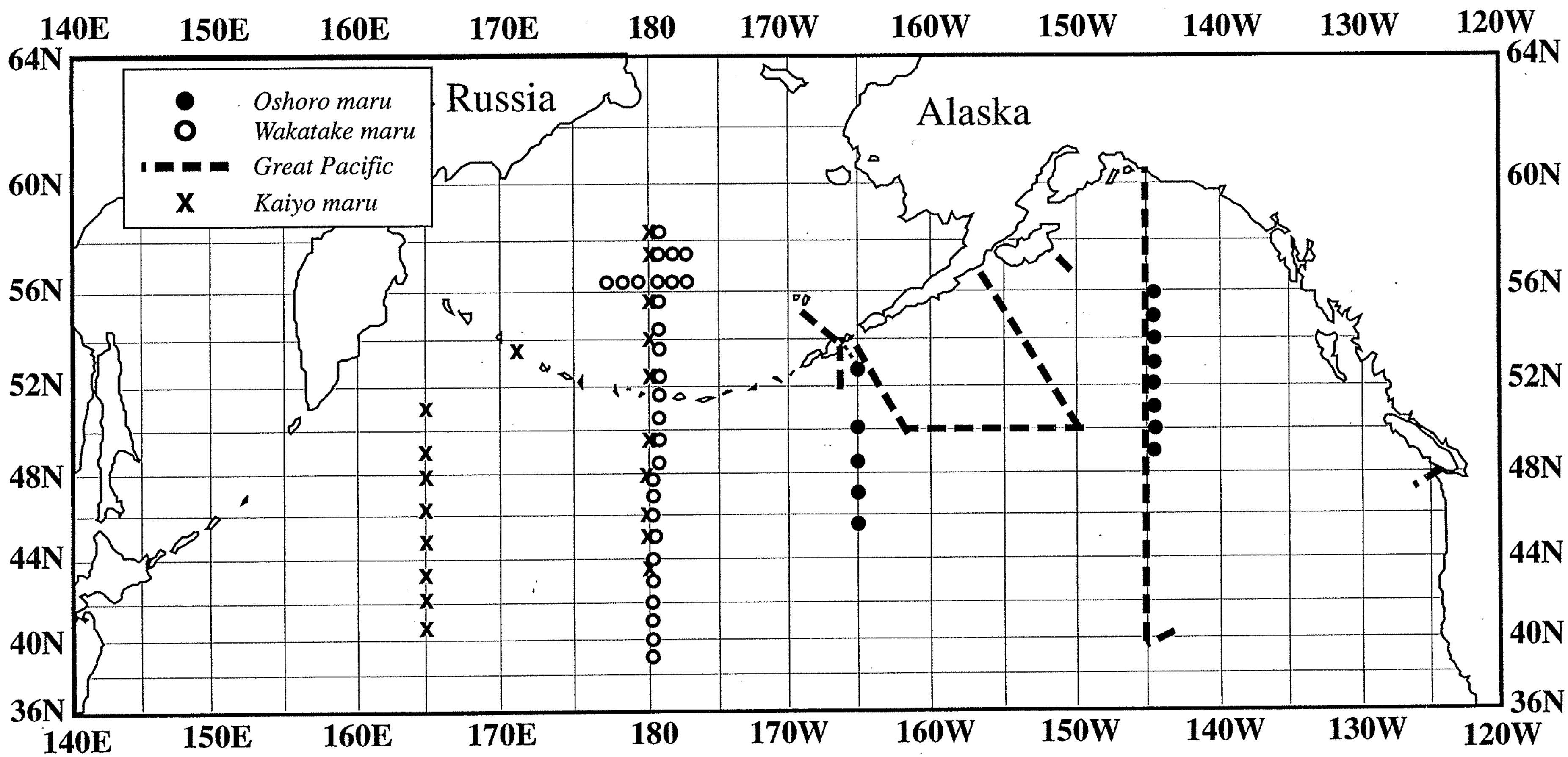
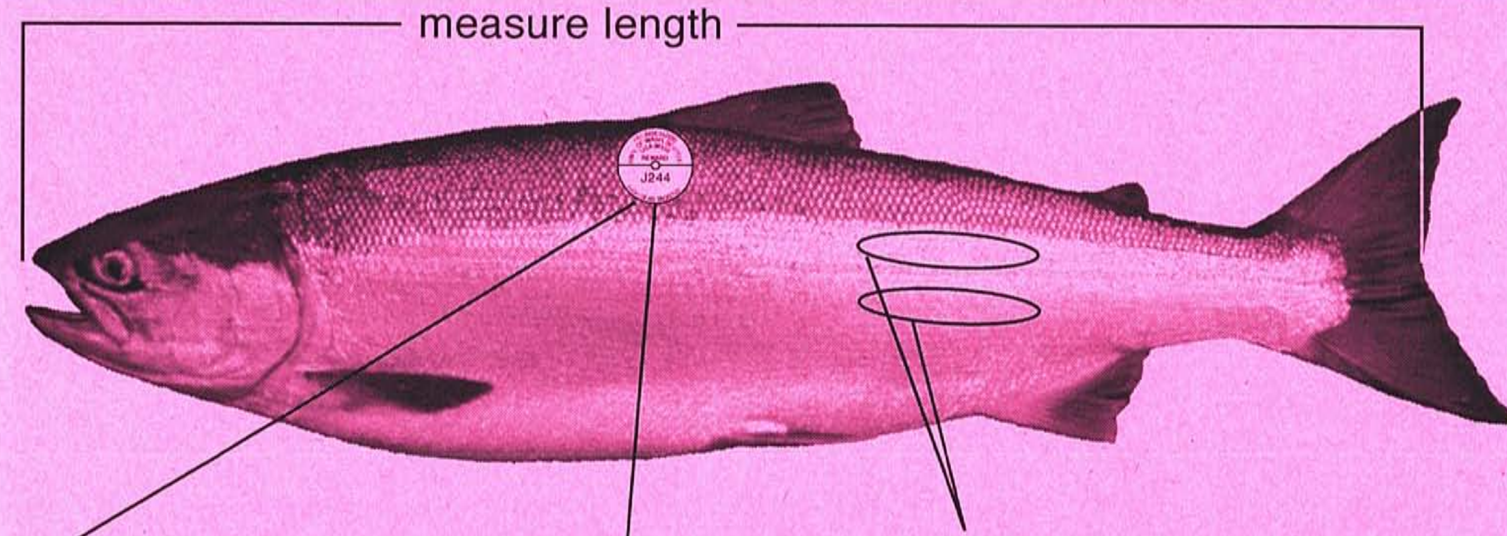


Figure 5. Sampling areas of vessels on which FRI personnel participated in salmon research, 1998.

RETURN HIGH SEAS SALMON AND STEELHEAD TAGS



scrape off scales from these areas on both sides of the fish and place the scales into a folded piece of paper

Examples of high seas disk tags

Tag color is red/white or solid red

- Collect disk tag, if tag cannot be collected then get tag number and description
- Collect temperature tag, if present
- Collect scales and carefully measure fish length as shown
- Record location, date, species, gear, sex, and weight

RETURN a high seas salmon tag (or tag number and description)

GET a custom embroidered cap as a reward

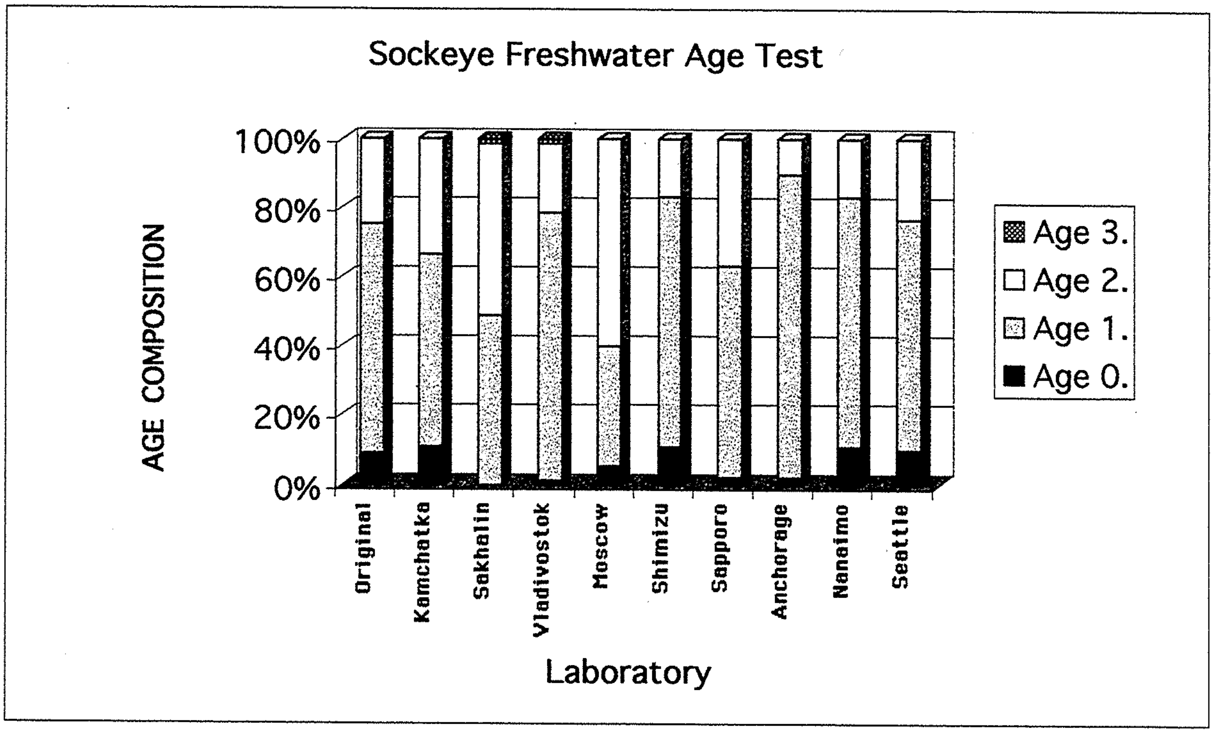
Some fish carry a temperature tag

$50 REWARD for return of an undamaged temperature tag

Send to: **High Seas Project**
University of Washington
Fisheries Research Institute
Box 357980
Seattle, WA 98195-7980

For details call: (206) 543-1101

INTERNATIONAL HIGH SEAS SALMON TAGGING



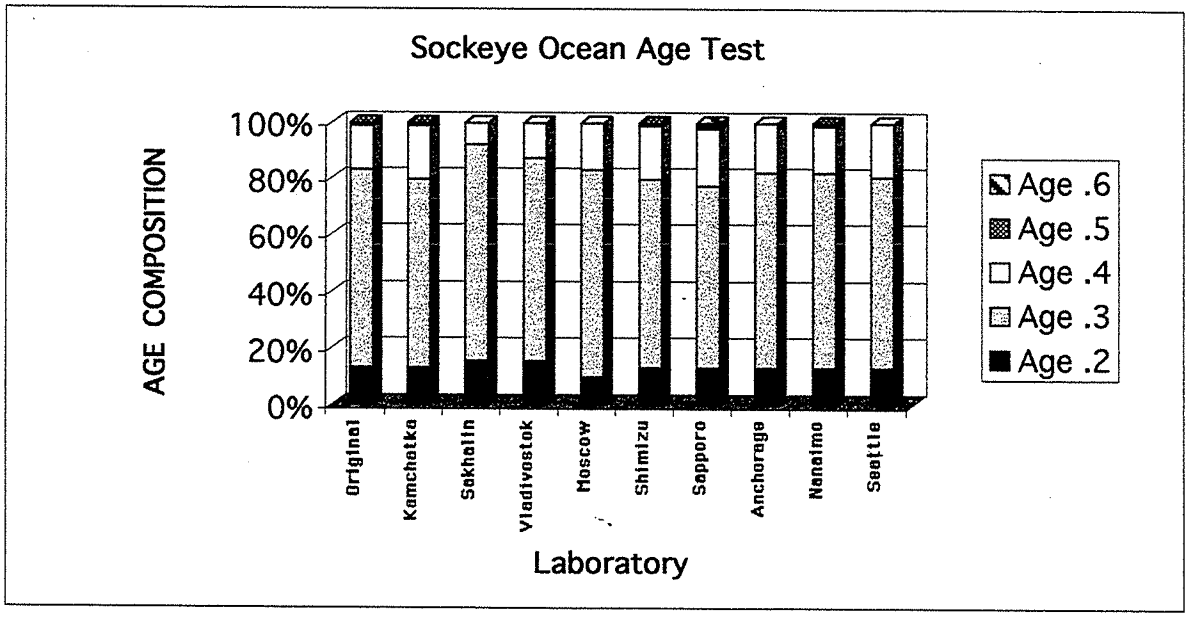


Figure 7. Results of the NPAFC sockeye salmon scale age test comparing freshwater and ocean age determinations among nine laboratories. The original samples (n = 90 fish) were from adult salmon returning to Kamchatka in June and July 1995. Comparisons with original age determinations by Kamchatka experts (chi square, $\alpha = .01$) showed no statistically significant differences in ocean ages, and significant differences in freshwater age determinations by the Sakhalin (p = .0002), Vladivostok (p = .0547), Moscow (p = .0001), Sapporo (p = .0494), and Anchorage (p = .003) laboratories.

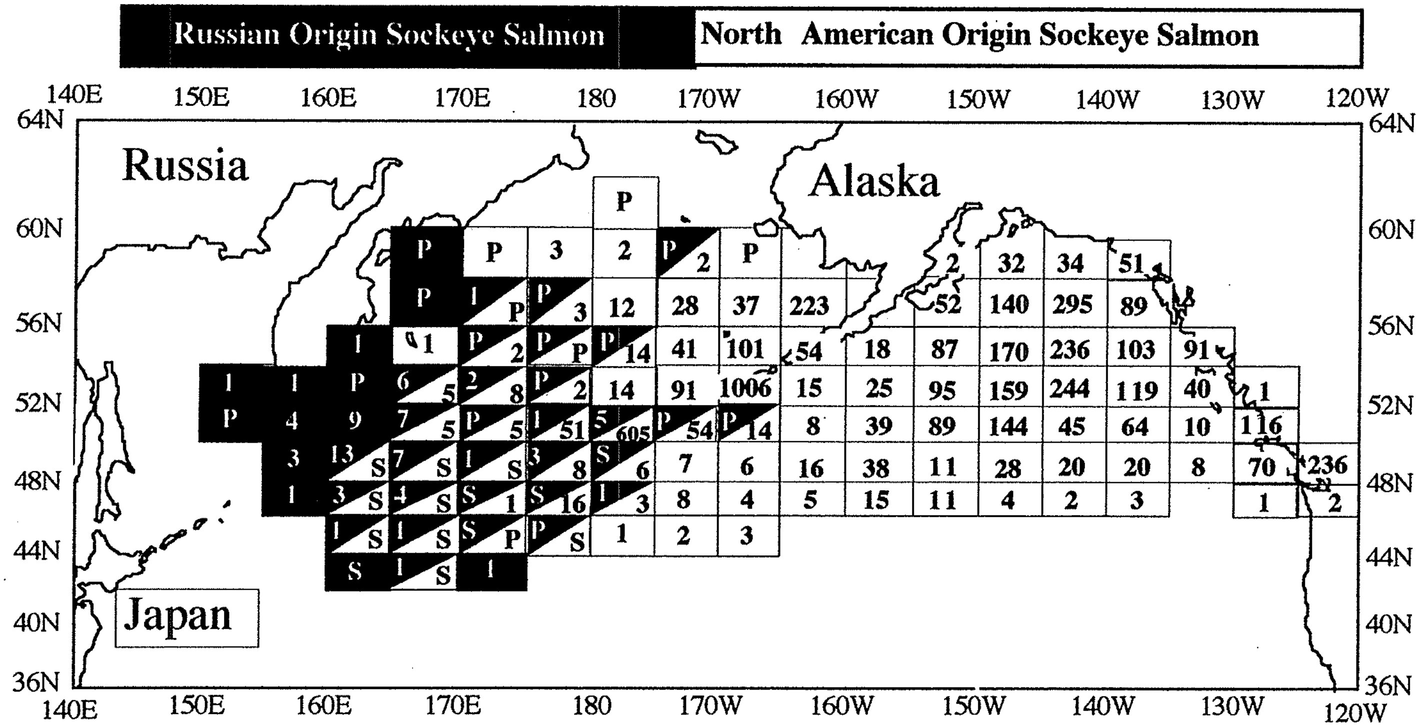


Figure 8. Ocean distribution of Russian (black areas) and North American (white areas) sockeye salmon shown by International North Pacific Fisheries Commission 2°-latitude by 5°-longitude statistical areas. If tagging experiments prove occurrence, the number of recoveries is shown. The high-seas salmon tag (1953-1997) and coded-wire tag (1983-1997) recovery databases are archived at FRI. If there is not information from tagging, then a *P* means occurrence is known from detection of stock-specific parasite "tags", and an *S* means a statistically-significant estimate for the stock group was obtained in FRI scale-pattern analyses.

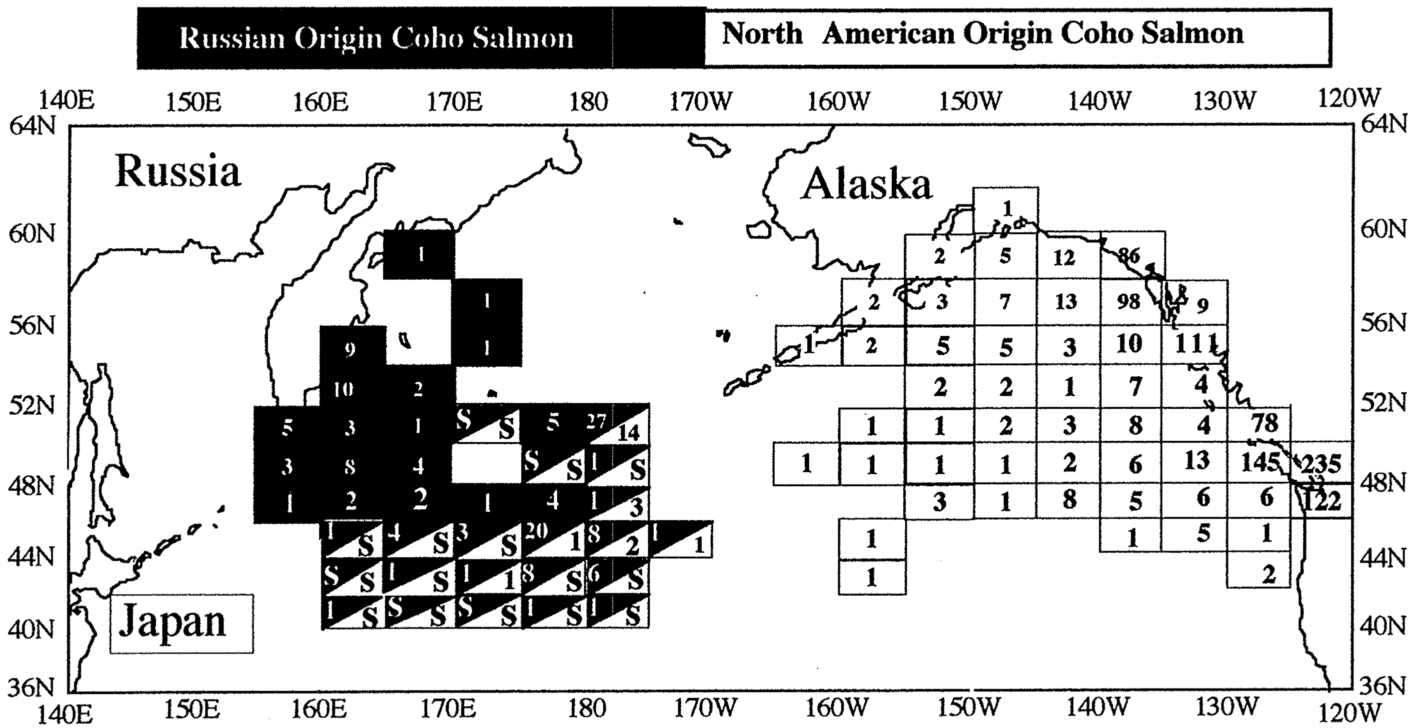


Figure 9. Ocean distribution of Russian (black areas) and North American (white areas) coho salmon shown by International North Pacific Fisheries Commission (INPFC) 2°-latitude by 5°-longitude statistical areas. If tagging experiments prove occurrence, the number of recoveries is shown. The high-seas salmon tag (1953-1997) and coded-wire tag (1983-1997) recovery databases are archived at the FRI. If there is not information from tagging, then an *s* means a statistically-significant estimate for the stock group was obtained in FRI scale-pattern analyses. Scale pattern estimates stratified by INPFC statistical subareas are applied to all 2°-latitude by 5°-longitude strata within that subarea.

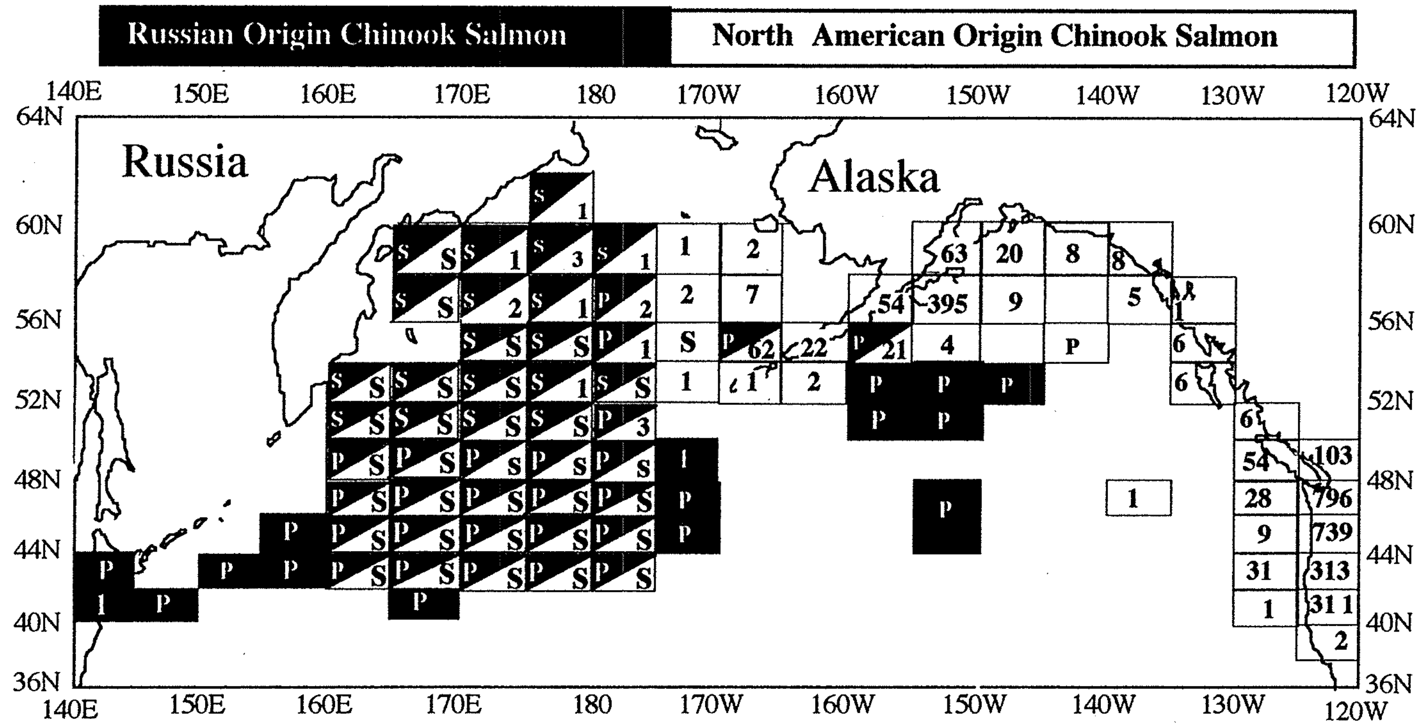


Figure 10. Ocean distribution of Russian (black areas) and North American (white areas) chinook salmon shown by International North Pacific Fisheries Commission (INPFC) 2°-latitude by 5°-longitude statistical areas. If tagging experiments prove occurrence, the number of recoveries is shown. The high-seas salmon tag (1953-1997) and coded-wire tag (1983-1997) recovery databases are archived at the FRI. If there is not information from tagging, then a *P* means occurrence is hypothesized from detection of *Myxobolus* spp. parasite "tags", and an *S* means a statistically-significant estimate for the stock group was obtained in NMFS and FRI scale-pattern analyses. Scale pattern estimates stratified by INPFC statistical subareas are applied to all 2°-latitude by 5°-longitude strata within that subarea.

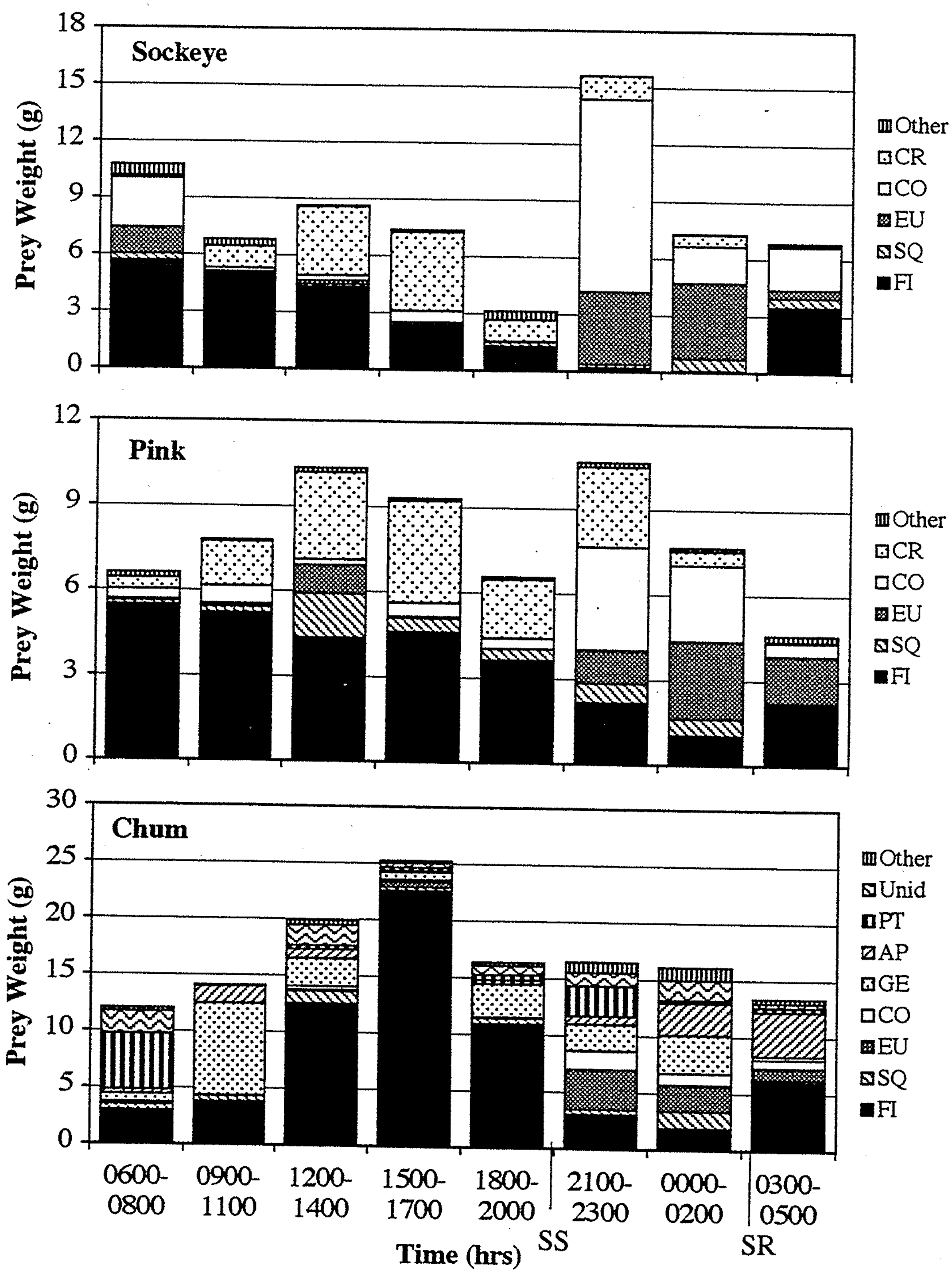


Figure 11. Mean weight (g) of each prey category observed in stomach contents of sockeye, pink, and chum salmon caught over a 24-hour period. Time (hrs) is the time period when the salmon were caught, SR=sunrise, SS=sunset. Prey categories include FI=fish, SQ=squid, EU=euphausiids, CO=copepods, CR=crab larvae, GE=gelatinous zooplankton (medusae, ctenophores, and salps), AP=appendicularians, PT=pteropods, Unid (chum)=unidentified prey, Other (sockeye and pink)=amphipods, pteropods, polychaetes, chaetognaths, appendicularians, mysids, and unidentified prey; Other (chum)=amphipods, crab larvae, polychaetes, chaetognaths, mysids.

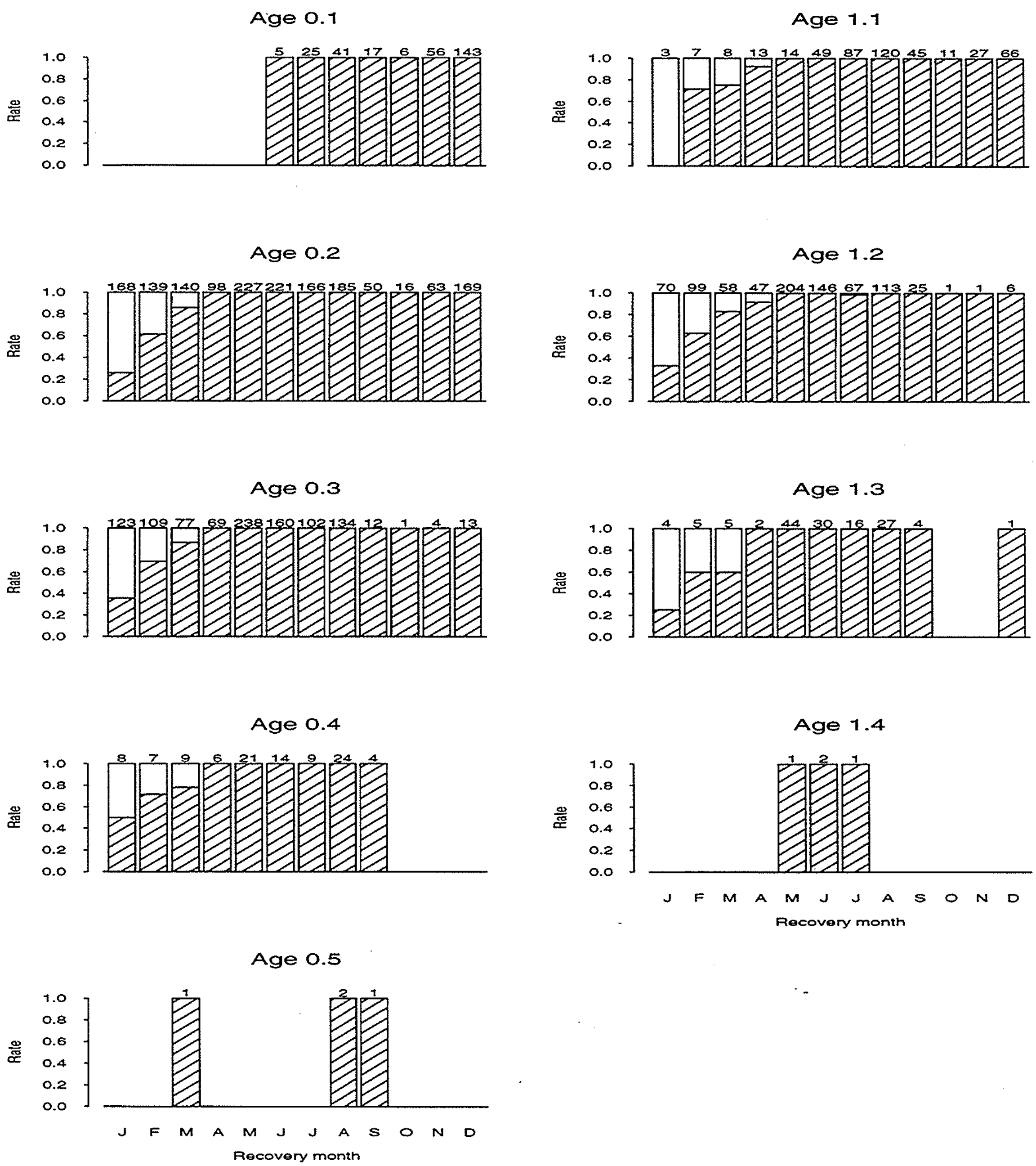


Figure 12. Age variability in time of annulus formation in chinook salmon recovered in Washington coastal waters. Recoveries are stratified by recovery age and month. Blank part indicates the portion of Lastan 1 and shaded area is the portion of Lastan 2 + 3. The number at the top of each bar represents the number of recoveries in each stratum.

☐ Lastan 1 = last annulus had not started forming.

▨ Lastan 2 + 3 = last annulus forming or completely formed.

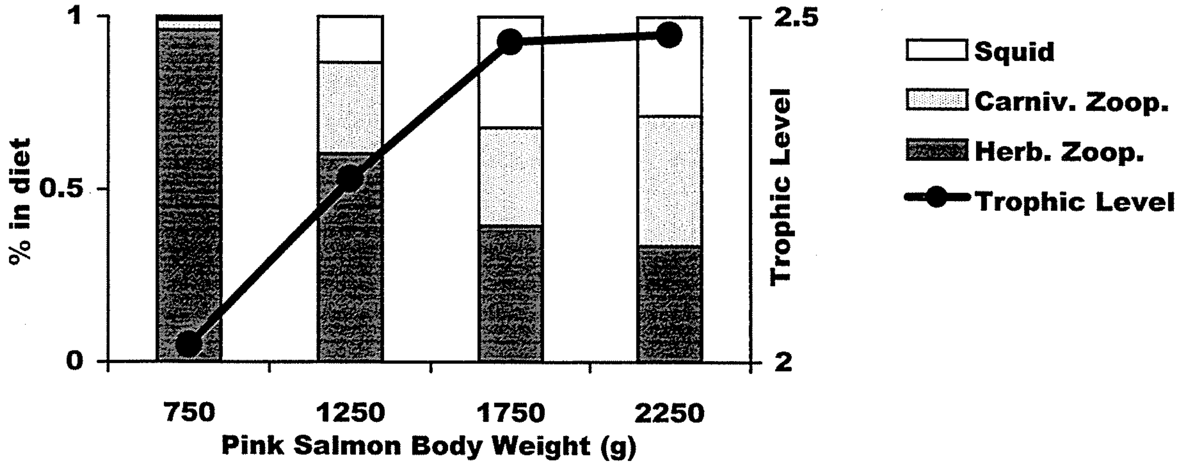


Figure 13.
Dependence of body size on feeding habits of pink salmon. Data from Alaskan Gyre food habits studies, 1980-1997. Bars show percentage of each of three trophic levels (squid, carnivorous zooplankton, and herbivorous zooplankton). Solid line shows overall trophic level of each size class of salmon. Body size reduction for average central Alaskan pink salmon across the 1976-1977 regime shift is approximately from 1,750 to 1,250 g size category.

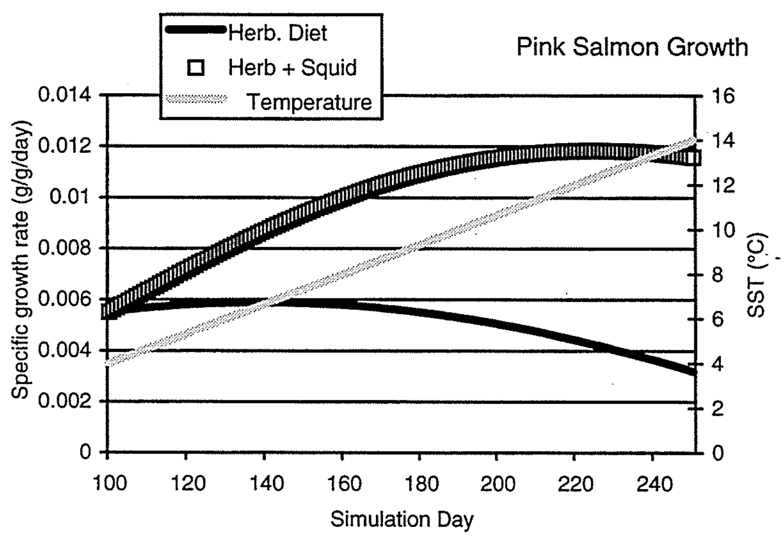


Figure 14.
Simulated pink salmon specific growth rate during season of maturation from two scenarios. Scenario 1: salmon diet consists only of herbivorous zooplankton. Scenario 2: diet switches to squid as body weight increases. Both scenarios begin in the 100th day of the year, with initial body weight 500g. Temperature used in simulation is fit to seasonal warming trend observed in NE Pacific surface waters. Specific growth rates drops as temperature increases, with greater drop evident in salmon feeding on less energy-dense prey.

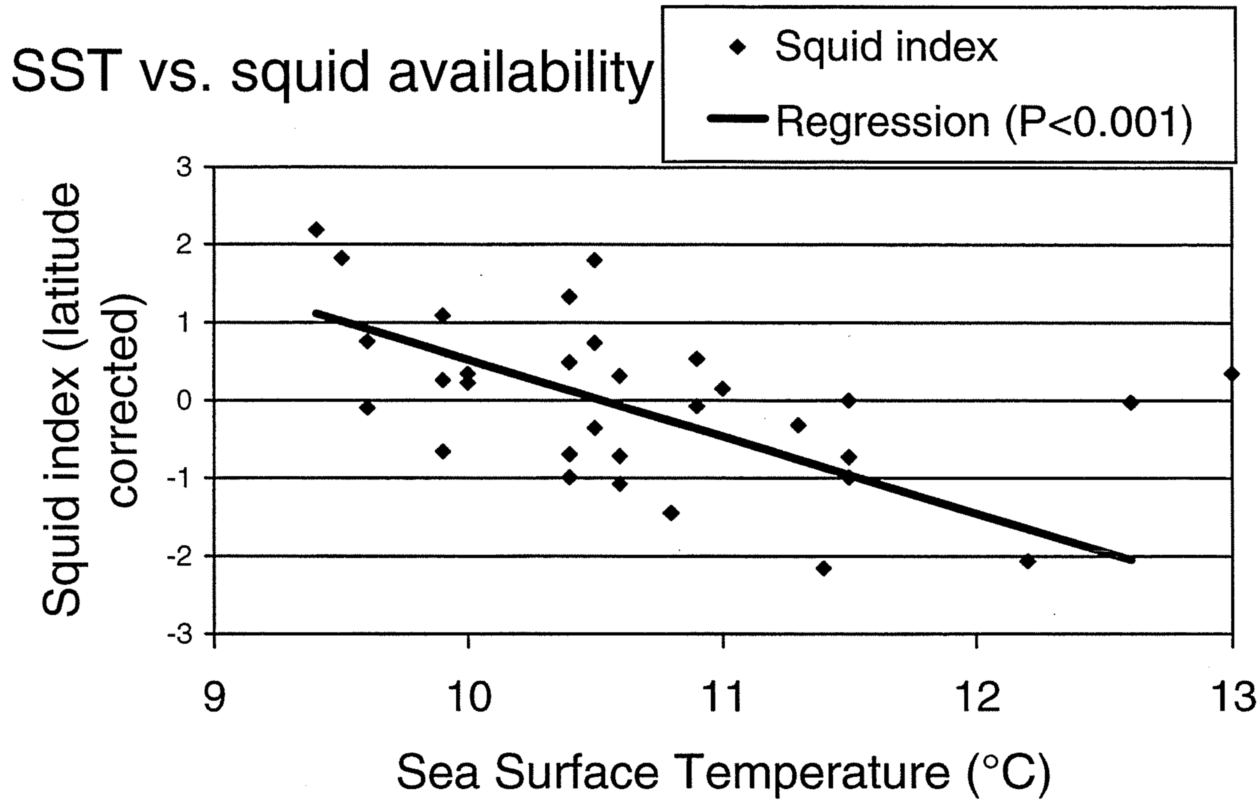


Figure 15.
Correlation between squid availability to salmon and sea surface temperature in the high seas Gulf of Alaska in July, 1980-98. Squid index is calculated by correcting % occurrence of squid in salmon stomachs for salmon species and size preferences. Index values are independent of the presence of other prey items. Latitudinal trends in abundance have also been removed. R^2 for regression is .40.

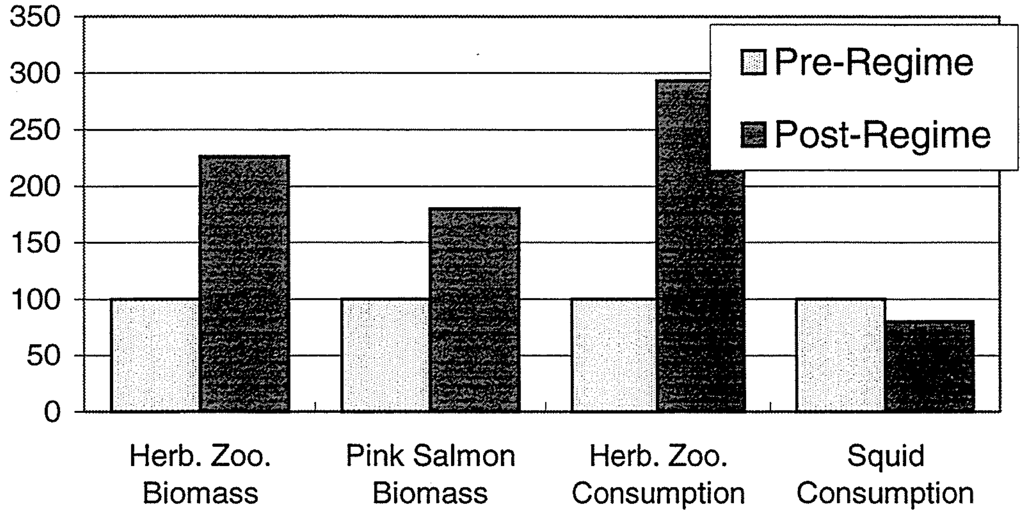


Figure 16.
Relative changes in herbivorous zooplankton biomass, central Alaskan pink salmon biomass, high seas Gulf of Alaska herbivorous zooplankton consumption, and squid consumption by maturing pink salmon, as indicated by bioenergetic modeling. All values scaled so pre-regime values=100.

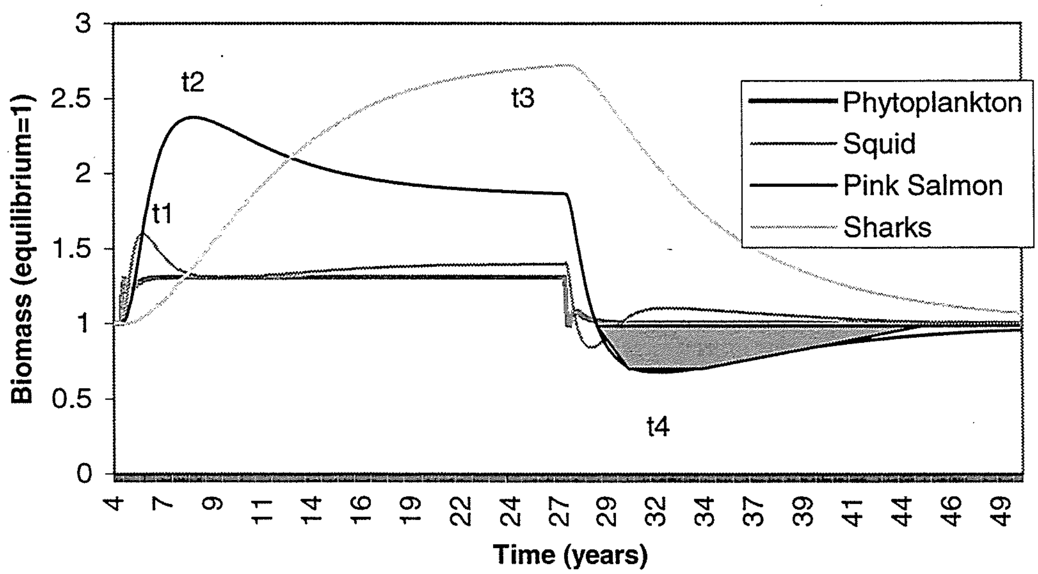


Figure 17.
Time track showing primary production, salmon prey, pink salmon, and salmon sharks during an ECOSIM regime shift experiment. Four phases of control for salmon populations are identified in the cycle: bottom-up in which production increases as the result of food availability (t1); accumulation in which salmon biomass reaches a maximum (t2); top-down in which salmon predators increase to t3; top-down "collapse" of salmon to minimum biomass (at t4) due to high predator build-up, and eventual recovery. Note the "trough" (hatched area) during which salmon biomass falls below original pre-shift values.

Table 1. Mean, standard deviation, maximum, and minimum temperatures for four temperature data tags. Statistics from chum salmon data include all data points. Statistics from other species exclude data from initial 4-5 days of adjustment to tagging trauma. Pink salmon and steeelhead data exclude final 1-5 days of anomalous behavior near coast immediately prior to capture. Tagging dates: coho (7/3/98), pink (7/3), and steelhead (7/9) in Gulf of Alaska; Chum (7/3) in central Aleutians. Recovery: coho 8/24/98 in Togiak Bay; pink 7/24 off Afognak Is.; steelhead 8/14 in Copper R. Delta; chum 9/4 at Tokachi R., Pacific coast of Hokkaido.

Temperature (°C)	Tag 52 - Coho Salmon 30 days, 15 min. intervals			Tag 189 - Pink Salmon 16 days, 7.5 min. intervals			Tag 198 - Steelhead 28 days, 7.5 min intervals			Tag 259 - Chum Salmon 63 days, 15 min. intervals		
	Day n=3,082	Night n=1457	All n=4,539	Day n=2,132	Night n=840	All n=2,972	Day n=3,567	Night n=1,741	All n=5,308	Day n=3,694	Night n=2,317	All n=6,011
Mean	10.40	10.25	10.35	9.74	11.56	10.25	11.73	12.07	11.84	8.30	9.47	8.75
Std. Dev.	1.37	1.38	1.38	1.61	0.82	1.65	2.07	1.27	1.85	2.72	2.57	2.72
Maximum	16.21	15.57	16.21	14.41	13.13	14.41	15.64	14.36	15.64	18.62	17.84	18.62
Minimum	6.62	6.24	6.24	5.70	8.78	5.70	6.38	8.54	6.38	1.61	1.61	1.61

Table 2. Percent of data at each temperature for four temperature data tags. Percentages from chum salmon data include all data points. Percentages from other species exclude data from initial 4-5 days of adjustment to tagging trauma. Pink salmon and steelhead data exclude final 1-5 days of anomalous behavior near coast immediately prior to capture. Tagging dates: coho (7/3/98), pink (7/3), and steelhead (7/9) in Gulf of Alaska; chum (7/3) in central Aleutians. Recovery: coho 8/24/98 in Togiak Bay; pink 7/24 off Afognak Is.; steelhead 8/14 in Copper R. Delta; chum 9/4 at Tokachi R., Pacific coast of Hokkaido.

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1										0.3%	0.0%	0.2%
2										3.0%	0.5%	2.0%
3										2.6%	0.5%	1.8%
4										3.5%	1.8%	2.8%
5				0.8%	0.0%	0.6%				5.2%	2.8%	4.3%
6	0.0%	0.1%	0.1%	3.9%	0.0%	2.8%	1.4%	0.0%	1.0%	18.3%	11.8%	15.8%
7	3.0%	3.0%	3.0%	8.6%	0.0%	6.2%	3.9%	0.0%	2.6%	16.5%	12.8%	15.1%
8	11.5%	16.1%	12.9%	21.2%	0.1%	15.2%	8.6%	0.2%	5.8%	14.5%	9.9%	12.7%
9	20.5%	23.3%	21.4%	19.7%	2.0%	14.7%	4.5%	0.3%	3.2%	12.8%	18.3%	14.9%
10	33.1%	25.0%	30.5%	23.8%	35.6%	27.1%	14.4%	27.8%	18.8%	6.9%	16.8%	10.7%
11	19.5%	21.9%	20.3%	14.4%	31.7%	19.3%	23.7%	29.6%	25.7%	5.8%	8.2%	6.7%
12	8.0%	7.5%	7.9%	5.4%	26.4%	11.4%	10.7%	4.0%	8.5%	5.8%	11.0%	7.9%
13	3.6%	3.0%	3.4%	1.8%	4.2%	2.5%	16.9%	34.6%	22.7%	1.9%	0.9%	1.5%
14	0.6%	0.1%	0.4%	0.2%	0.0%	0.2%	14.7%	3.4%	11.0%	1.5%	1.0%	1.3%
15	0.1%	0.1%	0.1%				1.2%	0.0%	0.8%	0.5%	1.5%	0.9%
16	0.0%	0.0%	0.0%							0.6%	1.1%	0.8%
17										0.2%	0.9%	0.5%
18										0.1%	0.0%	0.0%

Table 3. Preliminary release and recovery information for cooperative Japan-U.S. tags returned from 1 September 1997 to 15 September 1998. A blank indicates the information is not available. LL = longline, GN = gillnet, PS = purse seine. Age designation is European method, first number is number of freshwater annuli, second number is number of ocean annuli, S = spawning check. FL = fork length. TL = total length. BW = body weight.

U.S. Tag. No.	Japan Tag No.	Release Date	Release Lat (°N)	Release Long	Release 2° X 5° Area	Release Gear	Release FL (mm)	Release Age	Recovery Date	Recovery Lat (°N)	Recovery Long	Recovery Area Code	Recovery Gear	Recovery Sex	Recovery FL (mm)	Recovery BW (g)	Recovery Gonad (g)	Recovery Age	Recovery Location
A. Chum salmon																			
LL0102	LL4102	04-Jul-97	53°30	179°30W	W8052	LL	584	0.4	29-Sep-97	42°20	140°40E	02-1	Setnet	M	615	2300	119	0.4	Otobe Coast, Funka Bay, Pacific Ocean, Hokkaido, Japan
LL0103	LL4103	04-Jul-97	53°30	179°30W	W8052	LL	552	0.3	18-Oct-97	44°00	145°00E	02-2	Setnet	M	-	3300	-	-	Shiretoko Coast, Okhotsk Sea, Hokkaido, Japan
LL0115	LL4115	04-Jul-97	53°30	179°30W	W8052	LL	519	0.3	21-Oct-97	43°13	145°33E	02-1	Setnet	M	-	-	-	-	Konbumori Coast, Pacific Ocean, Hokkaido, Japan
LL0178	LL4178	05-Jul-97	54°30	179°30W	W8054	LL	618	0.3	22-Sep-97	45°16	142°14E	02-2	Setnet	M	640	2500	-	-	Sarufutsu Coast, Okhotsk Sea, Hokkaido, Japan
LL0278	LL4278	07-Jul-97	56°30	179°30W	W8056	LL	561	0.3	10-Sep-97	43°40	145°08E	02-0	Setnet	M	600	2480	158.6	0.3	Shibetsu Coast, Nemuro Strait, Hokkaido, Japan
LL0279	LL4279	07-Jul-97	56°30	179°30W	W8056	LL	679	0.4	05-Sep-97	45°16	142°14E	02-2	Setnet	M	650	3640	-	-	Sarufutsu Coast, Okhotsk Sea, Hokkaido, Japan

Table 3. continued

U.S. Tag. No.	Japan Tag No.	Release Date	Release Lat (°N)	Release Long	Release 2° X 5° Area	Release Gear	Release FL (mm)	Release Age	Recovery Date	Recovery Lat (°N)	Recovery Long	Recovery Area Code	Recovery Gear	Recovery Sex	Recovery FL (mm)	Recovery BW (g)	Recovery Gonad (g)	Recovery Age	Recovery Location
A. Chum salmon. continued.																			
LL0340	LL4340	08-Jul-97	57°30	179°30W	W8056	LL	560	0.3	11-Oct-97	40°36	141°30E	01-0	Trap	-	TL = 640	2100	-	-	Oirase River, Aomori Prefecture, Pacific Coast, Honshu, Japan
LL0343	LL4343	08-Jul-97	57°30	179°30W	W8056	LL	571	0.3	26-Sep-97	42°57	144°04E	02-1	Setnet	F	560	2100	301.8	0.3	Shiranuka Coast, Pacific Ocean, Hokkaido, Japan
LL0346	LL4346	08-Jul-97	57°30	179°30W	W8056	LL	595	0.3	09-Oct-97	43°23	144°17E	02-0	Setnet	M	600	2350	90.8	0.3	Bekkai Coast, Nemuro Strait, Hokkaido, Japan
LL0441	LL4441	10-Jul-97	57°30	178°30W	W8056	LL	549	0.3	20-Sep-97	43°40	145°08E	02-0	Setnet	M	590	2350	131.7	0.3	Shibetsu Coast, Nemuro Strait, Hokkaido, Japan
LL0581	LL4581	14-Jul-97	56°30	178°30W	W8056	LL	483	0.2	03-Nov-97	43°40	145°08E	02-0	Setnet	M	540	1400	-	0.2	Shibetsu Coast, Nemuro Strait, Hokkaido, Japan
LL0704	LL4704	16-Jul-97	56°30	178°30E	E7556	LL	484	0.2	14-Oct-97	43°23	144°17E	02-0	Setnet	M	525	1450	76.7	0.2	Bekkai Coast, Nemuro Strait, Hokkaido, Japan
LL2170, thermal tag (Kiwi) no. 259	MM1222	03-Jul-98	52°30	179°30W	W8052	LL	622	0.3	04-Sep-98	42°39	143°31E	02-1	Setnet	M	650	3000	-	0.3	Near mouth of Tokachi River, Pacific Coast, Hokkaido, Japan

Table 3. Continued.

U.S. Tag No.	Japan Tag No.	Release							Recovery										
		Date	Lat (°N)	Long	2° X 5° Area	Gear	FL (mm)	Age	Date	Lat (°N)	Long	Area Code	Gear	Sex	FL (mm)	BW (g)	Gonad (g)	Age	Location
A. Chum salmon. continued.																			
LL2281, archival tag (NWMT) no. 256	MM1333	05-Jul-98	54°30	179°30W	W8054	LL	670	0.4	10-Sep-98	43°23	145°48E	02-0	Setnet	F	690	3700	600	0.4	Shibetsu Coast, Nemuro Strait, Hokkaido, Japan
B. Pink salmon																			
LL1165, thermal tag (Kiwi) no. 189	DD6565	03-Jul-98	55°59	145°00W	W4554	LL	495	0.1	24-Jul-98	58°06	152°20W	56-3	PS			1400			Cape Izhut, Afognak Island, central Alaska, USA
C. Coho salmon																			
LL1156, thermal tag (Kiwi) no. 52	DD6556	03-Jul-98	55°59	145°00W	W4554	LL	592	1.1	24-Aug-98	59°02	160°20W	45-0	GN	M	~610	~3200			Togiak Bay, western Alaska, USA
D. Steelhead																			
LL1179, thermal tag (Kiwi) no. 198	DD6579	09-Jul-98	49°58	144°58W	W4548	LL	690	2.1S1	14-Aug-98	60°13	144°40W	60-0	GN	M		~3360		2.1S1	Softuk Bar, southeast tip of Copper R. Delta, central Alaska, USA

Table 4. Snouts recovered from fin-clipped salmonids by the Japanese salmon research vessel *Wakatake maru* (R32), summer 1998. N=24. Gear: B=surface longline; A and C=research gillnet, followed by mesh size (mm). Clipped fin: AD=adipose fin, LVentral=left ventral fin, RPectoral=right pectoral fin, LPelvic=left pelvic fin.

Sample No.	Date (yrmoday)	Location	Gear	Species	Fork Length (mm)	Body Weight (g)	Sex	Gonad Weight (g)	Clipped Fin
9-5	980623	43°00'N180°00'	C082	steelhead	508	1320	F	5	Ad
13-5	980623	43°00'N180°00'	C106	steelhead	462	1600	M	3	Ad, LVentral
21-8	980625	44°00'N180°00'	C121	steelhead	576	1840	M	3	Ad
22-17	980625	44°59'N180°00'	B	steelhead	580	1820	M	5	Ad
22-27	980625	44°59'N180°00'	B	steelhead	534	1440	F	5	Ad
27-9	980626	45°00'N180°00'	C138	steelhead	762	4250	M	12	Ad
33-4	980626	45°00'N180°00'	A115	steelhead	538	1390	M	2	Ad
33-5	980626	45°00'N180°00'	A115	steelhead	582	1680	M	1	Ad
42-10	980627	46°00'N180°00'	A115	steelhead	526	1280	F	5	Ad
42-14	980627	46°00'N180°00'	A115	steelhead	640	2520	F	26	Ad
49-7	980627	47°00'N180°00'	B	steelhead	592	2000	F	3	Ad
53-8	980628	47°00'N180°00'	C138	steelhead	680	2900	F	25	Ad
55-12	980628	47°00'N180°00'	A115	steelhead	740	4300	M	2	Ad
55-13	980628	47°00'N180°00'	A115	steelhead	680	3300	F	62	Ad
55-14	980628	47°00'N180°00'	A115	steelhead	654	3050	M	2	Ad
55-15	980628	47°00'N180°00'	A115	steelhead	670	2450	F	38	Ad
55-16	980628	47°00'N180°00'	A115	steelhead	582	1620	M	4	Ad, RPectoral
66-18	980628	47°30'N180°00'	B	steelhead	590	2100	F	7	Ad
71-9	980629	47°30'N180°00'	C121	steelhead	664	2400	F	54	Ad
73-4	980629	47°30'N180°00'	C082	steelhead	576	2100	F	15	Ad
76-14	980629	47°30'N180°00'	A115	steelhead	716	3650	M	10	Ad
76-16	980629	47°30'N180°00'	A115	steelhead	656	3000	F	24	Ad
76-17	980629	47°30'N180°00'	A115	steelhead	691	3450	F	40	Ad
76-18	980629	47°30'N180°00'	A115	steelhead	544	1680	F	14	Ad, LPelvic

Table 5. Snouts collected from salmonids without adipose fins caught by T/S *Oshoro maru*, 1998. Gear: A=commercial mesh gillnet; C=varied mesh gillnet; followed by mesh size (mm). N=46 (35 steelhead, 6 coho, 2 sockeye, 2 chum, and 1 chinook)

Species	Gillnet station	Date	Latitude	Longitude	Gear	Fork Length (mm)	Weight (g)	Sex	Gonad weight (g)
Steelhead	9802	6/13/98	43°00'N	180°00'	A121	570	1660	M	3
Steelhead	9802	6/13/98	43°00'N	180°00'	A121	555	1740	F	10
Steelhead	9802	6/13/98	43°00'N	180°00'	C048	565	1780	M	2
Steelhead	9802	6/13/98	43°00'N	180°00'	C106	560	1740	M	5
Steelhead	9802	6/13/98	43°00'N	180°00'	C138	725	3450	F	48
Steelhead	9803	6/14/98	45°00'N	180°00'	C106	720	2550	M	2
Steelhead	9803	6/14/98	45°00'N	180°00'	C121	695	3400	M	21
Steelhead	9803	6/14/98	45°00'N	180°00'	C138	650	2600	F	20
Steelhead	9806	6/27/98	48°30'N	165°00'W	A115	580	2020	M	14
Steelhead	9806	6/27/98	48°30'N	165°00'W	A115	605		M	5
Steelhead	9806	6/27/98	48°30'N	165°00'W	C093	521	1300	F	11
Steelhead	9808	6/29/98	45°30'N	165°00'W	C093	573	1940	F	32
Chum	9809	7/3/98	56°00'N	145°00'W	A115	614	2480	M	1
Coho	9809	7/3/98	56°00'N	145°00'W	A121	614	3150	F	61
Steelhead	9810	7/4/98	55°00'N	145°00'W	C055	358	480	F	4
Coho	9810	7/4/98	55°00'N	145°00'W	C121	634	3550	F	51
Coho	9811	7/5/98	54°00'N	145°00'W	A115	608	3400	F	135
Steelhead	9811	7/5/98	54°00'N	145°00'W	A115	615	2760	F	26
Chinook	9811	7/5/98	54°00'N	145°00'W	A121	596	3150	F	23
Coho	9811	7/5/98	54°00'N	145°00'W	C055	648	3800	M	16
Sockeye	9811	7/5/98	54°00'N	145°00'W	C121	575	2600	M	92
Sockeye	9811	7/5/98	54°00'N	145°00'W	C138	632	3650	M	96
Coho	9812	7/6/98	53°00'N	145°00'W	A121	613	2840	F	32
Steelhead	9812	7/6/98	53°00'N	145°00'W	C072	339	440	M	1
Chum	9813	7/7/98	52°00'N	145°00'W	A115	473	1300	F	14
Steelhead	9813	7/7/98	52°00'N	145°00'W	C055	313	320	M	1
Steelhead	9813	7/7/98	52°00'N	145°00'W	C055	313	300	M	1
Steelhead	9813	7/7/98	52°00'N	145°00'W	C063	321	325	F	2
Steelhead	9813	7/7/98	52°00'N	145°00'W	C063	369	580	F	2
Steelhead	9813	7/7/98	52°00'N	145°00'W	C072	323	310	F	1
Steelhead	9813	7/7/98	52°00'N	145°00'W	C072	321	330	M	1
Steelhead	9813	7/7/98	52°00'N	145°00'W	C072	320	290	M	1
Coho	9813	7/7/98	52°00'N	145°00'W	C082	622	3350	F	32
Steelhead	9814	7/8/98	51°00'N	145°00'W	A121	604	3200	M	40
Steelhead	9814	7/8/98	51°00'N	145°00'W	C063	334	440	M	1
Steelhead	9814	7/8/98	51°00'N	145°00'W	C063	321	290	M	1
Steelhead	9814	7/8/98	51°00'N	145°00'W	C063	353	390	M	1
Steelhead	9814	7/8/98	51°00'N	145°00'W	C072	331	340	M	1
Steelhead	9815	7/9/98	50°00'N	145°00'W	A115	*			
Steelhead	9815	7/9/98	50°00'N	145°00'W	CO55	300	255	F	4
Steelhead	9815	7/9/98	50°00'N	145°00'W	C063	**			
Steelhead	9815	7/9/98	50°00'N	145°00'W	C093	548	1920	F	9
Steelhead	9816	7/10/98	49°00'N	145°00'W	A115	653	3100	M	52
Steelhead	9816	7/10/98	49°00'N	145°00'W	A121	608	2640	M	21
Steelhead	9816	7/10/98	49°00'N	145°00'W	C121	612	2660	M	7
Steelhead	9816	7/10/98	49°00'N	145°00'W	C138	612	2780	F	22

* no data taken; head only recovered from net; may not be ad-clipped

** no data taken; head and body were separated

Table 6. Release and recovery information for coded-wire tagged chinook salmon recovered from the North Pacific Ocean and Bering Sea, 1 September 1997 through 31 August 1998. TSFT = tip of snout to fork of tail. Agency codes: ADFG=Alaska Dept. Fish and Game, CDFG = California Department of Fish and Game, CDFO = Canada Dept. of Fisheries and Oceans, COOP = Washington Dept. of Fisheries-Coop., MIC = Metlakatla Indian Community, MUCK = Muckleshoot Tribe, NSRA = Northern Southeast Regional Aqualture Assoc., ODFW = Oregon Dept. Fish and Wildlife, QDNR = Quinault Dept. Natural Resources, SUQ = Suquamish Indian Tribe, WDFW = Washington Dept. Fish and Wildlife.

RELEASE									RECOVERY														
					TOTAL											BODY SIZE		GONAD				
TAG	BROOD		STATE/		NO.	DATE			DATE			LAT		LONG		TSFT	WT		WT			
CODE	YEAR	RELEASE SITE	PROV	AGENCY	TAGGED	Y	M	D	Y	M	D	D	M	D	M	(mm)	(g)	Sex	(g)	GEAR	SPECIES	OCEANIC REGION
021043	91	BABINE R, UPPER	BC	CDFO	15861	93	05	05	96	02	15	AREA_517				690	4000	M		TRAWL	CHINOOK	BERING_SEA
044133	92	TAIYA INLET 115-34	AK	NSRA	11818	94	05	20	96	04	11	54	52	158	14 W	635	3400	F		TRAWL	CHINOOK	GULF_OF_ALASKA
062528	94	YUBA CITY	CA	CDFG	53486	95	05	18	96	07	23	48	22	124	53 W	440	1250	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
070755	93	BIG CR - L COL. R	OR	ODFW	54731	94	08	04	96	07	23	48	17	125	02 W	530	1650	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
180212	94	CHILLIWACK RIVER	BC	CDFO	24677	95	06	07	96	07	27	48	23	124	51 W	546	1020	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
180213	94	STAVE RIVER	BC	CDFO	24930	95	05	29	96	07	29	48	22	125	01 W	450	1050	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
180738	92	FEE CHANNEL	BC	CDFO	16900	94	04	15	96	02	19	54	48	165	37 W	620	2800	F		TRAWL	CHINOOK	BERING_SEA
181040	93	CHUCKWALLA RIVER	BC	CDFO	29052	94	05	20	96	02	22	AREA_517								TRAWL	CHINOOK	BERING_SEA
181233	93	CHEHALIS RIVER/BC	BC	CDFO	49158	94	04	18	96	07	23	48	17	125	02 W	640	3100	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
181241	93	CAPILANO RIVER	BC	CDFO	74475	94	05	26	96	08	03	48	21	125	16 W	720	5100	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
181241	93	CAPILANO RIVER	BC	CDFO	74475	94	05	26	96	07	23	48	22	124	53 W	630	2300	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
181420	93	CHILLIWACK RIVER	BC	CDFO	48434	94	05	27	96	08	10	48	02	125	20 W	716	4100	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
181945	94	CHEHALIS RIVER	BC	CDFO	49288	95	04	21	96	07	23	48	22	124	53 W	430	850	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
181945	94	CHEHALIS RIVER	BC	CDFO	49288	95	04	21	96	08	01	48	17	125	05 W	445	1000	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
212509	93	WHITE R 10.0031	WA	MUCK	48971	95	04	21	96	07	00	48	25	124	52 W	438	810	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
634619	92	MINTER CR 15.0048	WA	WDFW	79637	94	05	02	96	08	03	48	21	125	16 W	610	2200	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
635012	92	SNAKE R-LOWR 33.0002	WA	WDFW	203177	93	06	24	96	08	11	48	10	125	12 W	540	2130	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
635163	93	SNAKE R-LOWR 33.0002	WA	WDFW	101161	95	04	17	96	08	08	48	04	125	18 W	470	1150	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
635217	92	CAPITOL LAKE (13)	WA	COOP	62663	94	06	01	96	07	27	48	23	124	51 W	610	2200	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
635624	94	WHATCOM CR 01.0566	WA	COOP	96211	95	05	25	96	07	30	48	24	124	52 W	360	5500	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
635639	93	SNAKE R-LOWR 33.0002	WA	WDFW	82618	95	04	17	96	07	26	48	20	124	50 W	450	1200	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
044234	94	TAKU R 111-32	AK	ADFG	10224	96	05	22	97	10	07	55	10	164	47 W	500	1700	M		TRAWL	CHINOOK	BERING_SEA
044533	94	BEAR COVE 113-41	AK	NSRA	21119	96	05	16	97	10	15	55	21	165	00 W	530	2166	F	0.1	TRAWL	CHINOOK	BERING_SEA
0601060103	95	FEATHER RIVER	CA	CDFG	100033	96	05	03	97	10	19	48	07	125	17 W	550	1500	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
0601140510	95	RODEO MINOR PORT	CA	CDFG	49410	96	07	24	97	10	19	48	07	125	16 W	450	950	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
070854	94	ELK RIVER	OR	ODFW	194243	95	10	11	97	10	4-7	54	58	165	06 W	580	1980	F		TRAWL	CHINOOK	BERING_SEA
070951	95	ELK RIVER	OR	ODFW	174479	96	09	15	97	09	28	AREA_519				430	1300	M		TRAWL	CHINOOK	BERING_SEA
070951	95	ELK RIVER	OR	ODFW	174479	96	09	15	97	10	17	AREA_517				470	1700	F		TRAWL	CHINOOK	BERING_SEA
070962	94	SALMON R/OR - COAST	OR	ODFW	172256	95	08	15	97	9-1	30-3	55	10	165	10 W	520	1760	M		TRAWL	CHINOOK	BERING_SEA
071252	95	SALMON R/OR - COAST	OR	ODFW	23938	96	06		97	9-1	30-3	55	10	165	10 W	430	1120	F		TRAWL	CHINOOK	BERING_SEA
075418	94	TRASK R	OR	ODFW	24881	95	08	20	97	10	15	55	18	164	14 W	630	3400	F		TRAWL	CHINOOK	BERING_SEA
180212	94	CHILLIWACK RIVER	BC	CDFO	24677	95	06	07	97	10	18	48	09	125	13 W	790	7800	F		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
180640	94	KITSUMKALUM R	BC	CDFO	30009	95	06	21	97	09	28	54	42	165	41 W	690	3400	M		TRAWL	CHINOOK	BERING_SEA
180642	94	KITSUMKALUM R	BC	CDFO	30865	95	06	21	97	10	10	AREAS_509_517_519				640	3900	F		TRAWL	CHINOOK	BERING_SEA
181216	92	YUKON RIVER	YK	CDFO	49957	93	06	15	97	06	02	59	29	167	49 W	833	7500	M		TRAWL	CHINOOK	BERING_SEA
181316	93	BABINE R, UPPER	BC	CDFO	29432	95	04	30	97	10	04	AREAS 517_519				750	6250	M		TRAWL	CHINOOK	BERING_SEA

Table 6. Continued.

RELEASE									RECOVERY												
					TOTAL											BODY SIZE		GONAD				
TAG	BROOD		STATE/		NO.	DATE			DATE			LAT		LONG		TSFT	WT		WT			
CODE	YEAR	RELEASE SITE	PROV	AGENCY	TAGGED	Y	M	D	Y	M	D	D	M	D	M	(mm)	(g)	Sex	(g)	GEAR	SPECIES	OCEANIC REGION
181346	95	NITINAT LAKE	BC	CDFO	27741	96	05	04	97	10	07	55	10	164	47 W	490	1700	M		TRAWL	CHINOOK	BERING_SEA
181347	95	NITNAT LAKE	BC	CDFO	28070	96	06	02	97	10	10	55	38	164	57 W	480	1700	M		TRAWL	CHINOOK	BERING_SEA
181432	93	DOME CREEK	BC	CDFO	50396	95	04	10	97	10	03	56	03	166	08 W	710	5700	F		TRAWL	CHINOOK	BERING_SEA
181442	93	BULKLEY R UPPER	BC	CDFO	83981	95	04	21	97	10	08	55	05	164	51 W	750	5700	M		TRAWL	CHINOOK	BERING_SEA
181442	93	BULKLEY R UPPER	BC	CDFO	83981	95	04	21	97	10	15	54	16	166	02 W		3600	F		TRAWL	CHINOOK	BERING_SEA
181504	94	DOME CREEK	BC	CDFO	25115	96	04	10	97	10	10	AREAS_509_517_519				510	1900	M		TRAWL	CHINOOK	BERING_SEA
181525	94	COLDWATER RIVER	BC	CDFO	20826	96	05	02	97	09	29	54	42	165	42 W	500	1600	F		TRAWL	CHINOOK	BERING_SEA
181641	94	SHUSWAP R LOWER	BC	CDFO	75085	95	05	21	97	10	05	54	41	165	34 W	640	3700	F	30.0	TRAWL	CHINOOK	BERING_SEA
181805	94	SARITA R	BC	CDFO	22306	95	05	15	97	10	02	AREA_517				530	2200	F		TRAWL	CHINOOK	BERING_SEA
181805	94	SARITA R	BC	CDFO	22306	95	05	15	97	10	17	AREAS_509_517				610	3500	F		TRAWL	CHINOOK	BERING_SEA
181832	94	NITINAT RIVER	BC	CDFO	36427	95	05	26	97	9-1	30-3	55	10	165	10 W	690	5140	F		TRAWL	CHINOOK	BERING_SEA
182125	94	STAVE RIVER	BC	CDFO	24708	95	05	29	97	10	19	48	07	125	17 W	690	4300	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
182155	94	KITSUMKALUM R	BC	CDFO	29252	95	06	21	97	10	15	55	18	164	14 W	700	4900	F		TRAWL	CHINOOK	BERING_SEA
182224	94	ROBERTSON CREEK	BC	CDFO	27873	95	06	14	97	9-1	30-3	54	50	165	03 W	630	3320	F		TRAWL	CHINOOK	BERING_SEA
182462	95	SHUSWAP R LOWER	BC	CDFO	74531	96	05	19	97	10	04	55	10	164	59 W	430	1220	F		TRAWL	CHINOOK	BERING_SEA
183148	95	ATNARKO SPAWN CH	BC	CDFO	87497	96	06	07	97	10	08	AREA_509				450	1200	M		TRAWL	CHINOOK	BERING_SEA
212452	93	SALMON R 21.0139	WA	QDNR	170604	94	08	12	97	10	17	AREA_517				760	6200	M		TRAWL	CHINOOK	BERING_SEA
212740	94	GROVERS CR 15.0299	WA	SUQ	3898	95	06	09	97	10	19	48	07	125	17 W	700	4500	M		TRAWL	CHINOOK	NORTHEASTERN_PACIFIC
212920	94	QUINAULT LAKE (21)	WA	QDNR	73642	95	06	29	97	10	11	55	38	164	31 W	540	2220	M		TRAWL	CHINOOK	BERING_SEA
312235	93	DEEP CR 244-20	AK	ADFG	5719	95	07	21	97	10	08	AREAS_509_517_519				630	3300	M		TRAWL	CHINOOK	BERING_SEA
312427	94	CROOKED CR 244-30	AK	ADFG	38408	95	06	06	97	10	17	AREAS_517_519				580	2700	F		TRAWL	CHINOOK	BERING_SEA
312427	94	CROOKED CR 244-30	AK	ADFG	38408	95	06	06	97	10	03	54	38	165	35 W	569	2800	F		TRAWL	CHINOOK	BERING_SEA
312427	94	CROOKED CR 244-30	AK	ADFG	38408	95	06	06	97	09	12	54	42	165	28 W	600	2900	M		TRAWL	CHINOOK	BERING_SEA
312429	94	SELDOVIA HBR 241-11	AK	ADFG	40694	95	06	02	97	09	12	54	43	165	24 W	600	2700	M		TRAWL	CHINOOK	BERING_SEA
312430	94	HALIBUT CV LAG241-15	AK	ADFG	36685	95	06	13	97	09	18	54	04	166	36 W	590	3400	F		TRAWL	CHINOOK	BERING_SEA
312430	94	HALIBUT CV LAG241-15	AK	ADFG	36685	95	06	13	97	09	28	54	30	165	36 W	680	4450	F	50.0	TRAWL	CHINOOK	BERING_SEA
312431	94	BUSKIN R 259-21	AK	ADFG	38455	95	05	27	97	08	02	54	46	165	50 W	570	2500	F		TRAWL	CHINOOK	BERING_SEA
312433	94	HOMER SPIT 241-13	AK	ADFG	40479	95	06	15	97	09	08	54	46	165	42 W	610	2720	M		TRAWL	CHINOOK	BERING_SEA
312434	94	DECEPTION CR 247-41	AK	ADFG	41965	95	05	25	97	10	01	54	43	165	42 W	590	1900	M		TRAWL	CHINOOK	BERING_SEA
312434	94	DECEPTION CR 247-41	AK	ADFG	41965	95	05	25	97	09		54	48	165	25 W	650	3400	M		TRAWL	CHINOOK	BERING_SEA
312435	94	NINILCHIK R 244-20	AK	ADFG	54353	95	05	31	97			NO_DATA								TRAWL	CHINOOK	
312435	94	NINILCHIK R 244-20	AK	ADFG	54353	95	05	31	97	10	17	AREAS_517_519				630	3500	M		TRAWL	CHINOOK	BERING_SEA
312507	95	HOMER SPIT 241-13	AK	ADFG	39070	96	06	05	97	09	19	54	45	165	54 W	485	1900	M		TRAWL	CHINOOK	BERING_SEA
312508	95	SHIP CR 247-50	AK	ADFG	40108	96	06	07	97	10	11	55	57	165	31 W	450	1300	F		TRAWL	CHINOOK	BERING_SEA
312509	95	BUSKIN R 259-21	AK	ADFG	40681	96	05	23	97	09	15	54	48	165	43 W	450	1150	M		TRAWL	CHINOOK	BERING_SEA
312513	95	HOMER SPIT 241-13	AK	ADFG	38787	96	06	14	97	10	06	AREAS_509_517_519				430	1200	F		TRAWL	CHINOOK	BERING_SEA
312513	95	HOMER SPIT 241-13	AK	ADFG	38787	96	06	14	97	10	05	57	37	165	33 W	510	1800	F		TRAWL	CHINOOK	BERING_SEA
312514	95	DECEPTION CR 247-41	AK	ADFG	42595	96	06	18	97	10	1-4	54	40	165	35 W	500	1540	M		TRAWL	CHINOOK	BERING_SEA
312514	95	DECEPTION CR 247-41	AK	ADFG	42595	96	06	18	97	09	27	AREA_517				540	2000	M		TRAWL	CHINOOK	BERING_SEA
312514	95	DECEPTION CR 247-41	AK	ADFG	42595	96	06	18	97	10	15	55	25	164	10 W	480	1700	M		TRAWL	CHINOOK	BERING_SEA
312514	95	DECEPTION CR 247-41	AK	ADFG	42595	96	06	18	97	09	28	54	43	166	00 W	470	1800	F		TRAWL	CHINOOK	BERING_SEA
312515	95	NINILCHIK R 244-20	AK	ADFG	50962	96	06	13	97	09	23-29	54	40	165	35 W	470	1400	F		TRAWL	CHINOOK	BERING_SEA

Table 6. Continued.

RELEASE									RECOVERY														
					TOTAL												BODY SIZE			GONAD			
TAG	BROOD		STATE/		NO.	DATE			DATE			LAT		LONG			TSFT	WT		WT			
CODE	YEAR	RELEASE SITE	PROV	AGENCY	TAGGED	Y	M	D	Y	M	D	D	M	D	M		(mm)	(g)	Sex	(g)	GEAR	SPECIES	OCEANIC REGION
071118	95	UMPQUA R	OR	ODFW	48758	96	06	29	98	04	14	58	22	149	17	W	580	2760	M		TRAWL	CHINOOK	GULF_OF_ALASKA
180220	95	SALMON R/PR.GEORGE	BC	CDFO	27656	96	05	12	98	01	21-22	NO_DATA					530	2000	M		TRAWL	CHINOOK	
180608	94	KITSUMKALUM R	BC	CDFO	10526	95	06	21	98	01	28	55	10	165	15	W	630	5200	M		TRAWL	CHINOOK	BERING_SEA
181229	94	ATNARKO SPAWN CH	BC	CDFO	58670	95	06	07	98	02	14	55	10	164	40	W	700	4300	F	20.0	TRAWL	CHINOOK	BERING_SEA
181859	94	NITINAT LAKE	BC	CDFO	21056	95	05	12	98	02	07	55	22	164	05	W	750	5900	M		TRAWL	CHINOOK	BERING_SEA
181954	94	CONUMA R	BC	CDFO	39203	95	05	24	98	03	11	54	53	164	49	W	660		F		TRAWL	CHINOOK	BERING_SEA
182156	94	KITSUMKALUM R	BC	CDFO	30170	95	06	21	98	03	11	54	51	164	57	W	640	3100	F		TRAWL	CHINOOK	BERING_SEA
182251	95	TRANQUILLE EST	BC	CDFO	50229	96	06	19	98	02	19	55	27	164	06	W	460	1150	F	2.5	TRAWL	CHINOOK	BERING_SEA
183147	95	ATNARKO R UPPER	BC	CDFO	88051	96	06	11	98	02	07	NO_DATA					450	1120	F	20.0	TRAWL	CHINOOK	
183148	95	ATNARKO SPAWN CH	BC	CDFO	87497	96	06	07	98	02	16	55	10	164	20	W	530	2050	F	5.0	TRAWL	CHINOOK	BERING_SEA
471705	93	TAMGAS CR	AK	MIC	47627	95	05	22	98	02	20	54	34	165	10	W	770	5500	M		TRAWL	CHINOOK	BERING_SEA
635762	94	SIMILKAMEEN R	WA	WDFW	212446	96	04	23	98	02	07	NO_DATA					560	2100	F	20.0	TRAWL	CHINOOK	

Table 7. Catch of salmon in numbers by station, date, location, water temperature and salinity, and species from fishing operations on board the *Kaiyo maru*, February 1998. Thermocline depth estimated from CTD data. Trawl start time is the local time when the crew began to set the net and the trawl end time is the time when the crew completed retrieval of the net on to the deck. Trawl tow duration is one hour. LT=local time, sock=sockeye, chin=chinook, and sthd=steelhead.

			5 m Depth		100 m Depth		Thermo-cline	Local sun-rise	Local sun-set	Trawl Operations		Catch						
Sta	Date	Location	Temp (°C)	Sal (ppt)	Temp (°C)	Sal (ppt)	depth (m) (approx)	time	time	Start time (LT)	End time (LT)	Sock	Chum	Pink	Coho	Chin	Sthd	Total
1	7-Feb-98	40°30N 165°00E	8.751	33.724	9.206	34.045	180	06:03	16:24	10:06	12:30	0	0	0	0	0	0	0
2	9-Feb-98	42°15N 165°00E	5.072	32.440	5.138	33.305	160	06:04	16:23	07:49	09:54	1	2	282	0	2	0	287
3	9-Feb-98	43°08N 164°59E	4.774	32.672	4.794	33.207	175	06:04	16:23	15:31	17:32	16	48	45	0	5	0	114
4	10-Feb-98	45°00N 165°00E	3.871	30.268	4.283	33.221	150	06:07	16:17	07:39	09:34	8	1106	462	0	3	0	1579
5	10-Feb-98	46°15N 165°00E	2.822	33.558	2.874	32.979	150	06:07	16:17	15:37	17:35	0	3	1	0	1	0	5
6	11-Feb-98	47°59N 164°59E	3.717	error	2.748	32.937	125	06:13	16:12	07:38	09:32	0	2	0	0	0	0	2
7	11-Feb-98	49°15N 165°00E	2.643	33.333	3.233	33.515	100	06:13	16:12	15:31	17:27	0	0	0	0	0	0	0
8	12-Feb-98	51°00N 165°00E	2.455	29.946	2.514	33.011	100	06:18	16:00	07:47	09:40	0	0	0	0	0	0	0
9	13-Feb-98	53°01N 171°42E	3.415	32.335	3.453	33.112	175	05:57	15:37	08:52	11:08	2	2	0	0	1	0	5
10a	15-Feb-98	58°30N 179°59E	1.617	30.202	1.572	32.938	175	06:35	15:58	07:47	09:36	0	0	0	0	5	0	5
10b	15-Feb-98	58°21N 179°47E	1.617	30.202	1.572	32.938	175	06:35	15:58	09:53	12:22	0	0	0	0	3	0	3
11	15-Feb-98	57°27N 179°59E	1.587	31.730	1.611	32.934	150	06:35	15:58	15:30	17:20	0	0	0	0	0	0	0
12	16-Feb-98	55°30N 179°58W	2.274	32.887	2.294	33.048	150	06:23	16:09	07:37	09:24	0	0	0	0	0	0	0
13	16-Feb-98	54°09N 179°58W	2.810	34.802	2.837	33.096	125	06:23	16:09	14:48	16:32	0	0	0	0	4	0	4
14	18-Feb-98	52°30N 179°56E	3.116	33.151	3.482	33.240	200	06:10	16:18	07:10	09:19	0	0	0	0	0	0	0
15	19-Feb-98	49°29N 179°59W	3.297	31.081	3.297	32.868	125	06:20	16:24	07:49	09:35	1	0	0	0	1	0	2
16	19-Feb-98	48°11N 179°59W	3.810	32.607	3.479	32.870	125	06:20	16:24	14:32	16:21	0	0	0	0	1	0	1
17	20-Feb-98	45°54N 179°56W	5.675	33.218	5.691	33.278	150	05:56	16:33	14:10	15:58	19	8	8	11	5	0	51
18	21-Feb-98	45°00N 179°58W	6.482	32.92	6.232	33.311	175	05:52	16:36	08:05	09:54	2	200	20	9	1	0	232
19	22-Feb-98	43°31N 180°00	6.83*	33.28*	6.84*	33.45*	160	05:49	16:38	08:03	09:48	0	62	25	4	0	0	91
TOTAL												49	1433	843	24	32	0	2381
Percentage												2.1	60.2	35.4	1.0	1.3	0.0	100.0

*due to bad weather the CTD could not be used. These temperature and salinity values were collected by an XCTD, which provides data to two decimals.

Table 8. Gillnet stations, mean water temperature, and salinities by oceanic region along summer transect lines of the *Oshoro maru*, 1994-98.

Transect line	Ocean domain	Year	Number of stations	Latitude, °N start	Latitude, °N end	Sampling Dates start	Sampling Dates end	Water temperature, °C at 0m mean	at 0m s.d.	at 100m mean	at 100m s.d.	Water salinity, psu at 0m mean	at 0m s.d.	at 100m mean	at 100m s.d.
145° W	R/D Domains	1998	3	54	56	July 3	July 5	10.4	0.5	4.7	0.5	32.36	0.21	33.29	0.10
		1997	5	52	56	July 8	July 12	12.5	0.2	4.6	0.6	32.58	0.04	33.20	0.30
		1996	5	52	56	July 3	July 7	9.8	0.5	4.7	0.3	32.58	0.03	32.92	0.13
		1995	4	53	56	July 7	July 10	10.8	0.5	5.0	0.5	31.24	1.79	32.94	0.31
		1994	6	51	56	July 3	July 8	11.1	0.5	5.6	0.5	32.37	0.14	32.95	0.22
	Subarctic Current	1998	5	49	53	July 6	July 10	10.2	0.4	5.4	0.3	32.45	0.12	33.16	0.22
		1997	2	50	51	July 6	July 7	12.0	0.3	5.1	0.2	32.54	0.03	33.13	0.13
		1996	2	50	51	July 8	July 9	9.8	0.1	5.6	0.1	32.61	0.04	32.93	0.02
		1995	1	51.5	51.5	July 6	July 6	9.8	-	5.1	-	28.70	-	33.02	-
		1994	1	50	50	July 2	July 2	10.5	-	6.5	-	32.60	-	33.30	-
165° W	Ridge	1998	1	50	50	June 26	June 26	7.3	-	4.1	-	32.18	-	32.97	-
	Subarctic	1998	3	45.5	48.5	June 27	June 29	8.7	0.8	5.4	0.2	32.40	0.11	32.98	0.09
180°	Subarctic Current	1998	1	47	47	June 15	June 15	5.9	-	3.9	-	31.89	-	33.02	-
		1997	2	46	47	June 18	June 19	7.4	0.6	5.6	1.4	33.09	0.23	33.17	0.25
		1996	3	45	47	June 17	June 19	9.3	0.5	5.1	0.9	32.90	0.19	33.24	0.23
		1995	3	45	47	June 17	June 19	7.7	0.5	5.6	0.9	33.03	0.15	33.30	0.26
		1994	2	45	46	June 17	June 18	7.0	1.4	5.7	2.1	33.15	0.21	33.30	0.42
	Transition Domain	1998	2	43	45	June 13	June 14	8.3	0.7	6.2	0.3	32.94	0.31	33.35	0.02
		1997	3	40	44	June 12	June 15	9.6	1.5	8.3	1.7	33.62	0.26	33.76	0.41
		1996	4	41	44	June 13	June 16	11.0	0.3	8.1	0.9	33.53	0.19	33.80	0.12
		1995	3	42	44	June 14	June 16	9.9	0.6	8.8	0.3	33.77	0.23	34.00	0.00
		1994	2	42	43	June 14	June 15	9.9	0.4	8.4	0.5	33.85	0.07	33.85	0.07
	Transition Zone	1998	1	39	39	June 11	June 11	14.5	-	11.0	-	34.12	-	34.23	-
		1997	1	39	39	June 11	June 11	13.6	-	11.8	-	34.43	-	34.39	-
		1996	2	39	40	June 11	June 12	14.2	0.2	11.7	0.7	34.24	0.13	34.33	0.10
		1995	2	40	41	June 12	June 13	11.9	0.4	10.4	0.1	34.15	0.07	34.20	0.00
		1994	3	39	41	June 11	June 13	13.0	0.9	11.1	0.4	34.10	0.00	34.20	0.00

Table 9. Salmon ocean age composition by region, including physical characteristics for those stations where salmon were caught, *Kaiyo maru*, February 1998.

Region	Stations	Dates	Locations	Temp range 5 m (°C)	Species	Catch	Percent Ocean Age		
							1	2	3
Western NPO	St. 1-6	7-11 February	40°30'N-47°59'N, 165°00'E	3.72-8.75	Sockeye	25	12	88	0
					Chum	1161	100	<1	<1
					Pink	790	100	0	0
					Coho	0			
					Chinook	11	100	0	0
					Total	1987			
Aleutians (Attu Is.)	St. 9	13 February	53°01'N 171°42'E	3.42	Sockeye	2	0	50	50
					Chum	2	0	50	50
					Pink	0			
					Coho	0			
					Chinook	1	100	0	0
					Total	5			
Bering Sea	St. 10 & 13	15-16 February	54°09' & 58°30'N, 180°00'	1.62-2.81	Sockeye	0			
					Chum	0			
					Pink	0			
					Coho	0			
					Chinook	12	83	17	0
					Total	12			
Central NPO	St. 15-19	19-22 February	43°31'N-49°29'N, 180°00'	3.30-6.83	Sockeye	22	41	55	4
					Chum	270	8	90	2
					Pink	53	100	0	0
					Coho	24	100	0	0
					Chinook	8	63	25	12
					Total	377			

Table 10. Mean catch (number of salmonids) per unit (30-tans, 1500 m) of effort by C-gear (research mesh gillnet) calculated by oceanographic region for the *Wakatake maru*, 1991-1998. Research-mesh gillnet is composed of 3 tans each of the following mesh sizes: 48, 55, 63, 72, 82, 93, 106, 121, 138, and 157 mm.

Year	Sampling Dates	No. of Sta.	Locations	Mean Temperature 0 m	Mean Temperature 100 m	Mean Salinity 0 m	Mean Salinity 100 m	Mean Catch per 30 tans C-gear: Sockeye	Chum	Pink	Coho	Chinook	Steelhead	Dolly Varden	Masu	Total Salmonids
Central North Pacific - Transition Zone																
1998	17-18 Jun	2	39°N-40°N, 180°	14.8	11.5	34.3	34.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	19-20 Jun	2	39°N-40°N, 180°	13.3	11.0	34.3	34.3	0.0	2.0	0.0	0.5	0.0	0.0	0.0	0.0	2.5
1996	15-17 Jun	3	38°N-40°N, 180°	14.3	11.2	34.2	34.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	18-21 Jun	4	38°N-41°N, 180°	13.0	10.8	34.1	34.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	18-20 Jun	3	38°N-40°N, 180°	14.2	11.6	34.3	34.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	17-22 Jun	5	38°N-42°N, 180°	12.9	10.6	34.2	34.2	0.0	13.4	0.0	0.0	0.0	0.0	0.0	0.0	13.4
1992	17-20 Jun	4	38°N-41°N, 180	12.8	10.2	34.2	34.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	12-14 Jun	3	38°N-40°N, 180°	14.3	11.2	34.2	34.3	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.7
Central North Pacific - Transition Domain																
1998	20-25 Jun	5	41°N-45°N, 180°	9.4	6.8	33.3	33.5	0.0	6.8	1.0	22.2	0.0	1.4	0.0	0.0	31.4
1997	21-25 Jun	5	41°N-45°N, 180°	10.0	7.7	33.5	33.6	0.2	11.6	1.4	21.0	0.2	2.4	0.0	0.0	36.8
1996	18-20 Jun	3	41°N-43°N, 180°	11.8	8.0	33.6	33.7	0.0	5.0	0.0	1.3	0.0	0.7	0.0	0.0	7.0
1995	22-24 Jun	3	42°N-44°N, 180°	10.6	8.4	33.7	33.9	0.0	3.7	2.0	9.0	0.0	0.3	0.0	0.0	15.0
1994	21-24 Jun	4	41°N-44°N, 180°	10.5	8.6	33.9	33.9	0.0	9.0	1.3	11.0	0.0	2.5	0.0	0.0	23.8
1993	23-25 Jun	2	43°N-44°N, 180°	9.2	7.7	33.7	33.9	0.0	27.5	0.0	8.5	0.0	1.0	0.0	0.0	37.0
1992	21-22 Jun	2	42°N-43°N, 180°	9.4	9.1	33.7	34.0	0.0	15.0	0.0	5.5	0.0	0.5	0.0	0.0	21.0
1991	15-19 Jun	5	41°N-45°N, 180°	10.4	8.3	33.5	33.8	0.0	10.6	0.4	29.2	0.0	3.2	0.0	0.0	43.4
Central North Pacific- Subarctic Current																
1998	26-28 Jun	3	46°N-47°N, 180°	6.8	4.1	33.0	33.1	6.0	13.3	1.0	27.3	2.3	6.7	0.0	0.3	57.0
1997	26-28 Jun	3	46°N-47°N, 180°	8.8	4.8	32.8	33.0	0.7	35.3	24.7	8.3	2.0	1.7	0.0	0.0	72.7
1996	21-26 Jun	4	44°N-47°N, 180°	9.2	5.1	33.1	33.2	0.0	53.0	1.3	19.0	0.8	1.0	0.0	0.0	75.0
1995	25-27 Jun	3	45°N-47°N, 180°	7.8	4.7	33.0	33.2	0.7	33.0	6.7	25.7	0.7	7.7	0.0	0.0	74.3
1994	25-27 Jun	3	45°N-47°N, 180°	6.5	3.9	32.9	33.0	1.3	15.3	22.0	25.0	1.0	9.0	0.0	0.0	73.7
1993	26-28 Jun	3	45°N-47°N, 180°	7.3	3.6	33.0	33.2	0.0	58.3	2.7	16.3	0.3	5.0	0.0	0.0	82.7
1992	23-25 Jun	3	44°N-46°N, 180°	7.6	4.8	33.2	33.3	0.0	12.7	0.3	19.3	0.3	1.0	0.0	0.0	33.7
1991	20-21 Jun	3	46°N-47°N, 180°	7.4	4.5	33.0	33.1	1.0	30.5	10.5	24.0	1.0	1.5	0.0	0.0	68.5
North Pacific Ridge Domain																
1992	26-Jun	1	47°N, 180°	6.7	3.1	33.0	33.1	0.0	40.0	1.0	34.0	0.0	2.0	0.0	0.0	77.0
Bering Sea																
1998	6-16 Jul	11	55°N-58°N,177°W-177°E	7.0	2.5	32.3	33.0	37.7	209.6	5.6	0.4	22.7	0.0	5.0	0.0	281.1
1997	6-17 Jul	10	55°N-58°N,177°W-177°E	8.4	3.0	32.8	32.9	57.0	143.9	379.7	0.3	3.5	0.0	0.1	0.0	584.5
1996	4-14 Jul	9	55°N-58°N, 177°W-179°E	7.5	2.9	32.8	33.0	55.1	200.7	4.8	0.1	6.8	0.0	0.2	0.0	267.7
1995	5-15 Jul	11	55°N-58°N, 177°W-177°E	7.5	2.0	32.9	33.1	37.8	63.8	174.5	0.5	6.5	0.0	0.2	0.0	283.3
1994	5-15 Jul	11	55°N-58°N, 177°W-177°E	6.7	1.8	32.9	33.2	50.3	224.0	13.1	0.0	5.2	0.0	0.2	0.0	292.7
1993	6-16 Jul	11	55°N-58°N, 177°W-177°E	7.2	2.1	33.1	33.2	58.2	111.6	141.2	0.8	1.4	0.0	0.0	0.0	313.2
1992	4-14 Jul	11	55°N-58°N, 177°W-177°E	6.4	2.5	33.0	33.3	22.8	257.5	9.0	0.3	5.4	0.0	0.5	0.0	295.5
1991	1-8 Jul	8	55°N-58°N, 180°W-177°W	7.6	2.2	33.0	33.2	22.9	53.9	365.5	0.0	9.9	0.0	0.0	0.0	452.1

Table 11. Ocean age composition (%), mean fork length (FL, mm), body weight (BW, g) and standard deviation (sd) of sockeye salmon caught in the research–mesh gillnet (C-gear) during fishing operations of the *Wakatake maru*, 1991-1998.

Sampling		Ocean Age .1						Ocean Age .2						Ocean Age .3						Ocean Age .4					
			%	F L (mm)		B W (g)			%	F L (mm)		B W (g)			%	F L (mm)		B W (g)			%	F L (mm)		B W (g)	
Year	Dates	N	Age	mean	sd	mean	sd	N	Age	mean	sd	mean	sd	N	Age	mean	sd	mean	sd	N	Age	mean	sd	mean	sd
Central North Pacific - Subarctic Current (44°N-47°N, 180°)																									
1998	24-29 Jun	10	59	336	23	361	80	6	35	435	22	907	55	1	6	610		3000		0					
1997	26-28 Jun	0						5	100	461	41	1116	304	0						0					
1996	21-26 Jun	0						0						0						0					
1995	25-27 Jun	0						0						2	100	606	9	2950	354	0					
1994	25-27 Jun	2	50	365	49	464	91	1	25	452		980		1	25	615		3200		0					
1993	26-28 Jun	0						0						0						0					
1992	23-25 Jun	0						0						0						0					
1991	20-21 Jun	2	100	315	5	295	7	0						2						0					
Bering Sea (55°N-58°N, 177°W-177°E)																									
1998	7-17 Jul	221	56	331	36	403	219	141	36	471	43	1275	471	33	8	574	44	2715	768	0					
1997	6-17 Jul	215	41	341	25	422	97	273	53	461	28	1112	217	30	6	574	58	2489	802	0					
1996	4-14 Jul	270	59	340	29	382	119	139	30	472	38	1250	355	48	11	585	54	2659	865	0					
1995	5-16 Jul	44	11	330	45	399	200	292	72	495	30	1447	354	70	17	586	58	2599	792	2	0	624	63	2925	601
1994	5-15 Jul	133	37	430	26	404	97	209	57	474	30	1189	255	23	6	583	38	2643	651	0					
1993	6-16 Jul	297	52	351	25	430	101	246	43	483	36	1301	329	31	5	571	44	2423	773	2	0	628	20	3275	601
1992	4-14 Jul	92	39	337	31	392	105	126	54	483	31	1364	324	16	7	584	46	2929	803	1	0	650		4500	
1991	1-8 Jul	101	59	313	21	332	70	38	22	480	39	1335	477	30	18	595	44	2851	781	2	1	653	33	4225	460

Table 12. Ocean age composition (%), mean fork length (FL, mm), body weight (BW, g) and standard deviation (sd) of chum salmon caught in the research–mesh gillnet (C-gear) during fishing operations of the *Wakatake maru*, 1991-1998.

Sampling Year Dates	Ocean Age .1 N	% Age	FL (mm) mean	FL sd	BW (g) mean	BW sd	Ocean Age .2 N	% Age	FL (mm) mean	FL sd	BW (g) mean	BW sd	Ocean Age .3 N	% Age	FL (mm) mean	FL sd	BW (g) mean	BW sd
Central North Pacific - Transition Domain (41°N-45°N, 180°)																		
1998 20-25 Jun	25	89	318	16	306	56	3	11	394	9	633	21	0					
1997 21-25 Jun	7	13	337	40	381	127	42	79	423	23	862	240	4	8	481	38	1330	358
1996 18-20 Jun	1	8	328		380		10	77	434	15	1016	83	2	15	502	74	1450	636
1995 22-24 Jun	0						7	58	480	46	1317	409	5	42	503	47	1524	457
1994 21-24 Jun	5	15	334	9	408	23	22	67	422	29	831	192	6	18	480	32	1202	207
1993 23-25 Jun	4	8	326	9	355	13	37	79	425	16	841	126	6	13	479	26	1255	252
1992 21-22 Jun	1	3	362		520		24	83	418	12	846	143	3	10	470	21	1207	172
1991 15-19 Jun	9	19	309	13	271	41	34	71	413	25	757	166	5	10	525	65	1804	803
Central North Pacific - Subarctic Current (44°N-47°N, 180°)																		
1998 26-28 Jun	23	60	302	16	262	28	12	32	409	24	769	225	2	5	515	7	1590	127
1997 26-28 Jun	51	57	305	14	276	44	35	39	434	31	870	266	3	4	523	55	1653	516
1996 21-26 Jun	110	57	319	18	315	62	71	37	437	23	928	165	11	6	475	24	1168	140
1995 25-27 Jun	7	7	326	25	332	32	19	20	471	29	1236	255	58	62	492	22	1452	247
1994 25-27 Jun	10	23	341	21	419	72	22	51	414	27	780	209	10	23	482	26	1221	281
1993 26-28 Jun	56	37	338	19	385	98	83	55	419	24	784	140	11	7	501	31	1577	554
1992 23-25 Jun	11	31	309	6	291	30	21	60	422	21	797	163	3	9	488	4	1340	260
1991 20-21 Jun	2	3	344	25	430	85	47	83	421	25	804	164	8	14	491	40	1343	304
Central North Pacific - Ridge Domain (47°N, 180)																		
1992 26-Jun	18	47	316	8	289	24	12	32	436	24	931	195	6	16	491	19	1338	195
Bering Sea (55°N-58°N, 177°W-177°E)																		
1998 3-16 Jul	281	14	341	21	396	159	786	39	425	37	837	266	776	38	538	45	1834	491
1997 3-17 Jul	749	59	340	17	407	76	324	25	442	35	955	297	169	13	541	45	1866	507
1996 4-14 Jul	732	45	342	21	375	95	503	31	440	32	921	231	292	18	534	44	1740	465
1995 5-16 Jul	155	24	364	44	515	224	107	17	482	33	1280	337	259	40	523	38	1701	424
1994 5-15 Jul	328	18	356	22	438	102	582	31	437	32	887	226	824	44	510	35	1484	342
1993 6-16 Jul	78	7	368	20	488	90	544	51	442	29	942	223	352	33	535	42	1835	518
1992 4-14 Jul	928	36	350	22	204	220	857	33	429	32	583	472	629	25	514	40	1409	743
1991 1-8 Jul	2	1	363	11	450	14	112	29	449	34	995	272	167	44	556	39	2071	504

Sampling Year Dates	Ocean Age .4 N	% Age	FL (mm) mean	FL sd	BW (g) mean	BW sd	Ocean Age .5 N	% Age	FL (mm) mean	FL sd	BW (g) mean	BW sd	Ocean Age .6 N	% Age	FL (mm) mean	FL sd	BW (g) mean	BW sd
Central North Pacific - Transition Domain (41°N-45°N, 180°)																		
1998 20-25 Jun	0						0											
1997 21-25 Jun	0						0											
1996 18-20 Jun	0						0											
1995 22-24 Jun	0						0											
1994 21-24 Jun	0	0					0											
1993 23-25 Jun	0	0					0											
1992 21-22 Jun	1	4	542		1800		0											
1991 15-19 Jun	0	0					0											
Central North Pacific - Subarctic Current (44°N-47°N, 180°)																		
1998 26-28 Jun	1	3	573		2300		0											
1997 26-28 Jun	0						0											
1996 21-26 Jun	1	0	530		1620		0											
1995 25-27 Jun	10	11	522	35	1795	419	0											
1994 25-27 Jun	1	3	488		1220		0											
1993 26-28 Jun	1	1	494		1570		0											
1992 23-25 Jun	0						0											
1991 20-21 Jun	0						0											
Central North Pacific - Ridge Domain (47°N, 180)																		
1992 26-Jun	2	5	594	54	2600	424	0											
Bering Sea (55°N-58°N, 177°W-177°E)																		
1998 3-16 Jul	182	9	595	41	2524	585	10	0	622	47	3108	545	1	0	624		2550	
1997 3-17 Jul	36	3	608	48	2621	815	2	0	560	85	2250	1344	1	0	663		3500	
1996 4-14 Jul	82	5	581	58	2355	785	9	1	619	62	2813	1197	1	0	591		2500	
1995 5-16 Jul	115	18	574	36	2316	468	7	1	613	44	2957	793						
1994 5-15 Jul	133	7	562	47	2126	654	4	0	573	61	2330	605						
1993 6-16 Jul	83	8	588	56	2564	885	7	1	594	40	2617	647						
1992 4-14 Jul	154	6	586	46	2528	767	3	0	600	72	3017	1158						
1991 1-8 Jul	82	22	604	45	2844	703	17	4	613	27	3119	466						

Table 13. Ocean age composition (%), mean fork length (FL, mm), body weight (BW, g) and standard deviation (sd) of pink salmon caught in the research–mesh gillnet (C-gear) during fishing operations of the *Wakatake maru*, 1991-1998.

Year	Sampling Dates	N	% at Age	Fork length (mm) mean	Fork length (mm) sd	Body weight (g) mean	Body weight (g) sd
			Ocean Age .1				
Central North Pacific - Transition Domain (41°N-45°N, 180°)							
1998	20-25 Jun	4	100	450	20	1055	168
1997	21-25 Jun	6	100	433	25	1045	279
1996	18-20 Jun	0					
1995	22-24 Jun	6	100	467	33	1186	328
1994	21-24 Jun	7	100	469	38	1063	265
1993	23-25 Jun	0					
1992	21-22 Jun	0					
1991	15-19 Jun	2	100	431	21	860	198
Central North Pacific - Subarctic Current (44°N-47°N, 180°)							
1998	26-28 Jun	3	100	476	10	1193	83
1997	26-28 Jun	79	100	433	23	928	135
1996	21-26 Jun	5	100	436	45	844	349
1995	25-27 Jun	18	100	459	26	1070	360
1994	25-27 Jun	66	100	455	28	1023	210
1993	26-28 Jun	8	100	429	21	738	134
1992	23-25 Jun	2	100	458	0	920	57
1991	20-21 Jun	21	100	423	35	787	252
Central North Pacific - Ridge Domain (47°N, 180°)							
1992	26-Jun	1	100	450		910	
Bering Sea (55°N-58°N, 177°E-177°W)							
1998	3-16 Jul	60	100	414	40	859	342
1997	3-17 Jul	1537	100	446	27	1117	244
1996	4-14 Jul	43	100	455	35	1117	275
1995	5-16 Jul	1749	100	470	29	1298	266
1994	5-15 Jul	143	100	444	30	1055	262
1993	6-16 Jul	1434	100	449	27	1106	240
1992	4-14 Jul	100	100	451	27	1153	255
1991	1-8 Jul	1315	100	447	41	1108	362

Table 14. Ocean age composition (%), mean fork length (FL, mm), body weight (BW, g) and standard deviation (sd) of chinook salmon caught in the research–mesh gillnet (C-gear) during fishing operations of the *Wakatake maru*, 1991-1998.

Sampling		Ocean Age .1						Ocean Age .2						Ocean Age .3						Ocean Age .4					
			%	F L (mm)		B W (g)			%	F L (mm)		B W (g)			%	F L (mm)		B W (g)			%	F L (mm)		B W (g)	
Year	Dates	N	Age	mean	sd	mean	sd	N	Age	mean	sd	mean	sd	N	Age	mean	sd	mean	sd	N	Age	mean	sd	mean	sd
Central North Pacific - Subarctic Current (44°N-47°N, 180°)																									
1998	26-28 Jun	0						6	86	582	39	2488	472	1	14	780		6850		0					
1997	26-28 Jun	0						6	86	641	47	3408	1026	1	14	700		4400		0					
1996	21-26 Jun	3	100	395	44	823	320	0						0						0					
1995	25-27 Jun	0						1	50	562		2200		1	50	832		7800		0					
1994	25-27 Jun	0						3	100	616	33	3150	477	0						0					
1993	26-28 Jun	0						1	100	624		3700		0						0					
1992	23-26 Jun	0						1	100	575		2300		0						0					
1991	20-21 Jun	0						2	100	572	82	2625	926	0						0					
Central North Pacific - Ridge Domain (47°N, 180°)																									
1992	26-Jun	0						0						0						0					
Bering Sea																									
1998	3-16 Jul	140	60	348	41	528	311	62	27	545	57	2202	793	30	13	678	76	4346	1434	0					
1997	3-17 Jul	12	35	350	24	478	94	19	56	550	35	1954	390	3	9	714	100	4650	2079	0					
1996	4-14 Jul	24	43	407	31	826	221	25	45	567	46	2382	632	7	12	732	46	5121	1366	0					
1995	5-16 Jul	18	27	339	31	442	128	43	65	525	52	1813	522	4	6	726	61	4725	1300	1	2	812		6800	
1994	5-15 Jul	25	47	374	31	595	210	11	21	543	57	2179	740	17	32	720	41	4855	1129	0					
1993	6-16 Jul	1	8	352		480		7	59	573	25	2340	314	3	25	716	95	4710	2175	1	8	862		8600	
1992	4-14 Jul	17	36	356	27	525	116	23	49	567	47	2333	709	6	13	654	27	3822	648	1	2	850		7650	
1991	1-8 Jul	45	66	345	26	497	120	21	31	530	57	1816	634	2	3	715	18	4050	71	0					

Table 15. Ocean age composition (%), mean fork length (FL, mm), body weight (BW, g) and standard deviation (sd) of coho salmon caught in the research–mesh gillnet (C-gear) during fishing operations of the *Wakatake maru*, 1991-1998.

		Ocean Age .1					
	Sampling		%	Fork length (mm)		Body Weight (g)	
Year	Dates	N	Age	mean	sd	mean	sd
Central North Pacific - Transition Domain (41°N-45°N, 180°)							
1998	20-25 Jun	110	100	519	34	1763	345
1997	21-25 Jun	100	100	511	38	1771	442
1996	18-20 Jun	4	100	542	20	1925	155
1995	22-24 Jun	26	100	525	40	1786	328
1994	21-24 Jun	43	100	516	39	1563	414
1993	23-25 Jun	18	100	506	58	1562	472
1992	21-22 Jun	11	100	512	55	1678	486
1991	15-19 Jun	146	100	519	38	1611	343
Central North Pacific - Subarctic Current (44°N-47°N, 180°)							
1998	26-28 Jun	80	100	543	43	2122	494
1997	26-28 Jun	32	100	498	49	1468	398
1996	21-26 Jun	75	100	516	39	1653	399
1995	25-27 Jun	73	100	532	46	1836	512
1994	25-27 Jun	78	100	527	39	1829	415
1993	26-28 Jun	49	100	521	48	1755	512
1992	23-25 Jun	58	100	503	31	1514	340
1991	20-21 Jun	49	100	526	39	1821	419
Central North Pacific - Ridge Domain (47°N, 180°)							
1992	26-Jun	34	100	507	39	1611	367
Bering Sea (55°N-58°N, 177°E-177°W)							
1998	3-16 Jul	3	100	556	62	2430	725
1997	3-17 Jul	3	100	518	72	1740	1095
1996	4-14 Jul	1	100	630		3800	
1995	5-16 Jul	5	100	605	35	2910	668
1994	5-15 Jul	0					
1993	6-16 Jul	9	100	556	33	2166	581
1992	4-14 Jul	3	100	568	37	2450	492
1991	1-8 Jul	0					

Table 16. Ocean age composition (%), mean fork length (FL, mm), body weight (BW, g) and standard deviation (sd) of steelhead caught in the research–mesh gillnet (C-gear) during fishing operations of the *Wakatake maru*, 1991-1998.

		Ocean Age .1						Ocean Age .2						Ocean Age .3					
	Sample		%	F L (mm)		B W (g)			%	F L (mm)		B W (g)			%	F L (mm)		B W (g)	
Year	Dates	N	Age	mean	sd	mean	sd	N	Age	mean	sd	mean	sd	N	Age	mean	sd	mean	sd
Central North Pacific - Transition Domain (41°N-45°N, 180°)																			
1998	20-25 Jun	5	71	539	52	1684	245	2	29	708	76	3425	1167	0					
1997	21-25 Jun	7	64	549	63	1717	644	4	36	697	17	3323	349	0					
1996	18-20 Jun	2	100	555	11	1770	212	0						0					
1995	22-24 Jun	0						1	100	682		3000		0					
1994	21-24 Jun	9	100	564	16	1812	189	0						0					
1993	23-25 Jun	1	50	540		1520		1	50	656		2650		0					
1992	21-22 Jun	0						1	100	718		4000		0					
1991	15-19 Jun	8	73	542	49	1608	434	3	27	741	24	4533	797	0					
Central North Pacific - Subarctic Current (44°N-47°N, 180°)																			
1998	26-28 Jun	10	50	556	52	1726	543	8	40	645	28	2488	330	2	10	692	28	3350	71
1997	26-28 Jun	1	16	536		1750		4	67	685	47	3005	308	1	17	800			
1996	21-26 Jun	4	100	555	12	1608	116	0						0					
1995	25-27 Jun	16	73	574	41	1791	317	5	23	672	51	3050	752	1	4	700		3000	
1994	25-27 Jun	21	84	551	44	1850	231	4	16	692	61	3538	1090	0					
1993	26-28 Jun	4	40	563	24	1695	93	6	60	688	70	2975	424	0					
1992	23-25 Jun	0						3	100	663	49	2867	568	0					
1991	20-21 Jun	2	75	522	60	1315	403	1	25	710		3800		0					
Central North Pacific - Ridge Domain (47°N, 180°)																			
1992	26-Jun	1	50	548		1530		1	50	658		2350		0					

Table 17. Catch (number of salmonids) per unit effort by C-gear, summarized by oceanic region and transect lines of research vessel *Oshoro maru*, 1994-98. One unit of effort is equal to one operation of the 30-tan (1500 m) non-selective research mesh gillnet, except as indicated below.

Transect line	Ocean domain	Year	Total sets	Tans per unit effort	Sockeye mean	Sockeye s.d.	Chum mean	Chum s.d.	Pink mean	Pink s.d.	Coho mean	Coho s.d.	Chinook mean	Chinook s.d.	Steelhead mean	Steelhead s.d.
145° W	R/D Domains	1998	3	30	41.0	24.9	34.3	10.6	57.3	12.3	18.3	10.1	1.7	2.9	4.3	2.1
		1997	5	30	59.6	22.9	48.0	39.5	21.0	15.4	10.2	5.7	0.0	0.0	3.4	2.5
		1996	5	27	33.8	16.6	65.2	40.1	15.4	14.8	20.4	10.6	0.4	0.9	6.2	6.6
		1995	4	30	36.3	13.0	88.8	4.2	42.5	5.4	13.5	4.7	0.5	0.6	4.0	2.9
		1994	6	30	42.5	32.6	26.2	24.7	30.8	14.7	14.0	6.8	0.2	0.4	2.3	2.7
	Subarctic Current	1998	5	30	32.0	22.8	31.4	19.0	21.0	14.5	5.6	6.5	0.4	0.9	7.4	3.4
		1997	2	30	14.5	6.4	14.5	0.7	0.0	0.0	2.0	1.4	0.0	0.0	0.0	0.0
		1996	2	26	7.5	6.4	10.5	3.5	16.0	1.4	6.0	7.1	0.0	0.0	2.0	0.0
		1995	1	30	29.0	-	68.0	-	18.0	-	15.0	-	1.0	-	8.0	-
		1994	1	30	9.0	-	10.0	-	27.0	-	0.0	-	0.0	-	2.0	-
165° W	Ridge	1998	1	30	78.0	-	82.0	-	14.0	-	0.0	-	0.0	-	0.0	-
	Subarctic	1998	3	30	20.0	11.0	42.0	22.7	13.7	9.0	10.3	13.8	0.3	0.6	1.7	1.5
180°	Subarctic Current	1998	1	30	72.0	-	43.0	-	5.0	-	2.0	-	0.0	-	1.0	-
		1997	2	30	8.0	1.4	22.5	14.8	29.5	3.5	2.0	1.4	0.5	0.7	1.0	0.0
		1996	3	28	0.0	0.0	33.7	24.2	3.3	2.1	24.3	11.0	0.7	0.6	2.0	1.7
		1995	3	30	1.7	1.5	12.0	8.2	14.3	19.7	24.0	36.5	0.0	0.0	1.3	1.5
		1994	2	30	0.0	0.0	27.5	9.2	18.0	5.7	16.5	3.5	0.5	0.7	5.0	2.8
	Transition Domain	1998	2	30	2.0	2.8	18.5	0.7	0.5	0.7	12.0	11.3	0.0	0.0	5.0	1.4
		1997	4	30	0.3	0.5	8.0	5.4	5.8	7.3	3.0	3.4	0.0	0.0	1.3	1.5
		1996	4	30	0.0	0.0	5.8	6.9	0.5	1.0	7.0	8.2	0.0	0.0	1.0	0.8
		1995	3	30	0.0	0.0	0.7	0.6	0.0	0.0	2.3	1.5	0.0	0.0	0.3	0.6
		1994	2	30	0.0	0.0	24.0	25.5	4.5	3.5	38.0	28.3	0.0	0.0	0.5	0.7
	Transition Zone	1998	1	30	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-
		1997	1	30	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-
		1996	2	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		1995	2	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		1994	3	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 18. Ocean age composition and maturity at age of sockeye and chum salmon caught by the *Oshoro maru* research gillnet, 1994-98. Percent values indicate average percentage of fish in specific age class and maturity in each catch, grouped by oceanic region and year.

Species: Sockeye

				Percent of (year x domain) catch in each category												
				Ocean Age 1			Ocean Age 2			Ocean Age 3			Ocean Age 4			
Transect Line	Ocean Domain	Year	N	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total	%Mature Overall
145° W	R/D Domains	1998	119	14	3	17	3	34	37	2	42	44		3	3	82
		*1997	294	2	2	4	6	65	70	0.34	25	25				92
		1996	154	10	3	13	5	54	58		28	28		1	1	85
		1995	132	10	11	20	2	45	47		33	33				89
		1994	214	4	3	7	18	57	75		17	17		0.47	0.47	78
	Subarctic Current	1998	148	1		1	3	68	72		27	27				95
		1997	28	7	7	14	18	61	79		7	7				75
		1996	13	15		15		77	77		8	8				85
		1995	22	5	9	14	9	59	68		14	14		5	5	86
		1994	9	11		11	33	56	89							56
165° W	Ridge Domain	1998	74	59	7	66	11	7	18	3	14	16				27
	Subarctic Current	1998	59	27	8	36	8	31	39	2	24	25				63
180	Subarctic Current	1998	69	88	3	91	7	1	9							4
		1997	16	25		25	69	6	75							6
		1995	2	50		50	50		50							0
		1994	1	100		100										0
	Transition Domain	1998	1				100		100							0
		1997	1	100		100										0

*Catch included 1 immature ocean-age 5 fish.

Species: Chum

				Percent of (year x domain) catch in each category												
				Ocean Age 1			Ocean Age 2			Ocean Age 3			Ocean Age 4			
Transect Line	Ocean Domain	Year	N	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total	%Mature Overall
145° W	R/D Domains	1998	97	13		13	55	6	61	15	9	25		1	1	16
		*1997	232	39	3	43	53	2	54	2	0.43	3				6
		1996	276	17	1	18	74	3	77	1	3	4				7
		1995	315	8	3	11	59	19	77	6	5	11		0.32	0.32	27
		1994	133	47	7	53	31	10	41	2	4	6				20
	Subarctic Current	1998	153	51		51	45		45	3	1	4				1
		1997	29	41		41	59		59							0
		1996	18				100		100							0
		1995	62	2		2	81	11	92	5	2	6				13
		1994	8	13		13	50	25	75		13	13				38
165° W	Ridge Domain	1998	75	1	1	3	9	21	31	17	47	64		3	3	72
	Subarctic Current	1998	120	19		19	48	14	63	11	8	18				22
180	Subarctic Current	1998	42	19		19	71		71	5	5	10				5
		1997	41	76		76	15		15	2	2	5	2	2	5	5
		1996	58	48		48	34	9	43	2	7	9				16
		1995	23	39	9	48	13	9	22	17	9	26		4	4	30
		1994	43	56		56	40	2	42		2	2				5
	Transition Domain	1998	37	49	3	51	46		46	3		3				3
		1997	30	47		47	43	7	50	3		3				7
		1996	15	47		47	47	7	53							7
		1995	1										100		100	0
		1994	42	5	10	14	50	17	67	14	5	19				31

*Catch included 1 immature ocean-age 0 fish.

Table 19. Ocean age composition and maturity at age of chinook salmon and steelhead caught by the *Oshoro maru* research gillnet, 1994-98. Percent values indicate average percentage of fish in specific age class and maturity in each catch, grouped by oceanic region and year.

Species	Chinook									
				Percent of (year x domain) catch in each category						
Transect	Ocean			Ocean Age 1			Ocean Age 2			%Mature
Line	Domain	Year	N	Immature	Mature	Total	Immature	Mature	Total	Overall
145° W	R/D Domains	1998	5	40		40	60		60	0
		1996	3	33		33	67		67	0
	Subarctic Current	1998	2				100		100	0
165° W	Subarctic Current	1998	1				100		100	0
180	Subarctic Current	1997	1					100	100	100
		1996	1				100		100	0
		1994	1				100		100	0

Species	Steelhead															
				Percent of (year x domain) catch in each category												
Transect	Ocean			Ocean Age 0			Ocean Age 1			Ocean Age 2			Ocean Age 3			%Mature
Line	Domain	Year	N	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total	Overall
145° W	R/D Domains	1998	13	54		54		15	15		8	8		23	23	46
		1997	16	44	31	75		13	13		13	13				56
		*1996	32	59		59	16	9	25		6	6		3	3	25
		1995	1										100		100	0
		1994	14	79	7	86								14	14	21
	Subarctic Current	1998	37	51	3	54	14	22	35		11	11				35
		1996	4	50		50	25		25		25	25				25
		1994	2	50		50								50	50	50
165° W	Subarctic Current	1998	5				20	60	80		20	20				80
180	Subarctic Current	1998	1					100	100							100
		1997	2					50	50					50	50	100
		1996	6					50	50	17		17	17	17	33	67
		1994	10				60		60		10	10	10	20	30	30
	Transition Domain	1998	10					20	20		60	60		20	20	100
		1997	5					60	60		40	40				100
		1996	4				50	50	100							50
		1994	1				100		100							0

*Catch included one mature ocean-age 4 fish.

Table 20. Number sampled, mean and standard deviation of fork length (F.L., cm), body weight (B.W., g), and condition factor (C.F., B.W./F.L.^{3} * 10^6) of sockeye and chum salmon caught by the *Oshoro maru* research gillnet, 1994-98, grouped by ocean age.

Species	Sockeye

Transect	Ocean		Ocean Age 1							Ocean Age 2							Ocean Age 3							Ocean Age 4						
				F.L.		B.W.		C.F.			F.L.		B.W.		C.F.			F.L.		B.W.		C.F.			F.L.		B.W.		C.F.	
Line	Domain	Year	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.
145 W	R/D Domains	1998	20	348	24	518	137	12.1	1.8	44	554	48	2260	619	12.9	1.0	52	610	31	2910	517	12.7	1.0	3	556	41	2287	658	13.0	1.5
		*1997	12	413	80	1005	657	13.0	1.4	209	552	36	2225	471	12.9	2.3	74	610	39	2978	641	12.7	1.8							
		1996	20	359	52	589	458	11.6	1.2	90	563	46	2475	647	13.5	1.3	43	626	40	3360	669	13.5	1.3	1	610	-	3400	-	15.0	-
		1995	27	349	23	527	133	12.2	1.6	62	546	47	2083	565	12.5	1.1	43	607	41	2878	561	12.9	2.0							
		1994	16	347	25	503	99	11.9	1.6	160	555	39	2255	463	13.1	1.7	37	603	35	2775	528	12.5	1.2	1	650	-	2750	-	10.0	-
	Subarctic Current	1998	2	371	15	570	71	11.2	0.0	106	572	37	2641	584	13.9	1.1	40	613	31	3039	501	13.1	1.1							
		1997	4	457	82	1295	714	12.4	1.7	22	539	27	2031	398	12.8	1.2	2	617	59	2970	891	12.4	0.2							
		1996	2	369	4	550	14	11.0	0.7	10	578	29	2638	410	13.6	0.8	1	650	-	4050	-	14.7	-							
		1995	3	386	48	680	314	11.3	1.2	15	537	50	2157	577	13.8	3.2	3	593	105	3167	679	16.2	6.2	1	640	-	3000	-	11.4	-
		1994	1	360	-	560	-	12.0	-	8	547	28	2341	292	14.3	1.0														
165 W	Ridge Domain	1998	49	332	22	426	118	10.7	3.2	13	483	76	1454	738	11.7	2.2	12	603	44	3010	1060	13.2	2.2							
	Subarctic Current	1998	21	353	65	545	319	11.6	1.3	23	515	53	1723	588	12.1	0.8	15	589	26	2656	365	12.9	0.8							
180	Subarctic Current	1998	65	324	21	392	84	11.5	1.9	6	419	17	844	135	9.6	5.0														
		1997	4	329	38	436	116	12.2	1.5	12	442	27	896	166	10.3	0.8														
		1995	1	288	-	250	-	10.5	-	2	437	10	1230	42	14.8	1.5														
		1994	1	312	-	350	-	11.5	-																					
	Transition Domain	1998								1	480	-	1240	-	11.2	-														
		1997	1	308	-	312	-	10.7	-																					

*includes one ocean age 5 fish, FL 924, BW 7300, CF 9.25.

Species	Chum

Transect	Ocean		Ocean Age 1							Ocean Age 2							Ocean Age 3							Ocean Age 4						
				F.L.		B.W.		C.F.			F.L.		B.W.		C.F.			F.L.		B.W.		C.F.			F.L.		B.W.		C.F.	
Line	Domain	Year	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.
145 W	R/D Domains	1998	15	398	45	736	367	11.1	1.1	60	516	51	1631	561	11.6	1.3	24	579	72	2423	936	11.9	2.0	1	529	-	1820	-	12.3	-
		1997	99	390	29	742	189	12.3	1.4	126	459	29	1134	219	11.7	1.0	6	511	61	1583	531	11.6	1.9							
		1996	51	405	32	771	185	11.5	1.6	214	471	27	1216	209	11.5	0.9	12	586	97	2698	1428	12.3	1.2							
		1995	34	421	75	803	212	11.3	2.6	244	490	30	1387	245	11.8	1.7	36	527	28	1721	307	11.6	1.1	1	528	-	1540	-	10.5	-
		1994	71	390	16	696	132	11.7	1.6	54	464	31	1205	313	11.9	1.5	8	492	37	1494	452	12.3	1.8							
	Subarctic Current	1998	78	387	24	656	138	11.2	0.7	69	471	45	1264	335	11.8	0.7	6	554	65	2162	957	12.0	1.5							
		1997	12	370	24	640	138	12.5	1.1	17	444	27	1145	190	13.0	0.9														
		1996								18	476	49	1237	268	11.6	2.0														
		1995	1	402	-	640	-	9.9	-	57	470	33	1219	271	11.5	0.7	4	510	23	1550	283	11.6	1.1							
		1994	1	380	-	650	-	11.8	-	6	463	35	1213	263	12.1	0.6	1	460	-	1220	-	12.5	-							
165 W	Ridge Domain	1998	2	386	73	670	325	11.3	0.7	23	469	58	1100	363	10.6	2.2	48	518	29	1605	277	11.5	1.3	2	522	8	1575	35	11.1	0.2
	Subarctic Current	1998	25	322	27	378	117	11.0	1.3	75	445	41	1099	313	12.1	0.9	22	507	35	1551	291	11.9	1.3							
180	Subarctic Current	1998	8	343	32	474	134	11.5	1.4	30	387	22	661	94	11.5	2.2	4	433	54	940	334	11.3	0.3							
		1997	32	312	10	337	30	11.0	1.0	7	398	33	673	175	9.2	4.1	2	478	11	1210	184	11.0	0.9	2	466	118	1410	1174	12.0	2.2
		1996	28	321	26	322	49	9.8	1.2	27	436	21	917	140	11.0	0.8	5	472	17	1196	118	11.3	0.2							
		1995	21	315	10	320	36	10.2	0.7	5	431	8	902	109	11.2	1.0	6	500	57	1195	374	9.6	2.3	1	575	-	2200	-	11.6	-
		1994	24	316	23	362	90	11.4	1.3	18	406	24	733	132	10.8	0.8	1	472	-	1100	-	10.5	-							
	Transition Domain	1998	19	334	29	376	97	10.0	1.4	18	385	24	667	138	10.0	3.7	1	480	-	1180	-	10.7	-							
		1997	15	305	12	294	36	9.7	2.9	15	416	32	814	82	8.1	5.1	1	450	-	820	-	9.0	-							
		1996	7	329	16	354	57	9.9	1.3	8	426	16	863	102	11.2	0.5														
		1995																						1	516	-	1620	-	11.8	-
		1994	6	334	16	472	89	12.8	2.7	28	412	27	809	172	11.4	1.1	8	454	22	1045	209	11.1	1.1							

*includes 1 ocean age 0 fish: FL 402, BW 760, CF 11.7

Table 21. Number sampled, mean and standard deviation of fork length (F.L., cm), body weight (B.W., g), and condition factor (C.F., B.W./F.L.^{3} * 10^6) of pink and coho salmon caught by the *Oshoro maru* research gillnet, 1994-98.

Species	Pink

				Ocean Age 1					
Transect Line	Ocean Domain	Year	N	F.L. mean	s.d.	B.W. mean	s.d.	C.F. mean	s.d.
145 W	R/D Domains	1998	170	469	31	1228	325	11.7	1.2
		1997	102	475	27	1300	217	11.7	2.2
		1996	73	466	32	1217	339	11.5	2.9
		1995	170	483	31	1337	370	11.7	1.6
		1994	186	483	28	1472	424	12.8	2.3
	Subarctic Current	1998	104	480	30	1435	368	12.7	1.5
		1996	30	493	32	1582	358	13.0	1.6
		1995	18	475	25	1326	383	12.1	1.7
		1994	28	491	22	1699	357	14.2	1.7
165	Ridge Domain	1998	14	437	23	1050	191	12.5	0.7
	Subarctic Current	1998	40	452	33	1106	270	11.7	0.9
180	Subarctic Current	1998	5	418	38	832	223	11.2	0.6
		1997	58	418	24	841	136	11.0	2.3
		1996	10	427	25	843	189	10.7	0.9
		1995	44	410	28	733	141	10.7	1.8
		1994	38	427	23	839	144	10.7	0.9
	Transition Domain	1998	1	440	-	900	-	10.6	-
		1997	22	426	26	884	243	10.1	3.4
		1996	2	418	6	760	28	10.4	0.0
		1994	11	430	15	894	95	11.2	0.8

Species	Coho

				Ocean Age 1					
Transect Line	Ocean Domain	Year	N	F.L. mean	s.d.	B.W. mean	s.d.	C.F. mean	s.d.
145 W	R/D Domains	1998	54	615	34	3102	612	13.2	1.4
		1997	50	580	47	2670	711	13.3	1.4
		1996	111	587	44	2817	659	13.8	1.7
		1995	51	579	40	2607	565	13.3	1.7
		1994	87	602	50	3021	815	13.6	1.9
	Subarctic Current	1998	28	616	48	3239	1011	13.5	1.6
		1997	4	544	89	2390	1062	14.1	0.4
		1996	12	602	40	3237	468	14.8	1.8
		1995	15	566	57	2671	856	14.3	1.1
165 W	Subarctic Current	1998	31	567	45	2534	577	13.8	2.3
180	Subarctic Current	1998	2	510	28	1890	495	14.1	1.4
		1997	4	465	83	1195	698	11.0	0.9
		1996	69	505	42	1592	465	11.7	2.5
		1995	72	519	38	1783	402	12.6	1.2
		1994	33	529	41	1880	465	12.4	0.9
	Transition Domain	1998	24	503	43	1537	403	11.2	2.6
		1997	12	488	60	1474	741	11.0	3.7
		1996	30	510	37	1547	341	11.7	2.1
		1995	7	545	57	1940	469	11.9	1.3
		1994	76	522	40	1759	420	12.2	1.5

Table 22. Number sampled, mean and standard deviation of fork length (F.L., cm), body weight (B.W., g), and condition factor (C.F., B.W./F.L.^{3} * 10^6) of chinook salmon and steelhead caught by the *Oshoro maru* research gillnet, 1994-98, grouped by ocean age.

Species: **Chinook**

			Ocean Age 1							Ocean Age 2						
				F.L.		B.W.		C.F.			F.L.		B.W.		C.F.	
Transect Line	Ocean Domain	Year	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.
145 W	R/D Domains	1998	2	572	30	2390	325	13	0	3	662	78	4300	1704	14	1
		1996	1	374	-	550	-	11	-	2	563	10	2480	28	14	1
		1995								1	652	-	4100	-	15	-
	Subarctic Current	1998								2	656	84	4350	1697	15	0
		1995								1	644	-	3800	-	14	-
165	Subarctic Current	1998								1	676	-	4700	-	15	-
180	Subarctic Current	1997								1	642	-	3400	-	13	-
		1996								1	654	-	3360	-	12	-
		1994								1	680	-	4150	-	13	-

Species: **Steelhead**

			Ocean Age 0							Ocean Age 1							Ocean Age 2							Ocean Age 3						
				F.L.		B.W.		C.F.			F.L.		B.W.		C.F.			F.L.		B.W.		C.F.			F.L.		B.W.		C.F.	
Transect Line	Ocean Domain	Year	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.	N	mean	s.d.	mean	s.d.	mean	s.d.
145 W	R/D Domains	1998	7	331	25	396	81	10.8	0.4	2	556	5	1800	226	10.5	1.6	1	581	-	2240	-	11.4	-	3	747	46	4100	1015	9.7	1.0
		1997	12	314	36	345	149	10.6	1.6	2	587	11	2070	184	10.2	0.4	2	746	35	4000	707	9.8	3.1							
		*1996	19	323	22	342	88	10.0	1.3	8	525	45	1461	233	10.2	1.7	2	721	7	2910	14	7.8	0.3	1	700	-	3250	-	9.5	-
		1995	6	311	33	332	94	10.9	1.2	6	548	34	1897	546	11.5	3.3	1	609	-	3100	-	13.7	-	1	675	-	2550	-	8.3	-
		1994	12	327	28	372	80	10.6	1.2																					
	Subarctic Current	1998	20	356	55	527	320	10.5	1.2	13	570	39	2145	492	11.4	1.3	4	695	72	4038	1006	11.9	0.9							
		1997	2	337	55	520	99	14.1	4.2	1	518	-	1580	-	11.4	-	1	732	-	4930	-	12.6	-							
		1996								7	557	56	1901	672	10.7	0.8														
		1995	1	400	-	700	-	10.9	-																					
165 W	Subarctic Current	1998								4	561	28	1820	385	10.2	0.7	1	584	-	2060	-	10.3	-							
180	Subarctic Current	1998								1	585	-	1600	-	8.0	-														
		1997								1	575	-	1800	-	9.5	-								1	662	-	2700	-	9.3	-
		1996								3	560	39	1703	278	9.7	0.8	1	604	-	1880	-	8.5	-							
		1995								2	578	22	1900	198	9.8	0.1	2	676	25	3150	3041	10.8	11.0							
		1994								6	524	22	1547	232	10.7	1.0	1	664	-	3200	-	10.9	-							
	Transition Domain	1998								2	563	4	1760	28	9.9	0.0	6	677	45	2760	570	8.9	1.1	2	710	85	3225	884	9.0	0.7
		1997								3	554	12	1380	170	5.5	4.9	2	713	18	3650	212	10.1	0.2							
		1996								4	558	15	1850	319	10.6	1.0														
		1995								1	542	-	1400	-	8.8	-														
		1994								1	582	-	2000	-	10.1	-														

*includes 1 ocean age 4 fish; FL 800, BW 3950, CF 7.7.

Table 23.
Daily consumption, feeding rate, digestion coefficient, and feeding time estimates for major prey types of sockeye salmon, as determined by a 24-hour sampling experiment in the Bering Sea, 1997. Analysis assumes that feeding on a particular prey type is constant during a specific time interval (shown under Hours of feeding) and zero at all other times. Feeding rate is the rate of prey ingestion of a single salmon during the feeding interval, while total consumption is total food consumed by a single salmon over 24 hours. Digestion coefficient is β in the exponential stomach evacuation equation $S=S0*\exp(-\beta t)$, where S is the average prey weight of a single prey type in a stomach at time t hours, and S0 is the prey weight at t=0 hours. Numbers in parentheses are asymmetric 95% confidence intervals for parameters; x indicates insufficient data for range estimation.

Prey type	Digestion Coefficient (hours-1)	Total consumption (g/day)	Feeding rate (g/hour)	Hours of feeding
Euphausiids	0.15 (x)	3.8 (2.8-5.2)	0.97 (0.49-x)	1500-1900
Copepods	0.15 (x)	7.2 (4.5-11.0)	3.0 (1.2-x)	1500-1700
Fish	0.10 (0.01-0.18)	4.5 (3.5-6.0)	1.6 (0.65-x)	2100-0000
Crab larvae	0.16 (0.09-0.23)	4.3 (3.4-5.6)	0.47 (0.25-0.65)	0300-1200

Table 24. Percentage composition of prey in stomach contents of salmon in six coastal and offshore regions of the Aleutian Islands and North Pacific Ocean, 28 April-25 May 1998, F/V *Great Pacific*.

Prey categories: SQ = cephalopod (squid and octopus), FI = fish, EU = euphausiid, CO = copepod, AM = amphipod, CR = decapod (crab and shrimp), PT = pteropod, PO = polychaete, GE = gelatinous zooplankton (jellyfish, salp, and larvacea), OT = other, UN = unidentified.

		Sockeye		Chum		Pink		Coho		Chinook	
Region	Prey	N	%	N	%	N	%	N	%	N	%
Region 1:	SQ	22	2.2	5	1.0	12	9.2	0		3	36.7
Coastal, Unalaska I.	FI		27.9		0.0		21.9				30.0
(166°-167°W,	EU		13.1		33.0		10.6				33.3
53°-54°N)	CO		1.1		20.0		2.5				0.0
	AM		17.5		0.4		7.5				0.0
	CR		1.1		0.0		0.0				0.0
	PT		35.2		0.4		47.5				0.0
	PO		0.0		0.0		0.0				0.0
	CH		0.0		0.0		0.0				0.0
	GE		1.8		26.0		0.8				0.0
	UN		0.0		19.2		0.0				0.0
	OT		0.0		0.0		0.0				0.0
Region 2:	SQ	54	36.8	46	0.2	1	0.0	0		1	100.0
Offshore, Western	FI		17.6		1.5		0.0				0.0
Gulf of Alaska,	EU		2.9		0.0		0.0				0.0
(152°-164°W,	CO		15.2		6.7		95.0				0.0
50°-52°N)	AM		6.3		0.2		0.0				0.0
	CR		0.1		1.2		0.0				0.0
	PT		3.7		2.1		5.0				0.0
	PO		1.9		0.9		0.0				0.0
	CH		0.0		0.0		0.0				0.0
	GE		13.8		87.2		0.0				0.0
	UN		1.7		0.0		0.0				0.0
	OT		0.0		0.0		0.0				0.0
Region 3:	SQ	0		27	0.0	0		0		14	0.0
Coastal, Kodiak I. -	FI				0.0						98.6
Shelikof Strait	EU				0.0						1.4
(151°-157°W	CO				0.0						0.0
56°-57°N)	AM				0.0						0.0
	CR				0.0						0.0
	PT				28.3						0.0
	PO				0.0						0.0
	CH				0.0						0.0
	GE				33.7						0.0
	UN				38.0						0.0
	OT				0.0						0.0

Table 24. Continued.

Region 4:	SQ	38	6.1	37	0.0	0		0		9	1.1
Coastal, Central	FI		10.5		0.1						22.2
Gulf of Alaska	EU		12.1		7.0						55.6
(145°W, 59°N)	CO		5.3		0.3						0.0
	AM		0.1		0.0						0.0
	CR		0.0		0.0						12.2
	PT		59.3		77.4						0.0
	PO		0.0		0.8						0.0
	CH		0.0		0.0						0.0
	GE		6.7		4.7						0.0
	UN		0.0		9.6						0.0
	OT		0.0		0.0						8.9
Region 5:	SQ	36	6.5	48	0.1	46	5.2	12	87.4	1	100.0
Offshore, Central	FI		6.9		0.0		3.1		0.0		0.0
Gulf of Alaska -	EU		16.9		22.3		4.0		0.0		0.0
northeastern	CO		13.3		1.2		3.9		0.0		0.0
North Pacific	AM		33.2		9.9		51.4		0.1		0.0
(145°W,	CR		0.0		0.0		0.0		0.0		0.0
43°-55°N)	PT		7.6		3.8		27.9		12.5		0.0
	PO		3.2		3.3		0.0		0.0		0.0
	CH		0.0		0.0		0.0		0.0		0.0
	GE		9.4		22.9		0.0		0.0		0.0
	UN		2.8		36.6		4.3		0.0		0.0
	OT		0.0		0.0		0.3		0.0		0.0
Region 6:	SQ	0		0		0		9	0.0	13	0.0
Coastal, Washington	FI								62.2		61.5
(125°W, 48°N)	EU								0.0		0.0
	CO								0.0		0.0
	AM								0.0		0.4
	CR								37.8		38.2
	PT								0.0		0.0
	PO								0.0		0.0
	CH								0.0		0.0
	GE								0.0		0.0
	UN								0.0		0.0
	OT								0.0		0.0

Table 25. Mean % composition of stomach contents of salmonids caught in the Ridge/Dilute Domains along the 145° W transect line by the *Oshoro maru,* 1994-98. PW=prey weight; %empty=percent of stomachs that did not contain stomach contents. Empty stomachs were not included in other table entries. SCI=PW*100/body weight. Prey composition is based on visual estimates.

			%	mean	mean	Mean % composition by volume											
Species	Year	N	empty	pw	SCI	EU	CO	AM	CR	SQ	PT	FI	PO	CH	GE	OTH	UNID
Sockeye	1998	64	25	20	0.74	7	6	11	0	32	27	3	2	0	2	5	5
	1997	145	14	12	0.55	25	49	5	0	9	2	5	2	0	0	2	0
	1996	96	25	26	0.96	6	14	9	0	62	2	5	0	0	0	0	2
	1995	67	52	25	0.97	6	3	3	0	48	17	7	0	0	0	2	16
	1994	90	18	21	0.97	9	5	21	0	49	6	4	2	0	0	0	5
Chum	1998	60	38	6	0.36	4	4	18	1	0	33	0	0	0	10	0	29
	1997	122	27	6	0.58	22	5	3	0	0	14	1	7	0	26	0	22
	1996	105	42	5	0.30	25	3	9	0	1	4	2	2	0	27	0	27
	1995	70	51	8	0.55	9	0	3	0	0	5	3	8	0	2	0	69
	1994	97	19	4	0.35	3	0	32	0	1	21	0	1	0	3	0	39
Pink	1998	61	13	10	0.71	1	15	17	0	22	38	2	0	0	0	0	3
	1997	118	13	11	0.83	27	53	6	0	2	9	1	0	0	0	0	1
	1996	76	29	14	1.04	7	13	13	2	45	5	4	0	0	0	11	1
	1995	68	54	9	0.63	12	10	11	0	20	28	6	1	0	0	0	13
	1994	94	27	11	0.69	1	10	18	2	36	20	3	0	0	0	0	10
Coho	1998	70	37	37	1.16	8	0	7	0	77	8	0	0	0	0	0	0
	1997	88	56	17	0.63	13	4	2	0	59	7	14	0	0	0	0	0
	1996	92	27	43	1.50	0	0	0	0	99	0	1	0	0	0	0	0
	1995	65	54	17	0.68	15	0	2	0	65	0	18	0	0	0	0	0
	1994	89	34	41	1.47	3	0	7	0	73	9	7	0	0	0	0	1
Chinook	1998	17	47	15	0.47	0	0	6	0	94	0	0	0	0	0	0	0
	1997	0															
	1996	7	29	42	1.57	0	0	0	0	80	0	0	0	0	0	0	20
	1995	5	40	32	0.76	0	0	0	0	100	0	0	0	0	0	0	0
	1994	9	11	48	1.18	0	0	0	0	81	0	0	0	0	0	0	19
Steelhead	1998	17	6	47	2.24	0	0	1	0	46	5	46	0	0	0	1	0
	1997	26	8	29	1.60	0	0	3	0	10	8	58	0	0	0	21	0
	1996	42	38	19	1.30	0	0	1	0	44	0	29	4	0	0	18	4
	1995	40	35	13	0.68	0	0	0	0	47	8	32	12	0	0	0	0
	1994	17	18	3	0.55	0	0	9	0	43	9	33	0	0	0	0	6

Prey categories are: EU=euphasiids, AM=amphipods, CR=crab larvae, SQ=squids, PT=pteropods (shelled and naked), FI=fish, PO=polychaetes, CH=chaetognaths, GE=gelatinous zooplankton, including coelenterates, ctenophores, and salps. OTH=other groups, UNID=unidentified materual.

Table 26. Mean % composition of stomach contents of salmonids caught in the Subarctic Current along the 145° W transect line by the *Oshoro maru*, 1994-98. PW=prey weight; %empty=percent of stomachs that did not contain stomach contents. Empty stomachs were not included in other table entries. SCI=PW*100/body weight. Prey composition is based on visual estimates.

			%	mean	mean	Mean % composition by volume											
Species	Year	N	empty	pw	SCI	EU	CO	AM	CR	SQ	PT	FI	PO	CH	GE	OTH	UNID
Sockeye	1998	127	13	37	1.45	1	0	0	0	92	5	0	0	0	0	1	0
	1997	51	14	38	1.83	0	0	0	0	93	3	4	0	0	0	0	0
	1996	39	18	30	1.20	0	0	0	0	100	0	0	0	0	0	0	0
	1995	11	27	30	1.35	0	0	0	0	88	0	0	0	0	0	0	13
	1994	12	25	20	1.19	0	0	0	0	100	0	0	0	0	0	0	0
Chum	1998	105	31	4	0.30	2	1	11	0	1	27	1	4	0	6	0	47
	1997	37	16	7	0.73	6	0	1	0	0	1	0	7	0	28	0	56
	1996	25	44	6	0.43	2	0	2	0	7	2	0	0	0	37	1	49
	1995	10	0	12	0.74	0	0	0	0	0	0	0	0	0	29	0	72
	1994	16	50	2	0.17	0	0	0	0	0	13	0	1	0	1	0	84
Pink	1998	116	16	23	1.52	0	0	1	0	80	16	2	0	0	0	0	0
	1997	1	0	11	0.71	0	0	0	0	60	20	20	0	0	0	0	0
	1996	51	6	18	1.09	0	0	0	0	71	23	6	0	0	0	0	0
	1995	10	20	5	0.30	1	0	18	0	49	3	0	0	0	0	21	9
	1994	14	21	8	0.45	0	0	0	0	66	25	0	0	0	0	0	9
Coho	1998	57	12	41	1.28	0	0	0	0	93	2	3	0	0	0	2	0
	1997	11	27	59	2.10	0	0	0	0	100	0	0	0	0	0	0	0
	1996	22	45	36	1.18	0	0	0	0	100	0	0	0	0	0	0	0
	1995	19	42	43	1.87	0	0	0	0	100	0	0	0	0	0	0	0
	1994	1	100														
Chinook	1998	8	25	65	1.45	0	0	0	0	99	0	0	0	0	0	0	1
	1997	0															
	1996	1	100														
	1995	2	100														
	1994	0															
Steelhead	1998	48	4	22	1.23	2	0	2	0	61	14	17	3	0	0	0	2
	1997	8	25	24	0.92	0	0	0	0	83	0	0	17	0	0	0	0
	1996	5	0	13	0.50	0	0	1	0	51	26	22	0	0	0	0	0
	1995	19	11	15	1.02	0	0	18	0	61	0	9	9	0	0	3	0
	1994	1	0	1	0.07	0	0	0	0	100	0	0	0	0	0	0	0

Prey categories are: EU=euphasiids, AM=amphipods, CR=crab larvae, SQ=squids, PT=pteropods (shelled and naked), FI=fish, PO=polychaetes, CH=chaetognaths, GE=gelatinous zooplankton, including coelenterates, ctenophores, and salps. OTH=other groups, UNID=unidentified materual.

Table 27. Mean % composition of stomach contents of salmonids caught in the Subarctic Current and Ridge Domain along the 165° W transect line by the *Oshoro maru*, 1998. PW=prey weight; %empty=percent of stomachs that did not contain stomach contents. Empty stomachs were not included in other table entries. SCI=PW*100/body weight. Prey composition is based on visual estimates.

Ocean Domain	Species	Year	N	% empty	mean pw	mean SCI	Mean % composition by volume											
							EU	CO	AM	CR	SQ	PT	FI	PO	CH	GE	OTH	UNID
Ridge Domain	Sockeye	1998	26	31	4	0.38	2	7	36	0	10	24	5	0	0	0	0	17
	Chum	1998	18	22	6	0.35	0	3	14	0	13	40	0	0	0	6	0	23
	Pink	1998	11	0	17	1.42	0	39	18	0	1	19	4	0	0	0	0	20
Subarctic Current	Sockeye	1998	45	16	8	0.56	3	5	54	0	29	2	0	1	0	1	0	5
	Chum	1998	58	10	5	0.48	3	3	7	0	2	2	0	0	0	0	0	83
	Pink	1998	47	15	7	0.58	0	3	44	0	33	17	4	0	0	0	0	0
	Coho	1998	28	25	44	1.69	0	0	0	0	94	6	0	0	0	0	0	0
	Chinook	1998	6	17	37	1.12	0	0	0	0	100	0	0	0	0	0	0	0
	Steelhead	1998	9	33	16	0.83	0	0	1	0	33	0	50	17	0	0	0	0

Prey categories are: EU=euphasiids, AM=amphipods, CR=crab larvae, SQ=squids, PT=pteropods (shelled and naked), FI=fish, PO=polychaetes, CH=chaetognaths, GE=gelatinous zooplankton, including coelenterates, ctenophores, and salps. OTH=other groups, UNID=unidentified materual.

Table 28. Chum salmon stomach samples collected from the central Bering Sea by longline fishing operations of the *Wakatake maru* in July 1991-1997. The total number examined (N), mean fork length (FL, mm), mean body weight (BW, g), and percent empty stomachs (% empty) were calculated based on all chum stomach samples examined. Remaining table values were calculated from those stomach samples that contain prey. Mean prey weight (PW, g), mean stomach content index (SCI; stomach content weight X 100/body weight), mean percent composition of prey categories euphausiids (EU), copepods (CO), amphipods (AM), crab larvae (CR), squid (SQ), pteropods (PT), fish (FI), polychaetes (PO), chaetognaths (CH), gelatinous zooplankton (GE, including medusae, ctenophores, salps), all other groups (OTH; including appendicularia, ostracods, heteropods, mysids, all other groups), and unidentified material (UNID). Morishita's Index=N(N-1)/sum ($n_i(n_i$-1)), where N=100 and n_i=mean percent composition in each prey category.

Age	Maturity	N	FL	BW	% Empty	PW	SCI	Mean Percent Composition of Prey Categories												
								EU	CO	AM	CR	SQ	PT	FI	PO	CH	GE	OTH	UNID	Morishita's Index
0.1	IM	103	368	504	4	7.1	1.431	4	5	26	1	7	10	12	0	6	11	4	14	7.734
	MT	1	359	510	0	7.0	1.373	0	0	40	25	10	0	25	0	0	0	0	0	3.474
	Total	104	368	504	4	7.1	1.431	3	5	26	2	7	10	12	0	6	11	4	14	7.759
0.2	IM	376	442	935	1	12.0	1.285	11	5	9	0	8	9	11	1	1	21	12	12	8.808
	MT	53	481	1260	0	16.8	1.387	13	4	4	1	13	6	11	2	0	25	5	16	7.399
	Total	429	446	975	1	12.6	1.297	12	5	9	0	9	8	10	1	1	21	11	13	8.777
0.3	IM	187	506	1472	3	17.0	1.149	19	7	9	0	6	10	9	0	0	22	5	13	7.698
	MT	266	559	2049	3	22.9	1.136	19	5	4	0	6	11	6	1	0	23	9	16	7.269
	Total	453	537	1811	3	20.4	1.142	19	6	6	0	6	11	7	1	0	22	7	15	7.627
0.4	IM	8	549	1940	0	18.9	1.024	21	14	3	0	8	19	0	0	0	15	0	20	6.203
	MT	92	612	2781	3	23.7	0.869	17	2	4	0	5	13	7	1	1	27	10	13	6.818
	Total	100	607	2714	3	23.3	0.881	18	3	4	0	5	13	6	1	1	26	9	14	6.904
0.5	IM	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	MT	11	658	3535	0	17.4	0.517	19	1	1	0	2	11	12	0	1	32	11	10	5.568
	Total	11	658	3535	0	17.4	0.517	19	1	1	0	2	11	12	0	1	32	11	10	5.568
Total	IM	674	449	1030	2	12.7	1.266	13	6	12	0	8	9	10	1	1	19	8	13	9.083
	MT	423	563	2144	3	22.1	1.095	18	4	4	0	7	11	7	1	0	24	9	15	7.290
	Total	1097	493	1460	2	16.3	1.200	14	5	9	0	7	10	9	1	1	21	9	14	8.594

Table 29. ANOVA of final linear model, where the dependent variable is frequency of Lastan 1 (last annulus not yet forming) and the independent variables are recovery age and month (recmo).

Source	Df	Sum of Sq	Mean Sq	F Value	p-value
age	2	78.25	39.13	6.85	0.002
recmo	3	233.83	77.94	13.65	0.000
age*recmo	6	74.75	12.46	2.18	0.057
Residuals	60	342.67	5.71		

Table 30.
Results from 10-day runs of two bioenergetics models of adult pink salmon in the Alaskan Gyre in July at 7° C, simulating the possible change in forage demand across the 1976-77 regime shift. Food consumption estimates are based on size selectivity seen in food habits data collected between 1980-97.

Characteristic	**Pre-1976**	**Post- 1976**
Central Alaskan pink salmon return (millions)	11.7	25.5
Adult pink salmon body size	1.7 kg	1.4 kg
Mean per-capita growth over 10 days	5.26 x 10-3 g/g/day (8.5 g/fish/day)	5.33 x 10-3 g/g/day (7.1 g/fish/day)
Total biomass growth over 10 days	970 mt	1,800 mt
Mean trophic level	2.46	2.27
Growth Efficiency	0.174	0.168
Total 10-day small zooplankton consumption	2,300 mt	6,750 mt
Total 10-day large zooplankton consumption	1,600 mt	2,650 mt
Total 10-day squid consumption	1,800 mt	1,450 mt