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THE 1996 INTERNATIONAL COOPERATIVE SALMON RESEARCH CRUISE OF THE *OSHORO MARU* AND A SUMMARY OF 1994-1996 RESULTS

by

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ABSTRACT

This document reports on the 1996 international cooperative salmon research cruise of the *Oshoro maru*, and summarizes data collected from 1994 to 1996. An objective of international cooperative high-seas salmon research conducted under the North Pacific Anadromous Fish Commission Science Plan is salmon stock assessment through annual surveys along standard transects in the North Pacific Ocean and Bering Sea. Salmon surveys conducted by the *Oshoro maru*, Hokkaido University, Faculty of Fisheries, along 180° in the central North Pacific Ocean in June since 1978 have provided a valuable time series of fisheries and oceanographic data. This was the third consecutive year of cooperative Japan-U.S. research gillnet sampling for salmon along a 145°W transect in the central Gulf of Alaska in early July. In 1996, *Oshoro maru* catches by gillnet totaled 361 salmon in the central North Pacific (180° transect) and 1,982 salmon in the central Gulf of Alaska. At longline stations, 17 salmon along the 180° transect and 33 salmon in the Gulf of Alaska were tagged and released. Biological samples and data were collected from salmon for various studies of distribution, abundance, stock origins, maturity and growth, food habits, bioenergetics, and other aspects of ocean biology and ecology.

In the central Gulf of Alaska from 1994 to 1996, salmon were caught by research gillnet (C-gear) in two oceanic domains, the Subarctic Current and the Dilute Domain. From 1994 to 1996, mean sea surface temperatures in early July at gillnet stations along the 145°W transect decreased from 10.7°C to 9.8°C in the Subarctic Current and from 11.5°C to 10.2°C in the Dilute Domain. In both domains, chum salmon (predominantly immature ages .1 and .2 fish) were usually the most abundant species in gillnet catches. Maturing sockeye (predominantly age .2), pink (age .1), and coho (age .1) salmon were more abundant in the Dilute Domain, and chinook salmon and steelhead were more abundant in the Subarctic Current. In the Dilute Domain, there was a substantial (approximately 50%) decrease in the abundance of sockeye salmon and an increase in the abundance of coho salmon from 1994 to 1996. Percentages of maturing chum salmon in the Dilute Domain decreased from 40% in 1994 to 5% in 1996. Size-at-age of chum, pink, and coho salmon was substantially larger in C-gear catches in the Gulf of Alaska than in the central North Pacific. Squid, primarily *Berryteuthis anonychus*, was 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 all species was more diverse and the mean stomach content index (prey weight*100/body weight) was often lower than in the Subarctic Current. From 1994 to 1996, there was an increase in the mean percentage of squid, presumably *Gonatus middendorffi*, in the stomach contents of sockeye, pink, and coho salmon in the Dilute Domain. Only three consecutive years of data from the 145°W transect in the Gulf of Alaska are available, but there is an apparent even- odd-year cycle in salmon abundance, size, and food habits.

INTRODUCTION

This document reports on the 1996 international cooperative salmon (*Oncorhynchus* spp.) research cruise of the *Oshoro maru* in the central North Pacific and Gulf of Alaska, and summarizes data collected during cooperative cruises from 1994 to 1996. An objective of international cooperative high-seas salmon research conducted under the North Pacific Anadromous Fish Commission (NPAFC) Science Plan is salmon stock assessment through annual surveys along standard transects in the North Pacific Ocean and Bering Sea (FAJ 1994a,b; NPAFC 1995, 1996). Salmon surveys conducted by the *Oshoro maru*, Hokkaido University (HU), Faculty of Fisheries (FOF), along 180° in the central North

Pacific Ocean since 1978 have provided a valuable time series of fisheries and oceanographic data. In recent years, the FOF and the Fisheries Research Institute (FRI), School of Fisheries, University of Washington, have cooperated in salmon research aboard the *Oshoro maru* in the central North Pacific and Gulf of Alaska (Walker 1993, Walker and Myers 1994, Walker et al. 1994, Myers et al. 1995). A primary objective of the 1996 cooperative research was to continue the collection of oceanographic and biological data along the 180° transect and along a 145°W transect in the central Gulf of Alaska. In 1996, FOF invited two FRI scientists (K. Myers and K. Aydin) and two Hokkaido Salmon Hatchery (HSH), Fisheries Agency of Japan (FAJ) scientists (M. Kaeriyama and S. Urawa) to participate in cooperative salmon research aboard the *Oshoro maru.* FOF scientists, *Oshoro maru* officers and personnel, and cadets from HU and Nagasaki University conducted oceanographic, gillnet, and longline research. FOF, FRI, and HSH scientists collected additional biological samples and data for various studies of distribution, abundance, stock origins, maturity and growth, food habits, bioenergetics, and other aspects of ocean biology and ecology of salmon in offshore waters.

METHODS

Survey Area, Cruise Schedule, and Post-Cruise Workshop

Hydrographic, plankton, and salmonid sampling and additional sampling for salmonid feeding ecology, growth, and stock identification studies was conducted in the central North Pacific and Gulf of Alaska (Fig. 1, Tables 1 and 2). In international waters, surface longlines (B-gear) and gillnets (C-gear is non-selective varied research mesh and A-gear is commercial mesh) were used to catch salmonids. At stations inside the U.S. EEZ, only the surface longline was used to catch fish. Along 180° longitude in the central North Pacific, fishing for salmonids was conducted northward from 41°N to 47°N latitude. In the central Gulf of Alaska, salmonids were sampled southward along 145°W from 58° 19'N to 50°N, and eastward, between 141-144°W and 51-53°N.

The *Oshoro maru* departed Hakodate on 3 June 1996. From 11 to 22 June, salmon and oceanographic research was conducted northward along the 180° transect. The vessel made a port call in Valdez, Alaska, from 27 to 30 June, where FRI and HSH scientists boarded the vessel. From 1-12 July, oceanographic and salmon research was conducted in the central Gulf of Alaska southward along the 145°W transect and at additional eastward stations. On 13 July, the *Oshoro maru* arrived in Juneau, Alaska, where FRI and HSH scientists disembarked.

On 15 July, FRI, FOF, HSH, U.S. National Marine Fisheries Service (NMFS), University of Alaska (UA), Oregon State University, and fishing industry scientists participated in a "Workshop on Opportunities for High Seas Fisheries Oceanographic Research in the North Pacific Ocean and the Bering Sea," which was sponsored by the Juneau Center School of Fisheries and Ocean Sciences, UA Fairbanks, and NMFS, Auke Bay Laboratory (ABL). K. Myers, FRI, served as moderator for the salmon research session, "Recent Progress on Oceanic Ecology of Salmon," at the post-cruise workshop.

Oceanographic Sampling

Oceanographic sampling (CTD casts, water samples for nutrient [PO4, NO3, NO2, Si) analyses, and zooplankton sampling with a Norpac net] was conducted by FOF scientists at each fishing station and between each station (Table 1A, B). At fishing stations, the CTD is lowered to a depth of 3,000 m, and the data are continuously recorded to a computer file. Summaries of temperature (°C), salinity (practical salinity units, psu; measurements based on electrical conductivity of seawater), dissolved oxygen, and sigma-T values at 25 depths are listed on computer printouts. Computer files of these data summaries were used to plot temperature and salinity isopleths along the 180° and 145°W

transects. Criteria used to define oceanographic regions along the transects are shown in Table 3.

Gillnet Research

Gillnet research was conducted by *Oshoro maru* personnel (Table 1C). The total length of gillnet used in 1996 was 47-49 tans (Table 4). Each tan is 50 m long. Unlike the net used in 1994 and 1995, the net used in 1996 varied from 12 to 24 tans of A-gear (19 tans used in 1994 and 1995) and from 25 to 30 tans of C-gear (30 tans used in 1994 and 1995; Table 4). Additional experimental meshes, which were not used in 1994 and 1995, were used at stations along the 180° transect (F-gear, 1 tan each of 7 meshes from 19-42 mm; Table 4).

Gillnet gear was set in the evening, allowed to soak overnight, and was retrieved the following morning. As the gillnet is hauled, the catch is sorted into baskets by mesh size and species. As the sorted fish move down the processing line, scale samples are collected, and species, fork length (mm), body weight (g), sex, and gonad weight (g) are recorded by mesh size on biological data forms. The catch by mesh size and species is recorded in an operations book and later entered onto computer data forms, which are the official form used to report catches to FAJ. All salmon catch and biological data were entered into a computer spreadsheet during the cruise.

At gillnet stations in the Gulf of Alaska, stomachs were collected from the first ten fish of each species in the processing line, and from up to 10 additional fish per species from a range of other mesh sizes (Table 2A). FOF and HSH personnel sampled chum salmon (*O. keta*) for isozyme analysis, and collected brain, otolith, and parasite samples for various studies (Table 2B,C). Blood samples were collected from a subsample of all species in the catch for growth and maturation studies (Table 2B). Several whole fish samples were collected for caloric analysis.

Longline Research and Tagging

The total amount of longline gear fished was 10 hachi, each hachi consisting of 34 hooks and gangions attached at intervals of 3 m to 127 m of mainline (Table 1C). The hooks are baited with small salted anchovy, and fish at a depth of about 2 m. Longlines were set in the early morning, fished for one and one-half to two and one-half hours, and retrieved after hauling the gillnet.

All viable salmonids caught on longlines were double-tagged with both FAJ (orange and white, 1.6 cm in diameter) and FRI (red, 2.0 cm in diameter) Petersen disk tags (Table 2D). The FAJ tags are labeled with the word "JAPAN" in English. The FRI tags have FRI's address on one side and identification in Russian (TINRO, which is the acronym for Russia's Pacific Research Institute of Fisheries and Oceanography) on the other side. The use of tags with a U.S. address and Russian identification may improve the return of FAJ tags by North American and Russian fishermen.

As the longline is retrieved, the fish are landed in a dipnet, hooks are removed, and the fish are placed in a tank with flowing water for recovery. Viable fish are removed from the tank and placed on a measuring board. Fork length (mm) is measured, and a scale sample is taken. The tags, which have a hole in the center, are threaded onto a plastic cinch strap, which is inserted into a hollow needle. The fish is held firmly upright, and the needle is inserted through the dorsal musculature, just in front of the dorsal fin. The plastic strap is quickly cinched, and the tagged fish is either put in the holding tank to recover or released immediately over the side. Data on species, length, and tag number of each fish are recorded on data forms.

At Gulf of Alaska stations, all double-tagged salmonids were injected with oxytetracycline hydrochloride (OTC) to induce a mark on the otolith for validation of ocean age and daily growth increments. The approximate dosage used was 25 mg OTC/kg fish dissolved in a .9% saline solution. Fish were injected in the dorsal musculature just beneath or behind the dorsal fin. Fish less than 40 cm in length were injected with 0.5 ml OTC solution, 40-49 cm fish with 1 ml OTC, and 50-59 cm fish with 2 ml OTC. Some of the fish caught on longline gear were sacrificed for isozyme (chum salmon) and blood samples.

Fish Lacking Adipose Fins

By prior arrangement with FAJ, snouts were collected from salmonids lacking an adipose fin (Table 2D). Snouts collected from fish lacking adipose fins were labeled with catch and biological information, frozen, and delivered to ABL during the Juneau port call, where they will be examined for coded-wire tags. ABL reports release and recovery information on coded-wire tags to NPAFC.

Scale Sampling

Scale samples were collected for age, growth, and stock origin studies, and for comparison with scales collected in the same areas in the past. Scale samples were collected by *Oshoro maru* personnel from all longline-caught fish and from up to 60 fish of each species caught in each mesh size of gillnet used in each set. All scales were collected from the International North Pacific Fisheries Commission (INPFC) preferred body area (identified by the letter "A" on data forms; Davis et al. 1990), except in cases where all preferred scales were missing (identified by the letter "C" on data forms), and placed on gummed cards. During the Juneau port call (14 July), FRI scientists used the scale press at the Douglas, Alaska, office of the Alaska Department of Fish and Game to make two sets of acetate impressions (one for FRI and one for HSH) of all scales collected by *Oshoro maru* personnel. Extra scales (scrape samples) were collected from all steelhead (*O. mykiss*) for identification of hatchery and wild origin of steelhead in the catch.

At FRI, acetate impressions were examined at magnifications of 40-100X, and ages were determined by counting the number of freshwater and ocean annuli. The scales were examined independently by two FRI scale readers. Many of the acetate impressions of scales were of poor quality (scales mounted with the wrong side up on gummed cards or covered with glue). After returning to Hokkaido, HSH personnel cleaned and remounted some of the chum salmon scales, and provided new copies of acetate impressions to FRI. These scales were reexamined by FRI personnel, and final ages were determined.

Maturity

Maturity of salmonids in the biological samples was determined from gonad weights. Criteria used for deciding maturity for each species are shown in Table 5.

Stomach Contents

Fresh stomach contents were examined in a shipboard laboratory from up to 20 fish of each species from each gillnet set. The methods used were adapted from those of Pearcy et al. (1988), and were similar to those described by Walker and Myers (1994) except that contents were examined with a microscope. Stomachs were removed from the esophagus to the pyloric valve. Each stomach was weighed to the nearest gram, the contents removed, and the empty stomach reweighed. The difference in weights was used as the prey weight (PW). The contents were classified to the following major prey categories: euphausiids, copepods, amphipods, decapods, squid, pteropods, fish, polychaetes, chaetognaths, gelatinous zooplankton (medusae, ctenophores, salps, appendicularia), "other" (prey category is noted), and "unidentified." Percent volume of each prey category was estimated subjectively. Stomach content indices (SCI), a measure of stomach content

weight as a percentage of total body weight, were calculated as: (prey weight*100/body weight). Fish with empty stomachs were not included in calculations of mean SCI and percent prey composition by volume. The data were entered into a computer spreadsheet, and were provided on computer disk to all participants.

If family, genus, or species could be identified, this was also recorded in data notebooks. General size categories for gonatid squids, i.e., "large", for example, *Berryteuthis anonychus* with a DML of 80-110 mm, and "small", for example, *Gonatus middendorffi* with a DML of approximately 40-60 mm, and counts of large prey (squid and fish) were also noted for approximately 50% of the samples. Sub-samples of fish, squid, and unidentified prey in good condition were frozen or preserved in buffered (10%) formalin for later identification to genus and species.

Blood Samples

Blood samples were collected from a subsample of all salmonid species. The blood samples will be analyzed for insulin-like growth factor (IGF-I) and insulin levels for growth studies and for levels of serum steroid hormone to determine maturity stage (primarily chum salmon). Blood was drawn from the caudal vein of freshly landed fish (gillnet, longline, and hook-and-line fishing) using 10 ml vacuum tubes and holders fitted with 19 gauge needles. Within approximately 1/2 hr of collection, the blood samples were centrifuged at 3000 rpm for 15 min. The serum was auto-pipetted (disposable tip) into two 1.5 ml cryo-tubes (approximately 1.0 ml of serum each), one for U.S. scientists and one for HSH, labeled with a species code-sample number, and stored in a shipboard freezer at -80°C.

Summary of Japanese Research Vessel Data By Oceanographic Region

The *Oshoro maru* (1994-1996) research gillnet (C gear) catch, age, length, weight, and maturity data, and salmonid stomach contents data (both A and C gear) were summarized by oceanographic region (Table 3). The identification of oceanographic regions was based on observed temperature and salinity in each year (Table 3, Fig. 2, Walker and Myers 1994, Myers et al. 1995). Relative abundance of salmonids was estimated by calculating catch per unit effort (CPUE), where one unit of effort was equal to one operation of the non-selective research-mesh gillnet. The 1994 age determinations were made by personnel at the National Research Institute of Far Seas Fisheries, FAJ, and the 1995-1996 age determinations were made by FRI personnel.

RESULTS AND DISCUSSION

Gillnet and Longline Catches

Salmonid sampling was conducted at 18 gillnet and 12 longline stations (Fig. 1; Tables 6 and 7). At the gillnet stations, the total catch was 2,343 salmonids (583 sockeye *O. nerka*, 707 chum, 377 pink *O. gorbuscha*, 593 coho *O. kisutch*, 16 chinook *O. tshawytscha*, and 67 steelhead; Table 6). At the longline stations, 17 salmon in the central North Pacific and 33 salmon in the central Gulf of Alaska were tagged and released (Table 7). The serial numbers of tags released at each station are reported annually to NPAFC by FAJ, and recoveries of tagged fish are reported by FRI.

Biological Samples

In the Gulf of Alaska, biological samples were collected for stock identification, food habit, and growth and maturity studies (Table 2). Snouts were collected from 38 salmonids lacking adipose fins (28 steelhead and 5 coho, 4 sockeye, and 1 pink salmon). Stomachs from 713 salmonids (55 steelhead and 174 sockeye, 163 chum, 176 pink, 137 coho, and 8 chinook salmon) were collected and analyzed aboard the vessel. Blood samples were collected from 22 sockeye, 52 chum, 15 pink, 15 coho, and 6 chinook

salmon, and 19 steelhead for laboratory analyses of growth hormone levels. Additional blood (68 chum), isozyme (355 chum), parasite (65 coho), brain (40 chum and sockeye), and otolith (145 chum and sockeye) samples were collected for maturity, stock identification, and migration studies.

Oceanographic Conditions and Salmon Distribution

In the central North Pacific Ocean, salmon were caught by C-gear in two oceanic domains, the Transition Domain (surface salinity <34.0 ‰ and >33.2 ‰) and the Subarctic Current (characterized by relatively cool, dilute surface waters and homogeneous environmental conditions; Table 8). No salmonids were taken by this gear in the Transition Zone (surface salinity >34‰). In mid-June 1996, the Subarctic Boundary (34 ‰ vertical isohaline from the surface to approximately 200-400 m) was located between 40°N and 41°N, which was similar to its position in 1994 and approximately 1° farther south than in 1995 (Fig. 2, Walker and Myers 1994, Myers et al. 1995). Average sea surface temperatures (SST) in June 1996 were approximately 1-2°C warmer than in 1994 and 1995 (Table 8). The approximate southern limit of salmon distribution in the central North Pacific in June 1996 was at 41°N (SST 11.5° C), where one steelhead was caught (Table 6). This was a 1° southward shift in the southern limit of salmonid distribution from 1995 (42°N, SST 10.5°C). No sockeye or chinook salmon were caught by C-gear in the Transition Domain. Coho and chum salmon were usually the most abundant species in catches in the Transition Domain. The relative abundance of all species in Transition Domain catches was higher in 1996 than in 1995. In the Subarctic Current, the catches were predominantly immature chum salmon and maturing pink and coho salmon. The relative abundance of chum salmon in Subarctic Current catches increased substantially from 1995 to 1996, coho salmon abundance in 1996 was similar to 1995, and the abundance of pink salmon decreased substantially from 1994 to 1996.

In the central Gulf of Alaska in early July, salmon were caught by C-gear in two oceanic domains: the Subarctic Current, which is marked in this region by the precipitous descent of the 4°C isotherm from approximately 100 m to 300 m below the surface, and the Dilute Domain, which is characterized by relatively warm (> 10°C) and dilute (32.8 ‰ isohaline below 80 m) surface waters. A prominent oceanographic feature of the central Gulf of Alaska, the Ridge Domain, which is characterized by cold (4°C isotherm within 100 m of the surface), nutrient-rich, and oxygen-poor water, was usually located to the west of the 145° survey line from 1994 to 1996 (Walker and Myers 1994, Myers et al. 1995). An apparent cooling trend in SSTs occurred from 1994 to 1996 (Table 8). In the Subarctic Current, mean SSTs decreased from 10.7°C in 1994 to 9.8°C in 1996. Mean SSTs also decreased in the Dilute Domain from 11.5°C in 1994 to 10.2°C in 1996. The relative abundance of salmon was highest in the Dilute Domain (Table 8). Chum salmon were the most abundant species in catches in this region in 1995 and 1996. From 1994 to 1996, the relative abundance of sockeye salmon in catches in the Dilute Domain decreased, and the abundance of coho salmon increased. In 1996, the relative abundance of all species of salmon was substantially lower in the Subarctic Current than in 1995. There was a substantial (over 50%) reduction in the mean CPUEs of pink salmon in both the Subarctic Current and Dilute Domain. Sampling has not been conducted far enough to the south to determine the position of the Subarctic Boundary or the southern limit of salmonid distribution along 145°W. The effect of changes in the configuration of the gillnet on CPUE of salmon in 1996 is not known (Table 4).

Maturity, Age Composition, and Average Body Size of Salmon

The percentages of maturing salmonids in research gillnet (C-gear) catches from 1994-1996 are summarized by oceanic domain in Table 9. Pink and coho salmon in all domains are maturing fish. In the Gulf of Alaska, the majority of sockeye salmon in catches in early July are maturing fish, although percentages of immature sockeye salmon

were relatively high (43%) in the Subarctic Current Domain in 1994. In contrast, the few sockeye salmon in mid-June catches in the central North Pacific are all immature fish. Chum salmon in catches in all domains are predominantly immature fish, and there is an apparent decreasing trend in percentages of maturing chum from 1994 to 1996, especially in the Dilute Domain. Few chinook salmon are caught in research gillnets, and most are immature fish. Steelhead catches in the Gulf of Alaska in early July are a complex mix of all life history stages (juvenile, immature, maturing, and kelt), whereas juvenile steelhead do not occur in offshore catches in the central North Pacific in mid June.

In the central North Pacific in mid June, ages .1 and .2 were the dominant ocean age groups of chum salmon (Table 11). All pink and coho salmon were age .1 fish. In the Subarctic Current, the few chinook salmon caught were age .2, and the majority of steelhead were age .1 (Tables 12-15). In Subarctic Current catches from 1994 to 1996, mean lengths and weights of age .2 chum salmon increased, the mean size of coho salmon decreased, and pink salmon were larger in 1994 and 1996, than in 1995 (Tables 11-13).

In the central Gulf of Alaska in early July, sockeye salmon in their third summer at sea (age .2 fish) were the dominant age group in all years (Table 10). Ocean ages .1 and .2 were the dominant age groups of chum salmon (Table 11). All pink and coho salmon were ocean age .1 fish (Tables 12 and 13). All chinook salmon were ocean age .2 (Table 14). Juvenile (age .0) steelhead occurred only in the central Gulf of Alaska catches, where they were often the predominant age group of steelhead, particularly in the Subarctic Current. The mean size-at-age of chum, pink, and coho salmon in the Gulf of Alaska catches is substantially larger than in the central North Pacific catches in all years.

Food Habits

Sampling for stomach contents during the *Oshoro maru* cruise was done primarily in the Gulf of Alaska. *Oshoro maru* personnel collected stomachs from coho salmon along the 180° transect, but these data were not available for this document.

In the Subarctic Current, the percentage of empty stomachs was substantially lower in 1996 than in 1995 for all species except chum salmon (Table 16). Mean prey weights and SCIs were also substantially lower in chum salmon and higher in pink, coho, and chinook salmon in 1996 than in 1995. In this region from 1994 to 1996, squid, primarily *Berryteuthis anonychus*, was the dominant prey of all species except chum salmon. This corroborates the results of Pearcy et al. (1988), and highlights the importance of this species in the diets of salmonids in the central Gulf of Alaska. In all years, sockeye, coho, and chinook salmon fed almost exclusively on squid, and steelhead also consumed squid and a relatively high percentage of fish. Both pink salmon and steelhead in this region also consistently fed on pteropods. Because of the high percentage of unidentified prey in 1994 and 1995, it is difficult to identify any changes in prey composition of chum salmon stomach contents. In 1996, chum salmon fed primarily on a mixture of euphausiids, amphipods, and gelatinous zooplankton, which were largely absent in the stomachs of other species.

In general, prey composition of salmon stomach contents is more diverse and mean SCI is often lower in the Dilute Domain than in the Subarctic Current catches in early July (Table 17). From 1994 to 1996, there has been an increase in the mean percentage of squid, presumably *Gonatus middendorffi*, in the stomach contents of sockeye, pink, and coho salmon. In sockeye, chum, and pink salmon stomachs, mean percent composition by volume of copepods and amphipods was higher and that of pteropods was lower in 1996 than in 1995. There was also an apparent increase in the mean percentage of gelatinous zooplankton in chum salmon stomachs in 1996, although a high percentage (61%) of the prey in chum salmon stomachs in 1995 could not be identified.

Even- Odd-Year Cycle in Abundance, Size, and Food Habits

Only three consecutive years of data from the 145°W transect in the Gulf of Alaska are available, but there is an apparent even- odd-year cycle in salmon abundance, size, and food habits. In both domains in even years (1994 and 1996), total relative abundance of salmon in C-gear catches was substantially lower, the mean lengths and weights of coho salmon and age .2 sockeye salmon were larger, and age .2 chum salmon were smaller than in 1995 (Tables 8, 10-13). Body weights of pink salmon in the Subarctic Current were also larger in even years (Table 12). In the Subarctic Current in even years, the mean percentage of empty stomachs was lower in sockeye, pink, coho, and chinook salmon and higher in chum salmon, and the mean percent composition by volume of squid in sockeye, chum, pink, and coho salmon stomachs was higher than in 1995 (Table 16). In the Dilute Domain in even years, the mean size of age .1 chum salmon was smaller, and the percentage of empty stomachs for all species of salmon was lower than in 1995 (Table 17).

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REFERENCES

Davis, N.D., K.W. Myers, R.V. Walker, and C.K. Harris. 1990. The Fisheries Research Institute's high-seas salmonid tagging program and methodology for scale pattern analysis. Am. Fish. Soc. Symp. 7:863-879.

Dodimead, A.J., F. Favorite, and T. Hirano. 1963. Salmon of the North Pacific Ocean, part II, review of oceanography of the subarctic Pacific region. Int. N. Pac. Fish. Comm. Bull. 13. 195 pp.

Favorite, F., A.J. Dodimead, and K. Nasu. 1976. Oceanography of the subarctic Pacific region, 1960-71. Int. N. Pac. Fish. Comm. Bull. 33. 187 pp.

Fisheries Agency of Japan. 1994a. Scientific research on salmon resources should be promoted by the North Pacific Anadromous Fish Commission. (NPAFC Doc. 80.) Fisheries Agency of Japan, Tokyo 100, Japan. 3 p.

Fisheries Agency of Japan. 1994b. A Japanese research plan for salmon stock assessment in the North Pacific Ocean. (NPAFC Doc. 81.) Fisheries Agency of Japan, Tokyo 100, Japan. 3 p.

Ito, J., K. Takagi, and S. Ito. 1974. The identification of maturing and immature chinook salmon, *Oncorhynchus tshawytscha* (Walbaum) in the offshore stage and some related information. Far Seas Fish. Res. Lab. Bull. 11:68-75.

Myers, K.W., R.V. Walker, N.D. Davis, W.S. Patton, K.Y. Aydin, E.K. Pikitch, and R.L. Burgner. 1995. Migrations, abundance, and origins of salmonids in offshore waters of the North Pacific - 1995. (NPAFC Doc. 152) FRI-UW-9506. University of Washington, Fisheries Research Institute, Box 357980, Seattle. 84 pp.

North Pacific Anadromous Fish Commission. 1995. Research planning and coordinating meeting. (NPAFC Doc. 121.) North Pacific Anadromous Fish Commission, 6640 NW Marine Drive, Vancouver, B.C., Canada V6T 1X2. 14 pp.

North Pacific Anadromous Fish Commission. 1996. Science plan 1995-96. North Pacific Anadromous Fish Commission, 6640 NW Marine Drive, Vancouver, B.C., Canada V6T 1X2. 10 pp.

Okazaki, T. 1984. Age composition, growth, sex ratio, and gonad development of *Salmo gairdneri* and *Salmo mykiss* in the North Pacific. Japan. J. Ichthyol. 31:23-37.

Pearcy, W.G., R.D. Brodeur, J.M. Shenker, W.W. Smoker, and Y. Endo. 1988. Food habits of Pacific salmon and steelhead trout, midwater trawl catches and oceanographic conditions in the Gulf of Alaska, 1980-1985. Bull. Ocean Res. Inst. 26(II):29-78.

Takagi, K. 1961. The seasonal change of gonad weight of sockeye and chum salmon in the North Pacific Ocean, especially with reference to mature and immature fish. Bull. Hokkaido Reg. Fish. Res. Lab. 23:17-34.

Walker, R.V. 1993. Summary of cooperative U.S.-Japan high seas salmonid research aboard the Japanese research vessel *Oshoro maru*, 1993. (NPAFC Doc. 21) FRI-UW-9311. Fisheries Research Institute, University of Washington, Seattle. 16 pp.

Walker, R.V., and K.W. Myers. 1994. Salmonid food habits in offshore waters of the Gulf of Alaska, June-July, 1994. (NPAFC Doc. 67) FRI-UW-9409. Fisheries Research Institute, University of Washington, Seattle. 10 pp.

Walker, R.V., K.W. Myers, G. Anma, and S. Sasaki. 1994. Summary of cooperative U.S.-Japan high seas salmonid research aboard the Japanese research vessel *Oshoro maru*, 1994. (NPAFC Doc. 66) FRI-UW-9408. Fisheries Research Institute, University of Washington, Seattle. 15 pp.

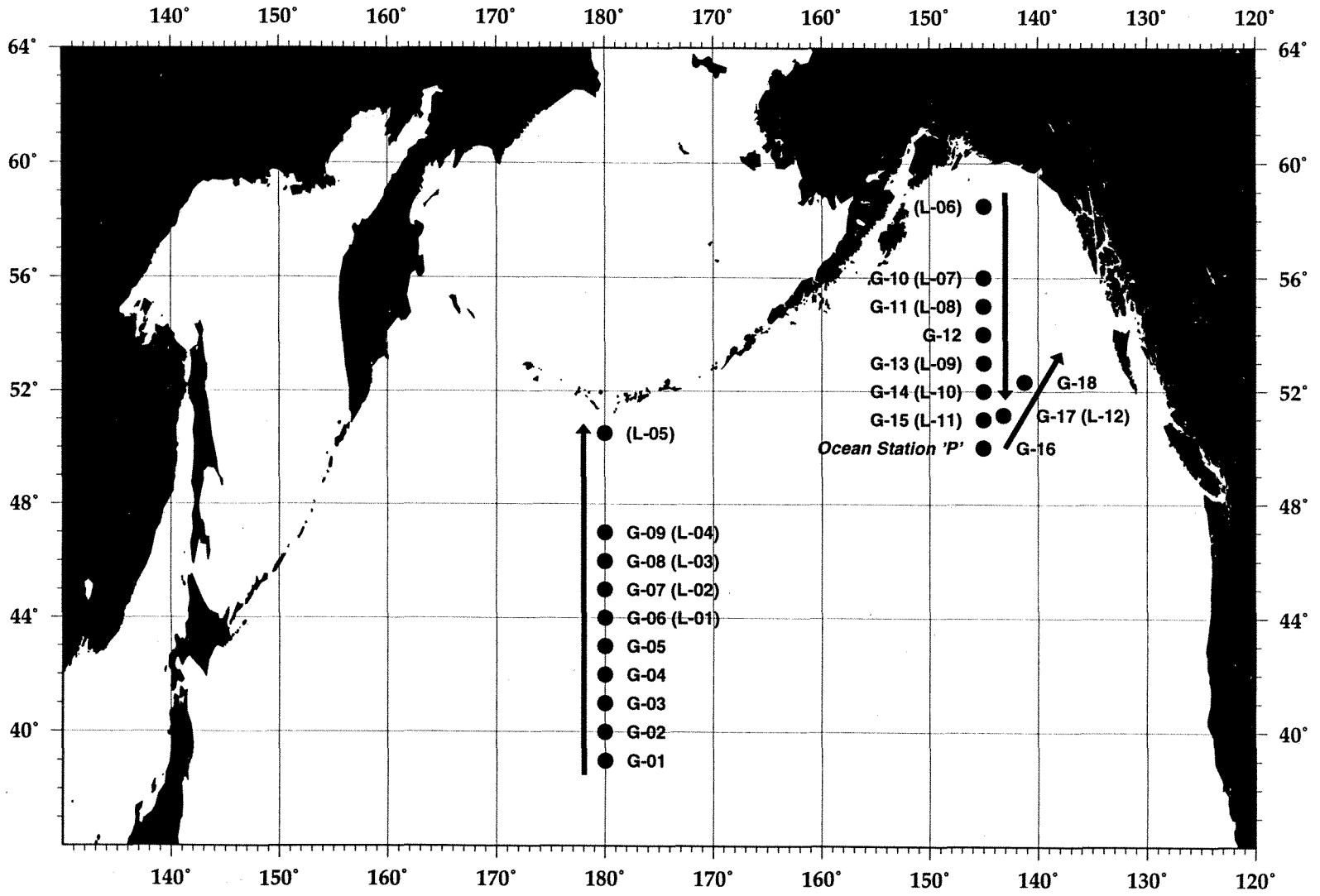

Figure 1. Location of fishing stations of the ***Oshoro Maru,*** 11 June to 11 July, 1996 (G=Gillnet stations, L=Longline stations).

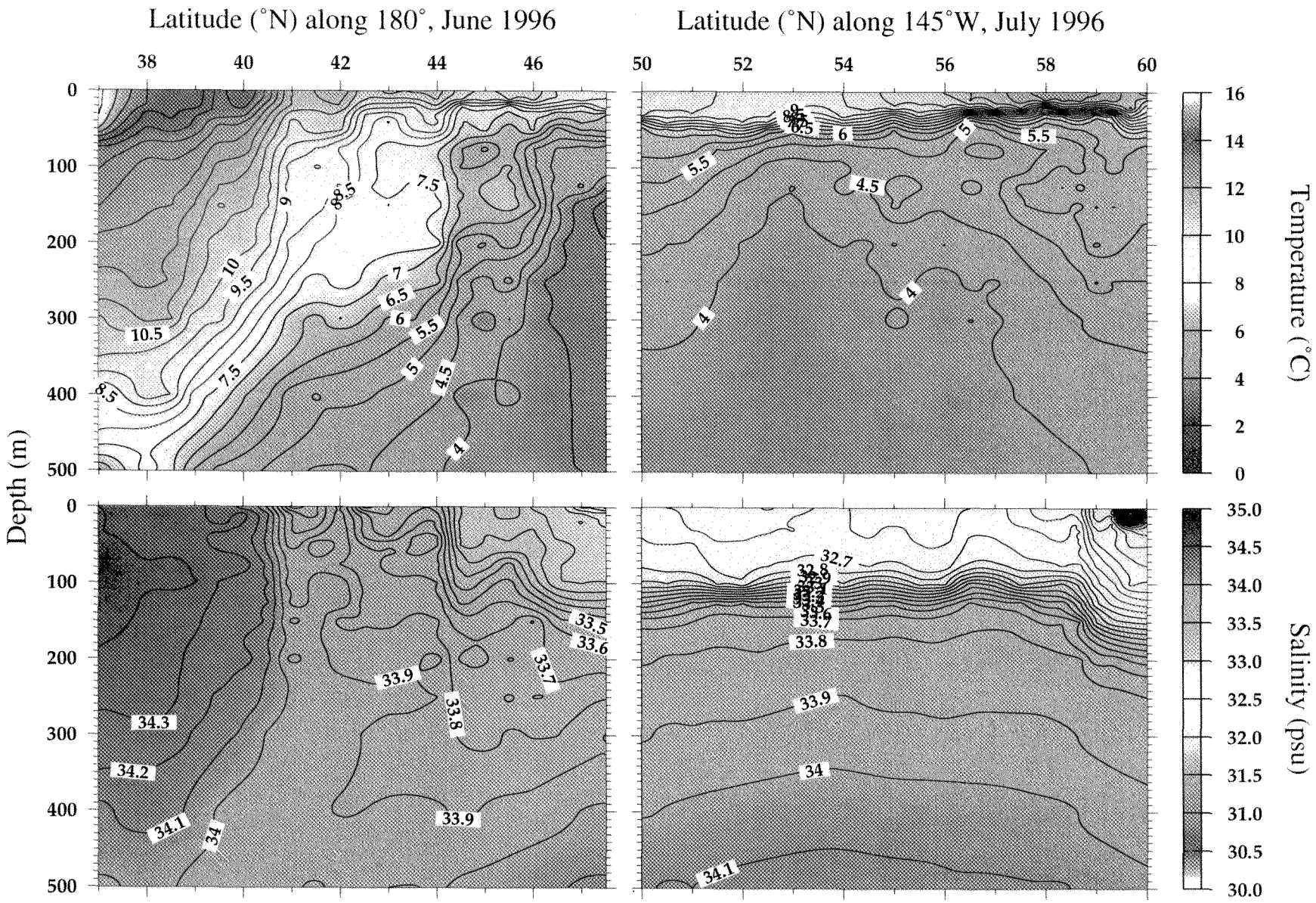

Figure 2. Temperature and salinity profiles of the 180° (upper and lower left) and 145° W (upper and lower right) transect lines, from CTD data.

Table 1. Description of research gear and fishing operations conducted aboard the Oshoro maru in 1996.

Research Item/Gear	Purpose	Specifications	Deployment	Sample/Data	Comments
A. Hydrographic **Neil Brown Mark III B CTD**	Collect temperature and salinity data; sampling along 180° in the North Pacific began in 1978, 145°W transect in 1980-81, 1994-95	CTD winch: Hydraulic 1t x 72 m/min., 6.4 ø x 4,000 m	Vertical, to 1500 m or 3,000 m depth, or to the bottom; Work on deck and data processing done by deck officers, crew, and cadets	Sal., temp., dynamic depth anomaly at 0, 10, 20, 30, 40, 50, 75, 100, 125, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1000, 1200, 1500, 2000, 2500, and 3000 m	Sigma-t, thermosteric anomaly, specific volume anomaly, geopotential anomaly calculated by ship-shipboard computer
B. Plankton **Norpac Net**	Estimate biomass and identify macrozooplankton; time series in the Gulf of Alaska with the same net and similar methods 1956-62, 1980-85, 1987-present	Ring diameter: 0.45 m; Mesh Size: 0.35 mm; Filtering Cloth: #200; Length: 1.8 m	Vertical tow: 0-150 m or bottom; Ship speed: 0 knots, drifting; Work on deck done by deck officers, crew, and cadets	Bottled with formalin	copepods are the predominant taxa collected by this gear
C. Salmonids **Research Gillnet**	Salmon abundance and biological data for ocean ecology and stock assessment; non-selective research (C) net introduced in 1971; systematic surveys with gillnet for abundance estimation commenced in 1972, 145°W transect in 1980-81,1994-95	Net configuration varied at different stations (Table 4); Overall length: 2.45 km (47 and 49 tans; 50 m/tan); Depth: approx. 6 m; Net configuration [research (C) or commercial (A) mesh size (mm)/amount (tans)]: Hydraulic net hauler: 0.3 t x 177 m/min.	Set (local) time: sunset, approximately 1800; Haul (local) time: sunrise, approximately 0500; Operation supervised by captain and officers; work done by all crew, cadets, and research staff	No. of fish by mesh and species; For each mesh size in C-net: fork length, sex, gonad weight, scale(s) for up to 100 fish of each species (body weight for up to 60 fish); A-net: same data as C-net except up to 60 fish of each species sampled per mesh.	1 scale per fish from sockeye, chum, and pink; 2 scales per fish from coho, chinook, and steelhead (1 scale from each side of body)

Table 1. Cont'd.

Research Item/Gear	Purpose	Specifications	Deployment	Sample/Data	Comments
C. Salmonids (cont'd)					
Surface Longline	Live capture of fish for high seas tagging research; long time series of data 1955-present in North Pacific	No. hachi (baskets) per operation: 10; Hachi mainline length: 127 m; No. branch lines/hachi: 34; Interval between branch lines: 3 m; Fishing depth of hooks: approximately 2 m; Bait: small salted anchovy	Set (local) time: before sunrise, approx. 0430; Haul (local) time: after sunrise and completion of gillnet operation, approx. 0630; Operation supervised by captain and deck officers; work done by all crew, cadets, and research staff	No. of fish by species; Mortalities: fork length, body weight, scale(s); Viable fish: fork length, scale(s), tag nos.	Fish are tagged with red and white 1.6 cm Petersen disk tags attached to the fish in front of the dorsal fin with a plastic cinch

Table 2. Additional salmonid research activities conducted aboard the *Oshoro maru* in 1996.

Subject	Sample (no. collected)	Fishing Gear	Method	Data or Samples Collected
A. Salmonid Feeding Ecology				
Food habits	Stomachs (713 salmonids) All species	Gillnet and longline	Stomachs from esophagus to pyloric valve collected from up to 20 fish of each species in each gillnet or longline operation (mortalities only)	Prey weight, % composition by prey type, % empty stomachs, collected in shipboard laboratory; type specimens of prey for identification to genus and species (preserved in formalin); specimens of prey for caloric content analysis (frozen)
B. Salmonid Ocean Growth and Maturity				
Growth and maturity indices and physiological studies	Blood serum samples; 22 sockeye, 120 chum, 15 pink, 15 coho, 6 chinook, 19 steelhead	Gillnet, longline, hook & line	Blood drawn from caudal vein; centrifuged at 3000 rpm for 15 min; 1.0 ml in each of two 1.5 ml cryo-tubes; frozen at -80°C	Accompanying scale samples and biological data
Age and Growth Validation	Marked fish (33 live fish); All species	Longline	During tagging operations in Gulf of Alaska, viable fish injected with 25 mg oxytetracycline hydrochloride/kg fish dissolved in 1% saline solution	Tag nos., scale samples, and accompanying biological data

Table 2. continued.

Subject	Sample (no. collected)	Fishing Gear	Method	Data or Samples Collected
C. Stock Identification				
Genetic stock identification	Isozyme samples (355 chum salmon)	Gillnet and longline	Samples for isozyme analysis from chum salmon	Heart, liver, eye, and muscle tissue (frozen); fork length, body weight, sex, gonad weight, scale sample
Parasite stock identification	Kidney (65 coho)	Gillnet	Samples for parasite study of coho salmon	Posterior 1/3 of kidney and accompanying biological data
Steelhead ocean life history and hatchery/wild stock identification	Scale samples (all steelhead in catch)	Gillnet and longline	Up to ten extra scales from all steelhead	Scales
D. Tagging				
High seas coded-wire tag recovery	Snouts from fish lacking the adipose or left ventral fin or both (38 fish); All species	Gillnet and longline (mortalities)	All fish in the catch were examined, and snouts were collected from fish with missing fins	Snouts (frozen) and accompanying catch, data, biological data, and scale samples; snouts provided to NMFS/ AFSC/ABL for analysis
Double-tagging experiments All species	Tagged fish (50 live fish)	Longline	All viable salmonids in longline catches along 180° and in Gulf of Alaska were double-tagged with Japan and FRI tags	Tag nos.: Japan AA2001-2050/FRI KK647-696; accompanying catch, data, biological data, and scale samples

Table 3. Criteria used to determine the oceanographic domain where salmon were caught during the research cruises of the *Oshoro maru* in summer, 1994-1996. The upper layer is the limit of winter turnover, approximately 0-200 m.

Oceanographic Domain	Criteria	References
Transition Zone	Thermocline persists all year; No temperature inversions; Salinity is maximum at the surface and decreases to a minimum at >500; m Salinity is >34.0 ‰ at the surface	Dodimead et al. 1963
Subarctic Boundary	34 ‰ vertical isohaline from the surface to approximately 200-400 m	Dodimead et al. 1963; Favorite et al. 1976
Transition Domain	Salinity is >33.2 ‰ at the surface and >33.4 ‰ at the bottom of the upper layer	Dodimead et al. 1963; Favorite et al. 1976
Subarctic Current	Characterized by relatively cool, dilute waters surface waters and homogeneous environmental conditions; along 180° in June, sea temperature and salinity approximately 3.5°C and 33.4 ‰ at 125 m; along 145°W in July, precipitous descent of 4°C isotherm from approximately 100 m to 300 m below the surface near the southern end of the transect	Favorite et al. 1976; Pearcy et al. 1988
Ridge Domain	Found below the surface layer; Cold, saline, nutrient-rich, O2-poor water flows upwards indicated by doming of 4°C isotherm to < 100 m below the surface	Favorite et al. 1976; Pearcy et al. 1988
Dilute Domain	Cannot identify below 300 m; Summertime temperatures are 4°-6° at 125-300 m and dilute water less than or equal to 33.0 ‰ at 0-125 m Dilute Domain can penetrate across top of Ridge Domain	Favorite et al. 1976
Alaska Stream	4° isotherm descends below 100 m and dilute water, < 32.6 ‰ at the surface; Alaska Stream can penetrate across top of Ridge Domain	Favorite et al. 1976

Table 4. Arrangement of gillnet mesh sizes and amount of each mesh size for A and C gear fished from the *Oshoro maru,* June-July, 1994-1996. Stations 1-9 were along 180° and stations 10-18 were in the Gulf of Alaska. (1 tan = 50 m.)

Commercial (A), Research (C), Experimental (F)	Mesh Size (mm)	Amount (no. of tans)				
		1994-1995	1996 station numbers			
		All stations	1-6	7-9	10-15	16-18
A	115	10	6	6	12	12
C	48	3	3	3	3	3
C	93	3	3	3	3	3
C	157	3	3	3	3	3
C	106	3	3	3	3	3
C	63	3	3	3	2	2
C	121	3	3	3	3	3
C	72	3	3	3	3	3
C	138	3	3	1	1	1
C	82	3	3	3	3	1
C	55	3	3	3	3	3
A	121	9	6	6	10	12
A	Total	19	12	12	22	24
C	Total	30	30	28	27	25
A + C	Total	49	42	40	49	49
F	19-42	0	7	7	0	0
A + C + F	Total	49	49	47	49	49

Table 5. Criteria used for determining maturity of salmonids. Table lists maximum gonad weight (g) of immature fish. Salmonids with a gonad weight higher than the value listed in the table were considered maturing fish. Sources are: Takagi (1961) for sockeye and chum salmon, Ito et al. (1974) for chinook salmon, and Okazaki (1984) for steelhead. All coho and pink salmon were considered maturing fish.

		Maximum immature gonad weight (g) (by date of capture)	
Species	Sex	June 12-20 (sets G1-G9)	July 1-11 (G10-G18)
Sockeye	Female	20	25
	Male	3	3
Chum	Female	20	25
	Male	3	3
Pink	Female	-	-
	Male	-	-
Coho	Female	-	-
	Male	-	-
Chinook	Female	80	100
	Male	10	20
Steelhead	Female	8	9
	Male	1	1

Table 6. Salmonids caught during gillnet operations. Location, sea surface temperature (SST, °C), surface salinity (psu, practical salinity units) and catch by research-mesh (C) and commercial-mesh (A) gillnet for each fishing station.

Sta.	Date	Location	SST Salin.	Gear	Sockeye	Chum	Pink	Coho	Chinook	Steel-head	Dolly Varden	Total Salmon
G01	12-Jun-96	39° 00 N	14.3	C	0	0	0	0	0	0	0	0
		179° 59 W	34.3	A	0	0	0	0	0	0	0	0
				Total	0	0	0	0	0	0	0	0
G02	13-Jun-96	40° 00 N	14.0	C	0	0	0	0	0	0	0	0
		180° 00	34.1	A	0	0	0	0	0	0	0	0
				Total	0	0	0	0	0	0	0	0
G03	14-Jun-96	41° 00 N	11.5	C	0	0	0	0	0	1	0	1
		179° 59 W	33.5	A	0	0	0	0	0	0	0	0
				Total	0	0	0	0	0	1	0	1
G04	15-Jun-96	42° 00 N	11.9	C	0	0	0	0	0	0	0	0
		179° 59 W	33.8	A	0	1	0	1	0	0	0	2
				Total	0	1	0	1	0	0	0	2
G05	16-Jun-96	43° 00 N	10.5	C	0	14	0	12	0	1	0	27
		179° 59 E	33.4	A	0	0	0	14	0	0	0	14
				Total	0	14	0	26	0	1	0	41
G06	17-Jun-96	44° 00 N	10.9	C	0	9	2	16	0	1	0	28
		179° 59 W	33.5	A	0	0	0	15	0	0	0	15
				Total	0	9	2	31	0	1	0	43
G07	18-Jun-96	44° 59 N	9.7	C	0	8	1	19	0	0	0	28
		180° 00	33.0	A	0	2	0	36	0	2	0	40
				Total	0	10	1	55	0	2	0	68

Table 6. continued.

Sta.	Date	Location	SST Salin.	Gear	Sockeye	Chum	Pink	Coho	Chinook	Steel-head	Dolly Varden	Total Salmon
G08	19-Jun-96	46° 00 N	9.9	C	0	56	4	17	1	3	0	81
		180° 00	33.0	A	0	3	1	14	0	0	0	18
				Total	0	59	5	31	1	3	0	99
G09	20-Jun-96	47° 00 N	9.0	C	0	37	5	37	3	0	0	82
		179° 59 E	32.7	A	0	2	0	19	4	0	0	25
				Total	0	39	5	56	7	0	0	107
G10	3-Jul-96	55° 59 N	10.5	C	57	19	15	22	1	0	0	114
		144° 59 W	32.5	A	99	16	13	68	1	1	0	198
				Total	156	35	28	90	2	1	0	312
G11	4-Jul-96	55° 01 N	10.5	C	21	119	41	32	0	3	0	216
		145° 00 W	32.6	A	52	60	40	77	0	4	0	233
				Total	73	179	81	109	0	7	0	449
G12	5-Jul-96	54° 00 N	9.6	C	23	91	9	24	0	2	0	149
		145° 00 W	32.6	A	53	41	7	42	0	1	0	144
				Total	76	132	16	66	0	3	0	293
G13	6-Jul-96	53° 01 N	9.5	C	22	39	8	21	0	10	0	100
		145° 00 W	32.6	A	39	10	16	30	0	1	0	96
				Total	61	49	24	51	0	11	0	196
G14	7-Jul-96	51° 59 N	9.4	C	46	58	4	3	2	16	0	129
		145° 00 W	32.6	A	71	13	15	12	3	8	0	122
				Total	117	71	19	15	5	24	0	251

Table 6. continued.

Sta.	Date	Location	SST Salin.	Gear	Sockeye	Chum	Pink	Coho	Chinook	Steel-head	Dolly Varden	Total Salmon
G15*	8-Jul-96	51° 00 N	10.0	C	12	11	15	11	0	2	0	51
		144° 59 W	32.6	A	22	7	23	25	1	1	0	79
				Total	34	18	38	36	1	3	0	130
G16	9-Jul-96	50° 00 N	10.0	C	3	8	17	1	0	2	0	31
		145° 00 W	32.6	A	16	3	27	1	0	0	0	47
				Total	19	11	44	2	0	2	0	78
G17	10-Jul-96	51° 10 N	10.0	C	7	13	15	2	0	0	0	37
		143° 09 W	32.4	A	13	1	31	6	0	0	0	51
				Total	20	14	46	8	0	0	0	88
G18	11-Jul-96	52° 20 N	10.0	C	9	56	14	5	0	7	0	91
		141° 15 W	32.1	A	18	10	54	11	0	1	0	94
				Total	27	66	68	16	0	8	0	185
	Sub-total	Central North Pacific		C	0	124	12	101	4	6	0	247
				A	0	8	1	99	4	2	0	114
				Total	0	132	13	200	8	8	0	361
	Sub-total	Gulf of Alaska		C	200	414	138	121	3	42	0	918
				A	383	161	226	272	5	17	0	1064
				Total	583	575	364	393	8	59	0	1982
	TOTAL			**C**	**200**	**538**	**150**	**222**	**7**	**48**	**0**	**1165**
				A	**383**	**169**	**227**	**371**	**9**	**19**	**0**	**1178**
				Total	**583**	**707**	**377**	**593**	**16**	**67**	**0**	**2343**

*Net damaged during this operation.

Table 7. Salmonids tagged and released during longline operations. Location, sea surface temperature (SST, C), surface salinity (psu, practical salinity units) and catch tagged and released.

Sta.	Date	Latitude	Longitude	SST	Salin.	Sock-eye	Chum	Pink	Coho	Chi-nook	Steel-head	Dolly Varden	Total Salmon
L01	17-Jun-96	43° 55 N	179° 56 W	10.9	33.5	0	0	0	0	0	0	0	0
L02	18-Jun-96	44° 56 N	179° 59 W	9.7	33.0	0	0	0	10	0	0	0	10
L03	19-Jun-96	45° 58 N	179° 52 W	9.9	33.0	0	0	0	4	0	0	0	4
L04	20-Jun-96	46° 57 N	176° 56 W	9.0	32.7	0	0	0	3	0	0	0	3
L05	22-Jun-96	50° 37 N	179° 48 W	*	*	0	0	0	0	0	0	0	0
L06	1-Jul-96	58° 19 N	145° 00 W	12.5	32.5	0	0	5	10	0	0	0	15
L07	3-Jul-96	56° 00 N	144° 59 W	10.5	32.5	0	0	4	5	0	0	0	9
L08	4-Jul-96	54° 59 N	144° 57 W	10.5	32.6	0	1	1	0	0	0	0	2
L09	6-Jul-96	53° 02 N	144° 58 W	9.5	32.6	0	2	0	0	0	0	0	2
L10	7-Jul-96	52° 03 N	144° 56 W	9.4	32.6	0	1	0	1	0	0	0	2
L11	8-Jul-96	51° 03 N	144° 56 W	10.0	32.6	0	2	0	0	0	0	0	2
L12	10-Jul-96	51° 14 N	143° 08 W	10.0	32.4	0	0	1	0	0	0	0	1
	TOTALS					**0**	**6**	**11**	**33**	**0**	**0**	**0**	**50**

*CTD data not taken at this station.

Table 8. Catch (number of salmonids) per unit of effort by C-gear, summarized by region. One unit of effort is equal to one operation of the non-selective research-mesh gillnet.

Year	Set Numbers (1996 only)	Sampling Dates	Number of Stations	Locations	Mean Temperature 0 m	Mean Temperature 100 m	Mean Salinity 0 m	Mean Salinity 100 m	Catch per unit C-gear: Sock-eye	Chum	Pink	Coho	Chin-ook	Steel-head	Total Salmon
Central North Pacific - Transition Zone															
1996	G01 - G02	12-13 June	2	39°N-40°N, 180°	14.2	11.7	34.2	34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	-	12-13 June	2	40°N-41°N, 180°	11.9	10.4	34.2	34.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	-	11-13 June	3	39°N-41°N, 180°	13.0	11.1	34.1	34.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central North Pacific - Transition Domain															
1996	G03 - G06	14-17 June	4	41°N-44°N, 180°	11.2	8.1	33.6	33.8	0.0	5.8	0.5	7.0	0.0	0.8	14.0
1995	-	14-16 June	3	42°N-44°N, 180°	9.9	8.8	33.8	34.0	0.0	0.3	0.0	2.3	0.0	0.3	3.0
1994	-	14-15 June	2	42°N-43°N, 180°	9.9	8.4	33.9	33.9	0.0	24.0	1.5	38.0	0.0	0.5	64.0
Central North Pacific - Subarctic Current															
1996	G07 - G09	18-20 June	3	45°N-47°N, 180°	9.5	5.2	32.9	33.2	0.0	33.7	3.3	24.3	1.3	1.0	63.7
1995	-	17-19 June	3	45°N-47°N, 180°	7.7	5.6	33.0	33.0	1.7	12.0	14.3	24.0	0.0	1.3	53.3
1994	-	17-18 June	2	45°N-46°N, 180°	7.0	5.7	33.2	33.2	0.0	27.5	18.0	16.5	0.5	5.0	67.5
Central Gulf of Alaska - Subarctic Current															
1996	G13 - G18*	6-11 July	6*	50°N-53°N, 145°W*	9.8	5.1	32.5	32.9	16.5	30.8	12.2	7.2	0.3	6.2	73.2
1995	-	6-7 July	2	51°N-53°N, 145°W	10.4	4.8	32.5	33.1	24.5	78.5	27.0	12.0	1.0	7.5	150.5
1994	-	2-5 July	4	50°N-53°N, 145°W	10.7	5.9	32.5	32.9	15.3	30.0	24.5	10.8	0.3	3.3	84.0
Central Gulf of Alaska - Ridge/Dilute Domains															
1996	G10 - G12	3-5 July	3	54°N-56°N, 145°W	10.2	4.8	32.6	32.9	33.7	76.3	21.7	26.0	0.3	1.7	159.7
1995	-	8-10 July	3	54°N-56°N, 145°W	11.0	5.2	32.4	32.8	41.7	88.7	44.7	15.3	0.3	3.0	193.7
1994	-	6-8 July	3	54°N-56°N, 145°W	11.5	5.5	32.3	33.1	67.3	15.7	38.0	13.7	0.0	1.3	136.0

*The fifth and sixth gillnet sets were not on the 145°W Transect line: G17 (51°10' N, 143°09' W) and G18 (52°20' N, 141°15' W).

Table 9. Percentage of maturing salmonids in C-gear catch of *Oshoro Maru* by oceanic zone, 1994-1996.

	Year	Sockeye		Chum		Pink		Coho		Chinook		Steelhead	
		N	% mat.	N	% mat.	N	% mat.	N	% mat.	N	% mat.	N	% mat.
Central North Pacific - Transition Domain	1996	0	0	21	10	2	100	28	100	0	0	4	50
	1995	0	0	1	0	0	0	3	100	0	0	0	0
	1994	0	0	46	28	11	100	76	100	0	0	1	0
Central North Pacific - Subarctic Current	1996	0	0	81	12	10	100	67	100	1	0	6	67
	1995	4	0	24	29	44	100	77	100	0	0	5	100
	1994	1	0	46	4	38	100	33	100	1	0	10	30
Central Gulf of Alaska - Subarctic Current	1996	98	88	180	7	69	100	44	100	2	0	37	22
	1995	49	88	157	22	55	100	22	100	2	0	15	73
	1994	61	57	117	15	99	100	45	100	1	0	13	15
Central Gulf of Alaska - Ridge/Dilute Domains	1996	100	87	217	5	59	100	85	100	1	0	5	40
	1995	125	89	265	28	134	100	43	100	1	100	9	67
	1994	203	83	45	40	115	100	42	100	0	0	3	67

Table 10. Ocean age composition (%), mean fork length (mm), body weight (g), and standard deviation (sd) of sockeye salmon caught by research gillnet (C-gear), listed by oceanographic region, 1994-1996.

Sockeye Salmon

	Ocean Age .1						Ocean Age .2						Ocean Age .3						Ocean Age .4					
	No.	%	Fork Length		Body weight		No.	%	Fork Length		Body weight		No.	%	Fork Length		Body weight		No.	%	Fork Length		Body weight	
Year	Fish	Age	Mean	sd	Mean	sd	Fish	Age	Mean	sd	Mean	sd	Fish	Age	Mean	sd	Mean	sd	Fish	Age	Mean	sd	Mean	sd
Central North Pacific - Subarctic Current																								
1996	0						0						0						0					
1995	1	25	322		320		3	75	433	9	1097	233	0						0					
1994	1	100	312		350		0						0						0					
Central Gulf of Alaska - Subarctic Current																								
1996	15	16	374	54	654	516	63	68	580	26	2758	405	13	14	627	34	3646	699	1	1	610		3400	
1995	11	26	375	31	658	178	24	57	541	47	2175	575	7	17	607	67	3121	524	0					
1994	5	10	358	14	556	46	44	85	551	38	2414	463	3	6	563	55	2413	890	0					
Central Gulf of Alaska - Ridge/Dilute Domains																								
1996	7	8	331	16	437	78	51	57	551	51	2251	661	32	36	627	42	3280	633	0					
1995	21	18	345	22	486	101	53	45	544	47	2038	566	43	37	606	34	2863	541	0					
1994	12	7	344	27	486	106	124	73	555	39	2204	443	34	20	607	32	2807	493	1	1	650		2750	

Table 11. Ocean age composition (%), mean fork length (mm), body weight (g), and standard deviation (sd) of chum salmon caught by research gillnet (C-gear), listed by oceanographic region, 1994-1996.

Chum Salmon

	Ocean Age .1						Ocean Age .2						Ocean Age .3						Ocean Age .4					
	No.	%	Fork Length		Body weight		No.	%	Fork Length		Body weight		No.	%	Fork Length		Body weight		No.	%	Fork Length		Body weight	
Year	Fish	Age	Mean	sd	Mean	sd	Fish	Age	Mean	sd	Mean	sd	Fish	Age	Mean	sd	Mean	sd	Fish	Age	Mean	sd	Mean	sd
Central North Pacific - Transition Domain																								
1996	9	53	352	47	464	225	8	47	426	16	863	102	0						0					
1995	0						0						1	100	516		1620		0					
1994	6	14	334	16	472	89	28	67	412	27	809	172	8	19	454	22	1045	209	0					
Central North Pacific - Subarctic Current																								
1996	28	47	322	26	322	49	27	45	436	21	917	140	5	8	472	17	1196	118	0					
1995	20	65	316	10	321	37	3	10	428	7	873	136	7	23	492	56	1166	350	1		575		2200	
1994	24	56	316	23	362	90	18	42	406	24	733	132	1	2	472		1100		0					
Central Gulf of Alaska - Subarctic Current																								
1996	73	43	400	25	730	156	93	54	464	31	1164	215	5	3	546	95	2120	1338	0					
1995	1	1	402		640		126	91	475	30	1314	266	11	8	518	24	1688	365	0					
1994	50	50	386	14	657	96	43	43	459	30	1138	257	8	8	485	37	1356	310	0					
Central Gulf of Alaska - Ridge/Dilute Domains																								
1996	31	16	402	37	756	199	151	80	476	26	1246	201	7	4	614	95	3111	1437	0					
1995	35	14	437	111	799	233	180	74	493	31	1386	254	28	11	531	27	1759	333	1		528		1540	
1994	22	55	399	17	782	159	17	43	477	31	1376	361	1	3	520		2320		0					

Table 12. Ocean age composition (%), mean fork length (mm), body weight (g), and standard deviation (sd) of pink salmon caught by research gillnet (C-gear), listed by oceanographic region, 1994-1996.

Pink Salmon

	Ocean Age .1					
	No.	%	Fork Length		Body weight	
Year	Fish	Age	Mean	sd	Mean	sd
Central North Pacific - Transition Domain						
1996	2	100	418	6	760	28
1995	0	100				
1994	11	100	430	15	894	95
Central North Pacific - Subarctic Current						
1996	10	100	427	26	843	189
1995	44	100	410	28	733	141
1994	38	100	427	23	839	144
Central Gulf of Alaska - Subarctic Current						
1996	69	100	491	36	1556	436
1995	55	100	489	27	1483	379
1994	99	100	492	24	1699	388
Central Gulf of Alaska - Ridge/Dilute Domains						
1996	56	100	466	32	1216	335
1995	134	100	479	32	1276	349
1994	115	100	477	28	1332	376

Table 13. Ocean age composition (%), mean fork length (mm), body weight (g), and standard deviation (sd) of coho salmon caught by research gillnet (C-gear), listed by oceanographic region, 1994-1996.

Coho Salmon

	Ocean Age .1					
	No.	%	Fork Length		Body weight	
Year	Fish	Age	Mean	sd	Mean	sd
Central North Pacific - Transition Domain						
1996	28	100	515	31	1597	294
1995	3	100	548	84	1900	600
1994	76	100	522	40	1759	420
Central North Pacific - Subarctic Current						
1996	65	100	504	42	1573	460
1995	77	100	520	41	1780	417
1994	33	100	529	41	1880	465
Central Gulf of Alaska - Subarctic Current						
1996	44	100	590	45	2959	642
1995	22	100	571	51	2668	755
1994	45	100	593	54	2998	928
Central Gulf of Alaska - Ridge/Dilute Domains						
1996	85	100	585	45	2800	671
1995	43	100	581	39	2626	552
1994	42	100	611	45	3045	683

Table 14. Ocean age composition (%), mean fork length (mm), body weight (g), and standard deviation (sd) of chinook salmon caught by research gillnet (C-gear), listed by oceanographic region, 1994-1996.

Chinook Salmon

	Ocean Age .2					
	No.	%	Fork Length		Body weight	
Year	Fish	Age	Mean	sd	Mean	sd
Central North Pacific - Subarctic Current						
1996	1	100	654		3360	
1995	0					
1994	1	100	680		4150	
Central Gulf of Alaska - Subarctic Current						
1996	2	100	563	10	2480	28
1995	2	100	648	6	3950	212
1994	0					
Central Gulf of Alaska - Ridge/Dilute Domains						
1996 *	0					
1995	1	100	609		3100	
1994	0					

*1996 catch included one age .1 chinook; fork length 374 mm; body weight 550 g.

Table 15. Ocean age composition (%), mean fork length (mm), body weight (g), and standard deviation (sd) of steelhead caught by research gillnet (C-gear), listed by oceanographic region, 1994-1996.

Steelhead

	Ocean Age .0						Ocean Age .1						Ocean Age .2					
	No.	%	Fork Length		Body weight		No.	%	Fork Length		Body weight		No.	%	Fork Length		Body weight	
Year	Fish	Age	Mean	sd	Mean	sd	Fish	Age	Mean	sd	Mean	sd	Fish	Age	Mean	sd	Mean	sd
Central North Pacific - Transition Domain																		
1996	0						4	100	558	15	1850	319	0					
1995	0						0						0					
1994	0						1	100	582		2000		0					
Central North Pacific - Subarctic Current																		
1996	0						3	75	560	39	1703	278	1	25	604		1880	
1995	0						3	60	566	26	1733	321	2	40	676	25	3150	3041
1994	0						6	86	524	22	1547	232	1	14	664		3200	
Central Gulf of Alaska - Subarctic Current																		
1996	26	72	324	28	365	112	6	17	532	57	1530	339	3	8	725	8	3583	1166
1995	4	27	338	55	418	200	9	60	541	35	1596	307	2	13	698	40	3500	212
1994	11	100	329	28	391	116	0						0					
Central Gulf of Alaska - Ridge/Dilute Domains																		
1996	1	20	324	0	420	0	3	60	527	10	1590	78	0					
1995	3	33	303	10	327	31	4	44	557	20	2125	403	0					
1994	2	100	348	74	430	184	0						0					

	Ocean Age .3						Ocean Age .4					
	No.	%	Fork Length		Body weight		No.	%	Fork Length		Body weight	
Year	Fish	Age	Mean	sd	Mean	sd	Fish	Age	Mean	sd	Mean	sd
Central North Pacific - Transition Domain												
1996	0						0					
1995	0						0					
1994	0						0					
Central North Pacific - Subarctic Current												
1996	0						0					
1995	0						0					
1994	0						0					
Central Gulf of Alaska - Subarctic Current												
1996	1	3	700		3250		0					
1995	0						0					
1994	0						0					
Central Gulf of Alaska - Ridge/Dilute Domains												
1996	0						1	20	800		3950	
1995	2	22	723	67	4625	2934	0					
1994	0						0					

Table 16. Mean percent composition of stomach contents of salmonids caught in the Central Gulf of Alaska - Subarctic Current Domain. 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. EU=euphausiids, CO=copepods, AM=amphipods, DE=decapods, SQ=squids, PT=pteropods (shelled and naked), FI=fish, PO=polychaetes, CH=chaetognaths, GE=gelatinous zooplankton, including coelenterates, ctenophores, and salps. Oth=other groups that may include ostracods, barnacles, or debris. Uid=Unidentified material.

Central Gulf of Alaska - Subarctic Current Domain

						Mean % composition by volume											
Species	Year	N	% empty	Mean pw	SCI	EU	CO	AM	DE	SQ	PT	FI	PO	CH	GE	Oth	Uid
Sockeye	1996	114	14	37	1.32	0	0	1	0	98	1	0	0	0	0	0	0
	1995	29	28	39	1.56	0	0	5	0	79	2	5	0	0	0	0	10
	1994	47	9	35	1.54	0	0	8	0	90	1	0	0	0	0	0	1
Chum	1996	98	44	3	0.28	21	1	16	0	2	2	0	1	0	17	0	38
	1995	23	13	12	0.73	0	0	1	0	0	0	0	0	0	18	0	81
	1994	56	36	3	0.30	1	0	20	0	2	17	0	2	0	1	0	58
Pink	1996	126	17	20	1.30	0	0	0	0	75	19	5	0	0	0	0	0
	1995	26	46	5	0.37	0	0	19	0	42	19	0	0	0	0	12[a]	9
	1994	48	23	18	1.06	0	0	3	0	71	15	1	0	0	0	0	10
Coho	1996	79	22	59	2.10	0	0	0	0	99	1	0	0	0	0	0	0
	1995	33	45	34	1.53	0	0	0	0	89	0	6	0	0	0	0	6
	1994	34	9	72	2.59	0	0	0	0	100	0	0	0	0	0	0	0
Chinook	1996	6	33	51	1.93	0	0	0	0	100	0	0	0	0	0	0	0
	1995	6	50	32	0.77	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	1996	45	29	18	1.28	0	0	1	0	56	10	21	3	0	0	9	0
	1995	37	27	18	1.15	0	0	11	2	59	4	18	6	0	0	0	0
	1994	13	8	3	0.63	0	0	0	0	58	10	24	0	0	0	0	7

[a] *Other* column represents ostracods.

Table 17. Mean percent composition of stomach contents of salmonids caught in the Central Gulf of Alaska - Ridge/Dilute Domains. 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. EU=euphausiids, CO=copepods, AM=amphipods, DE=decapods, SQ=squids, PT=pteropods (shelled and naked), FI=fish, PO=polychaetes, CH=chaetognaths, GE=gelatinous zooplankton, including coelenterates, ctenophores, and salps. Oth=other groups that may include ostracods, barnacles, or debris. Uid=Unidentified material.

Central Gulf of Alaska - Ridge/Dilute Domains

						Mean % composition by volume											
Species	Year	N	% empty	Mean pw	SCI	EU	CO	AM	DE	SQ	PT	FI	PO	CH	GE	Oth	Uid
Sockeye	1996	60	30	14	0.65	10	24	13	0	37	3	9	0	0	0	0	4
	1995	49	63	11	0.51	11	6	0	3	32	21	6	0	0	0	0	22
	1994	55	27	6	0.42	16	9	31	0	16	10	7	3	0	0	0	8
Chum	1996	65	40	6	0.35	10	4	13	0	1	6	3	1	0	36	0	26
	1995	57	58	6	0.49	13	0	4	0	0	7	4	11	0	1	0	61
	1994	56	11	5	0.36	5	0	37	0	0	22	0	0	0	4	0	31
Pink	1996	50	28	5	0.43	11	20	19	3	19	6	6	0	0	0	15[a]	1
	1995	52	52	9	0.68	15	12	9	0	16	25	8	1	0	0	0	14
	1994	58	29	4	0.30	2	16	25	3	12	27	5	0	0	0	0	8
Coho	1996	58	36	33	1.14	0	0	0	0	99	0	1	0	0	0	0	0
	1995	51	53	16	0.62	19	0	2	0	60	0	19	0	0	0	0	0
	1994	56	50	7	0.23	7	0	15	0	44	18	14	0	0	0	0	1
Chinook	1996	2	50	6	0.14	0	0	0	0	0	0	0	0	0	0	0	100
	1995	1	100														
	1994	0															
Steelhead	1996	10	30	13	0.69	0	0	0	1	14	0	43	1	0	0	26[b]	14
	1995	22	27	6	0.25	0	0	0	0	43	6	31	19	0	0	1	0
	1994	6	50	3	0.13	0	0	42	0	0	0	58	0	0	0	0	0

[a] *Other* column represents ostracods.

[b] *Other* column represents gooseneck barnacles and plastic debris.