

NPAFC

Doc. 266

Rev. _____

JAPAN-U.S. COOPERATIVE HIGH-SEAS SALMONID RESEARCH
ABOARD THE R/V *WAKATAKE MARU*
FROM JUNE 11 TO JULY 25, 1997

by

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Submitted to the

NORTH PACIFIC ANADROMOUS FISH COMMISSION

by

Japan and the United States of America

September 1997

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:

Nagasawa, K., N.D. Davis, and Y. Uwano. 1997. Japan-U.S. cooperative high-seas salmonid research aboard the R/V *Wakatake maru* from June 11 to July 25, 1997. (NPAFC Doc.) Nat. Res. Inst. of Far Seas Fish., Fisheries Agency of Japan, Shimizu; Fish. Res. Inst., Univ. Washington, Seattle. 32 pp.

Abstract

An annual Japan-U.S. cooperative high-seas salmonid research cruise, initiated in 1991, was conducted in the central North Pacific Ocean and Bering Sea to investigate the carrying capacity of the North Pacific Ocean for Pacific salmon from June 11 to July 25, 1997, on board the Japanese research vessel *Wakatake maru*. Research cruise activities included collection of data on oceanography, primary production, zooplankton, micro-nekton, salmonids, non-salmonids, salmonid predators, and salmonid parasites and diseases. Results of oceanographic data indicated the average sea surface temperature was 0.90°C cooler in the central North Pacific, and 0.61°C warmer in the Bering Sea in 1997 than in 1996. Fishing operations were conducted at 28 locations (21 stations along a transect at 180°00' or 179°30'W and 7 additional stations in the central Bering Sea). Longlines were used at 28 locations, whereas gillnets were fished at 21 locations outside the U.S. 200-mile EEZ. A total of 15,914 salmonids (*Oncorhynchus* spp. and *Salvelinus malma*) was caught by longline and gillnet. In the central North Pacific (39°00'N-51°30'N), a total of 1142 salmonids was caught. Coho salmon (*O. kisutch*) were the most abundant salmon in the catch (40% of salmonids), followed by chum (25%), pink (*O. gorbuscha*, 18%), steelhead (*O. mykiss*, 8%), sockeye (*O. nerka*, 6%), and chinook salmon (*O. tshawytscha*, 3%). Although the Subarctic Boundary is generally believed to be the southern limit of salmonid distribution, four chum, four coho, and one pink salmon were caught in Transition Zone waters (40°00'N), south of the Subarctic Boundary. In the central Bering Sea (52°30'N-58°30'N), a total of 14,772 salmonids was caught. Pink salmon were the most abundant salmon in the catch (72% of salmonids), followed by chum (19%), sockeye (9%), chinook and coho salmon (both <1%). One Dolly Varden was caught. In 1997, pink salmon abundance in the Bering Sea was greater than previous years (1991-1996). Results of examination of stomach contents indicated that squid, appendicularians, fish, and crustacean zooplankton were common in the stomachs of sockeye, pink, and chum salmon. Chum salmon were also feeding on heteropods and gelatinous zooplankton (siphonophores, salps, and ctenophores). Coho and chinook salmon stomachs contained euphausiids, squid, and fish. In the central North Pacific, Japanese anchovy (*Engraulis japonicus*) were observed in the stomachs of coho salmon, a first record of Japanese anchovy caught as far east as 180° longitude. A chinook salmon was observed to contain two small daggertooth (*Anotopterus pharao*, FL=140 mm and 165 mm) in its stomach. From tagging operations, a total of 779 salmonids including 404 chum (51.9%), 260 pink (33.4%), 85 sockeye (10.9%), 11 coho (1.4%), 5 chinook salmon (0.6%), and 14 steelhead (1.8%) was double-tagged and released north of 47°30'N from longline operations. Some of these released fish (n=503) were injected with oxytetracycline to induce a mark on the otolith for validation of growth increments. Snouts from 45 steelhead trout with clipped fins (53% of the steelhead trout catch) were sampled for later potential recovery of coded-wire tags.

Introduction

The recent decrease in the body size of Pacific salmon (*Oncorhynchus* spp.), especially chum salmon (*O. keta*), has led to concerns related to the salmonid carrying capacity of the North Pacific Ocean and the Bering Sea (Kaeriyama, 1989; Ishida et al., 1993; Helle and Hoffman, 1995; Bigler et al., 1996). To investigate issues related to ocean carrying capacity, the Fisheries Agency of Japan (FAJ) has annually chartered the R/V *Wakatake maru* since 1991 for a high-seas salmonid cruise in June and July in the central North Pacific Ocean and Bering Sea. Every year, a U.S. salmon scientist from the Fisheries Research Institute (FRI), Univ. of Washington, is invited to participate in this cooperative program.

Each year the sampling program of the R/V *Wakatake maru* has generally remained the same (Ishida et al., 1991, 1992; Nagasawa et al., 1994; Davis and Tadokoro, 1995; Myers et al., 1995; Davis et al., 1996). The cruise objectives are to develop a time series including data on oceanography, primary production and zooplankton abundance, and salmonid biological data by returning annually to the same locations. In addition, the 1997 research cruise provided an opportunity for a variety of other studies including the following: salmonid food habits, including estimates of digestion rates and daily ration, trophodynamics; salmon age and growth validation; stock identification; salmonid tagging and tag recovery; characterization of external body condition (injuries, scars, slash marks, and external parasites); and collection of Pacific pomfret (*Brama japonica*), Pacific saury (*Cololabis saira*), and neon flying squid (*Ommastrephes bartrami*) for studies of their ecology. This cruise report provides a summary of our sampling methods, and briefly reviews the results of oceanographic sampling, catch and distribution of salmonids, and salmonid food habits.

Sampling Methods

RESEARCH VESSEL

In 1997, the (old) R/V *Wakatake maru* (424 gross tons) that was used in the earlier years of this cruise series (1991-1996) was replaced by a new ship. The (new) R/V *Wakatake maru* is configured for gillnet and longline fishing and is a substantially larger ship (666 gross tons; Table 1).

STUDY AREA AND CRUISE SCHEDULE

The R/V *Wakatake maru* departed Hakodate, Japan, on June 11 and returned to Hakodate on July 25, 1997. Fishing operations were conducted in the central North Pacific Ocean and Bering Sea. The cruise track was located along a south-north transect between 39°00'N and 58°30'N latitude at 180°00' or 179°30'W longitude, and included an

east-west transect at 56°30'N between 177°30'W and 177°30'E in the central Bering Sea (Fig. 1). This cruise track was slightly different from that of previous years (1991-1996), when the south-north transect was set from 38°30'N to 58°30'N latitude at 179°30'W longitude (Ishida et al., 1991, 1992; Nagasawa et al., 1994; Davis and Tadokoro, 1994; Myers et al., 1995; Davis et al., 1996). The cruise track included 28 fishing stations (F-stations), where oceanographic data, primary production, zooplankton, and larval fish samples were collected and where longline and gillnet operations were conducted (from June 19 to July 18, 1997). Moreover, while enroute to and from the fishing research area, there were 58 transit stations (T-stations: 30 stations visited from June 12 to 18, and 28 stations visited from July 18 to 23), where a reduced set of oceanographic, primary production, and zooplankton samples were collected (Fig. 1). In 1997, an additional 19 transit stations were added between fishing stations along a transect at 180°00', or 179°30'W longitude, where oceanographic data were collected (from June 20 to July 9; Fig. 1).

OCEANOGRAPHIC SAMPLING

Oceanographic data were collected using an expendable bathythermograph (XBT) and a salinity-temperature-depth probe (STD; Table 2). At all transit stations (n=77), temperature and depth data were collected by XBT to a depth of approximately 780 m. At transit stations located at 5°-longitude intervals, and at all the 28 fishing stations, observations were supplemented with the STD to a depth of approximately 900 m (n=40; Fig. 1; Table 2). At these stations, sea surface water was collected for later precise salinity measurement in the laboratory. Oceanographic data will be analyzed at the Low- and High-latitude Oceanography Sections of the National Research Institute of Far Seas Fisheries (NRIFSF), Shimizu.

SAMPLING FOR PRIMARY PRODUCTION

At 21 fishing stations (stations 1 to 21) along a south-north transect and at 12 transit stations located at 5°-longitude intervals, seawater was collected at 0 m, 10 m, 20 m, 30 m, and 50 m using a bucket and a Niskin sampling bottle (Fig. 1; Table 2). Seawater was vacuum-filtered (100-120 mm Hg) for biogenic silica and coccolithophorids through 47-mm Nuclepore membranes (0.6 µm pore size) and for chlorophyll-*a* through 47-mm Whatman GF/F filters using Gelman plastic filter towers. All filters were frozen on board (approximately -50°C; Table 2). Additional coccolithophorids samples were collected in 1-l seawater samples collected from each depth layer and fixed with 20 ml of buffered formalin (pH=7.8). A 50-ml seawater sample was frozen for nutrient analysis. Phytoplankton identification samples (1-l volume) were collected from the surface and fixed by adding 10 ml of borax-buffered formalin (Table 2). Biogenic silica and coccolithophorid samples were sent to the Hokkaido National Fisheries Research Institute, Kushiro, for analysis. Chlorophyll-*a*, nutrient, and phytoplankton identification samples were sent to the NRIFSF for analysis.

MICRO-ZOOPLANKTON SAMPLING

To elucidate the species composition and abundance of micro-zooplankton, seawater was collected at several depths (0 m, 10 m, 20 m, 30 m, and 50 m) at 6 transit stations set at 5°-longitude intervals on the returning leg of the cruise track (Fig. 1). Ciliates were preserved in a 300-ml seawater sample fixed with Bouin's solution, and pico-nanoplankton were preserved in a 30-ml seawater sample fixed with a glutaraldehyde solution (Table 2). These samples were sent to the Fac. of Fish., Nagasaki University, Nagasaki, for analysis.

MACRO-ZOOPLANKTON SAMPLING

At 28 fishing stations and 12 transit stations at 5°-longitude intervals, macro-zooplankton were sampled with a remodeled Norpac net (Motoda, 1994; Tadokoro, et al. 1995; Nagasawa and Ishida, 1997). The net was towed vertically from 150 m to the surface at midnight (Table 2). A calibrated flow meter was attached to the opening of the net in a position slightly off-center. Samples were fixed in 10% borax-buffered formalin in sea water, and sent to the NRIFSF for analysis.

Additional Norpac tows were made at 21 fishing stations along a south-north transect (stations 1-21; Fig. 1). The Norpac net was towed vertically twice: one tow was from 150 m to the surface and a second tow was made from the thermocline to the surface (Table 2). These paired tows were conducted at noon and at midnight. Thermocline depth was estimated from STD or XBT data. The samples were sent to the Department of Aquatic Restoration Ecology, Tohoku University, Sendai, for analysis.

Salmonid prey were collected at 28 fishing stations using the fish larval net (1.3 m ring diameter, 4.5 m net length, 0.335-2.0 mm mesh size; Table 2). At approximately 2300 hours, the fish larval net was towed horizontally at the surface or 10 minutes. Samples were fixed in 10% borax-buffered formalin in sea water and sent to the NRIFSF for analysis.

FISHING OPERATIONS

A gillnet and longline were used for fishing operations (Table 2). The gillnet was used at 10 stations in the central North Pacific Ocean and 10 stations in the central Bering Sea, outside of the U.S. 200-mile EEZ (Fig. 1). For routine gillnet operations, the gillnet was set at 16:00 in the afternoon (Local Mean Time, LMT) and retrieved at 04:00 the following morning. The standard gillnet configuration consisted of 30 tans of research-mesh gillnet (C-gear; 48, 55, 72, 82, 93, 106, 121, 138, and 158 mm mesh size; 3 tans of each mesh size; 1 tan is 50 m long) and 19 tans of commercial-mesh gillnet (A-gear; 115 mm mesh size). However, at seven fishing stations (stations 1-7) at the southern end of the transect, the number of tans of commercial-mesh gillnet was reduced from 19 to 17 tans, and two tans of smaller mesh size (one tan each of 29 and 37 mm) were substituted in order to collect Pacific saury. At stations 23 to 28, we decreased the fishing effort by reducing the length of the commercial-mesh gillnet from 19 to 9 tans in order to reduce the catch of salmonids.

The longline was used at 28 fishing stations (Fig. 1; Table 2). The longline was set 30 minutes before sunset and hauled 30 minutes after sunset. The longline comprised 30 hachi (overall length 3.32 km; 1 hachi is 110.68 m long and has 49 hooks), and was baited with salted Japanese anchovy (*Engraulis japonicus*).

FISH EXAMINATION

Salmonids were processed soon after removal from the fishing gear (Table 3). In addition to the presence and count of salmon lice (Nagasawa et al., 1993), fork length (FL), body weight (BW), sex, and gonad weight (GW) were recorded. One or two scales were collected from the INPFC (International North Pacific Fisheries Commission) preferred area of the salmon for age determination (Davis et al., 1990). When external injuries, scars, and slash marks were found, the fish were photographed. The presence of visceral adhesions was recorded when this condition was observed during fish dissection (Table 3; Nagasawa, 1987).

All non-salmonid catches were identified and counted. In addition, fork length or dorsal mantle length were measured for non-salmonid fish or squid. When uncommon fish were caught, they were photographed and frozen for later taxonomic and ecological study (Nagasawa, 1997; Nagasawa and Davis, 1997a).

STOMACH CONTENT EXAMINATION

The method used for salmonid stomach examinations was described in detail by Nagasawa et al. (1994), and has remained similar since that time. From each salmonid species, a maximum of 10 stomach contents samples were examined from fish caught by longline and gillnet from at each station. The total stomach content weight was obtained by subtraction of the empty stomach weight from the full stomach weight. Stomach contents were identified to major categories under a stereoscopic microscope and the percent volume of each prey category was visually estimated. For samples from longline-caught fish, the weight of baitfish (salted Japanese anchovy) was subtracted from the weight of stomach contents because it was not considered prey (Nagasawa and Tadokoro, 1996; Nagasawa and Davis, 1997b).

DIGESTION RATES AND DAILY RATION OF SALMONIDS

In the vicinity of station 22 (57°30'N, 178°30'W), eight short-duration gillnet sets were conducted in one 24-hour period. These gillnet operations were made on July 11 and July 12 at different locations 3.8 to 5.0 nautical miles apart (Table 3). The purpose of these multiple gillnet operations was to collect samples from which diel variation in feeding activity of salmonids might be observed. A short gillnet composed of 19 tans of commercial-type gillnet (A-gear) was set at 06:00, 09:00, 12:00, 15:00, 18:00, 21:00, 24:00, and 03:00 (LMT), and retrieved after a 2-hour soak-time. Local sunset time was 20:47 and sunrise time was 03:12. Fish were processed as described above, and stomachs were removed and frozen for later examination at the FRI and the NRIFSF.

TROPHODYNAMICS IN SUBARCTIC NORTH PACIFIC WATERS

Samples were collected from salmonids, salmonid prey and salmonid predators, and other animals for investigation of trophic relationships using C-N stable isotope analysis. Samples were taken from the dorsal musculature of salmonids and salmon sharks (*Lamna ditropis*) caught by gillnet and longline. Specimens of fish including spiny dogfish (*Squalus acanthias*), Pacific saury, Pacific pomfret, Atka mackerel (*Pleurogrammus monopterygius*), albacore (*Thunnus alalunga*), and myctophids, and squids including neon flying squid, boreopacific gonate squid (*Gonatopsis borealis*), and boreal clubhook squid (*Onychoteuthis borealijaponica*), and seabirds including short-tailed shearwater (*Puffinus tenuirostris*), and tufted puffin (*Lunda cirrhata*) were collected from gillnet or longline catches. Planktonic prey organisms were sampled using the fish larval net. These samples were frozen and sent to the Tohoku National Fisheries Research Institute, Shiogama, for analysis.

SALMONID TAGGING, TAG RECOVERY, AND OTOLITH MARKING

Tagging operations on viable salmonids caught by longlines were conducted north of 47°30'N (station 11; Table 3). After fish were removed from the longline, they were placed in a tank with flowing water in which to recover. Viable fish were removed from the tank, and the fork length was measured and scale samples removed. Chum salmon and a few other salmonids were injected with oxytetracycline hydrochloride (OTC) with the intent to induce a mark on the otolith for validation of growth increments. The dosage of OTC was 50 mg OTC/kg fish dissolved in 0.9% saline solution. The volume of OTC injected was determined from calculated estimates of BW based on the measured FL. The OTC solution was injected into the peritoneal cavity of the fish. All tagged salmonids were double-tagged with FAJ (orange and white, 1.6 cm in diameter) and FRI (red, 2.0 cm in diameter) Petersen disk-tags. The tags were attached to the dorsal musculature in front of the dorsal fin with a plastic cinch strap. Immediately after tagging, the fish were released to the sea.

All recovered double-tagged fish were measured for FL, BW, gonad weight, and scales and otoliths were removed.

Snouts were collected from all fin-clipped salmonids because these fish may contain a coded-wire tag. Snouts were salted and frozen, and sent to the Auke Bay Laboratory (Nat. Mar. Fish. Serv., U.S. Dept. Commerce) for analysis.

CHUM SALMON CONTINENT OF ORIGIN

Tissue samples (muscle, heart, and liver) were collected from 487 chum salmon (162 from the North Pacific and 325 from the Bering Sea) for stock identification by gel electrophoretic analysis. Most of the fish were obtained from gillnet catches, but some chum salmon caught by longline were used to supplement sample sizes. These samples were stored frozen and sent to the Hokkaido Salmon Hatchery (FAJ), Sapporo, for analysis.

Results and Discussion

OCEANOGRAPHY

We plotted vertical profiles of temperature and salinity collected at 21 fishing stations along the south-north transect at 180°00' (from 39°00'N to 47°30'N) and 179°30'W (from 48°30'N to 58°30'N), and determined the oceanographic areas that were traversed by the transect based on the definitions of Dodimead et al. (1963) and Favorite et al. (1976). Stations 1 and 2 (39°00'N and 40°00'N) were located in the Transition Zone, an area where surface water salinity is greater than 34.0 practical salinity units (psu; Fig. 2). The Subarctic Boundary, denoted by the position of a vertical 34.0 psu isohaline in the upper layer (0-200 m), was located between 40°00'N and 41°00'N (between stations 2 and 3). The Transition Domain, which is characterized by salinities greater than 33.2 psu at the surface and greater than 33.4 psu at the bottom of the upper layer, was located between 41°00'N and 45°00'N (stations 3 to 7; Fig. 2). The Subarctic Current is an eastward-flowing current typically having cool, dilute surface waters and relatively homogeneous conditions. At 180°00' longitude, this current was identified by water temperatures of 3.5°C and by salinities of 33.4 psu at approximately 125 m. The Subarctic Current was located at 46°00'N to 47°30'N (stations 8 to 10; Fig. 2). The Ridge Domain, where cold, saline water flows upward such that the 4°C isotherm is present at less than 100 m, was located at 49°30'N to 50°30'N (stations 11-13). The Alaska Stream is a westward flowing current characterized by warm (>4°C), dilute water (<32.6 psu at less than 100 m). These characteristics were located at 51°30'N (station 14; Fig. 2). Stations 15 through 28 (52°30' to 58°30'N) were located geographically in the Bering Sea, a region characterized by cold, saline surface waters.

In 1997, central North Pacific sea surface temperatures were cooler and central Bering Sea temperatures were warmer than in 1996. The average sea surface temperature (SST) in the central North Pacific was 0.90°C cooler in 1997 than in this region in 1996 (stations 1-14; 1996 mean=10.4°C and 1997 mean=9.5°C). The average SST in July in the Bering Sea was 0.61°C warmer in 1997 than in this region in 1996 (stations 15-28; 1996 mean=7.6°C and 1997=8.2°C; Davis et al., 1996).

The position of the Subarctic Boundary in 1997 was approximately 40°30'N, which is approximately the same latitude where it was located in 1991, 1994, and 1996. However, the boundary was located further north in 1992, 1993, and 1995 (42°N-43°N; Davis et al., 1996).

SALMONID CATCHES

A total of 15,914 salmonids (*Oncorhynchus* spp. and *Salvelinus malma*) was caught by longline and gillnet (Table 4). However, the size of the salmonid catch and the species composition were different at fishing locations in the central North Pacific Ocean (stations 1-14) as compared to the central Bering Sea (stations 15-28). In the central North Pacific (39°00'N-51°30'N), a total of 1,142 salmonids were caught (7% of the total; Table 4).

Coho salmon (*O. kisutch*) were the most abundant salmon in the catch (40% of salmonids), followed by chum (25%), pink (*O. gorbuscha*, 18%), steelhead (*O. mykiss*, 8%), sockeye (*O. nerka*, 6%), and chinook salmon (*O. tshawytscha*, 3%; Table 4). In the Bering Sea (52°30'N-58°30'N), a total of 14,772 salmonids were caught (93% of the total; Table 4). Pink salmon were the most abundant salmon in the catch (72% of salmonids), followed by chum (19%), sockeye (9%), chinook and coho salmon (both <1%; Table 4). One Dolly Varden was caught.

The salmon catches during the eight short-duration gillnet sets resulted in a total salmonid catch of 1,753 during the 24-hour period (Table 4). Pink salmon were the most abundant fish caught (n=1,417, 81%), followed by sockeye salmon (n=233, 13%), chum salmon (n=94, 5%), chinook, and coho salmon (both <1%, Table 4). The sockeye catch was stable for each gillnet set throughout most of the day (n=16 to 29), however, substantially more sockeye salmon were caught in the gillnet at 03:00 (n=68). The chum salmon catch was small but fairly stable throughout the day (n=6 to 10), but peaked at noon and 03:00 (n=26 and 20). Pink salmon catches ranged from 114 to 145 fish during the day (06:00 to 18:00). However, the gillnet operations retrieved after 21:00 contained from 221 to 273 pink salmon. One coho salmon was caught in a morning gillnet set (06:00) and eight chinook salmon were caught in early afternoon gillnet sets (12:00 and 15:00).

NON-SALMONID CATCHES

Pacific pomfret (n=986), neon flying squid (n=135), and other squid (n=170) were the most abundant non-salmonid catch (Table 4). Other non-salmonid catches included Pacific saury, (n=26), sharks (n=11), Atka mackerel (n=6), longnose lancetfish (*Alepisaurus ferox*, n=5), and other fish (n=12; Table 4). In 1997, the northern-most catch of neon flying squid and Pacific pomfret was 42°00'N latitude (SST=11.1°C, Table 4), not as far to the north as catches in 1996 (43°30'N and 46°30'N, respectively; Davis et al., 1996).

SALMONID DISTRIBUTION AND ABUNDANCE

Sockeye salmon were caught at 45°00'N but were abundant north of 50°30'N (Table 4). Sockeye mean catch per unit of effort (number of fish per 30-tans of C-gear; CPUE) was substantially greater (eight times greater) in the Bering Sea than in the Subarctic Current (Table 5). Chum salmon were caught at all fishing stations north of 39°00'N, but were most abundant in the Bering Sea (CPUE=143.9; Table 5). Pink salmon were caught at 40°00'N, were abundant north of 50°30'N and particularly in the Bering Sea (Tables 4-5). The abundance of pink salmon in the central Bering Sea peaks biannually, and in 1997 pink salmon were more abundant than in previous odd-years (1991, 1993, 1995; Davis et al., 1996). Coho salmon were abundant in the Transition Zone and chinook salmon were caught at 44°00'N, but were relatively abundant in the Bering Sea (Table 5). Steelhead trout were caught between 41°00'N and 50°30'N, and were relatively abundant in the Transition Domain (Table 5).

Although the Subarctic Boundary is generally believed to be the southern limit of salmonid distribution (Dodimead et al., 1963), four chum, four coho, and one pink salmon were caught in Transition Zone waters (40°00'N), south of the Subarctic Boundary. In earlier cruises of the R/V *Wakatake maru* (1991 and 1993) salmonids have been caught south of the boundary (Davis et al., 1996). Observations of salmon catch south of the boundary in three of the last seven years indicates that the boundary may not be a limit to the southern distribution of salmon in the central North Pacific Ocean (Nagasawa et al. 1997).

Although all the pink and coho salmon caught during the cruise are ocean age .1s, catches of sockeye, chum, and chinook salmon, and steelhead trout are a mixture of ocean ages. This makes it impossible to attribute annual changes in mean size to real changes, or to changes in age composition (Table 6). Therefore, mean size data are preliminary for sockeye, chum, and chinook salmon, and steelhead until the size-at-age data are calculated. In 1997, the mean length (419 mm) and weight (910 g) of sockeye caught in the Bering Sea were larger than the mean size in 1996 (Table 6, 1996: 401 mm, 851 g; Davis et al. 1996). In 1997, in the central North Pacific, mean length and weight of chum salmon were larger than in 1996, in the Bering Sea, however, the size of chum salmon was smaller than in 1996 (Table 6; 1996: [NPO] 374 mm, 621 g, [BS] 419 mm, 896 g; Davis et al. 1996). In 1997, the average length of pink salmon caught in the Bering Sea (445 mm) was smaller than in 1996 (455 mm), but the average weight was the same in both years (1117 g, Table 5: Davis et al. 1996). In the central North Pacific, the average length of coho (507 mm) was smaller in 1997 and the body weight (1698 g) was larger than the sizes of coho salmon caught in 1996 (1996: 514 g, 1665 g, Davis et al. 1996). In the Bering Sea, average size of chinook salmon (494 mm, 1671 g, Table 6) was smaller in 1997 than in 1996 (1996: 518 mm, 2023 mm, Davis et al. 1996), and the mean size of steelhead trout (628 mm, 2548 g, Table 5) was larger in 1997 than in 1996 (555 mm, 1622 g, Davis et al. 1996).

SALMONID FOOD HABITS

The stomachs of sockeye and pink salmon were found to contain squid, appendicularians, chaetognaths, fish, and crustacean zooplankton (copepods, euphausiids, hyperiid amphipods, and ostracods). Fish in the stomachs of sockeye and pink salmon included *Hemilepidotus* sp., myctophids, fish larvae and Atka mackerel. Sockeye stomach contents also included polychaetes, and pink salmon stomach contents included crab zoea.

Chum salmon had many of the same prey in their stomachs as sockeye and pink salmon including squid, appendicularians, chaetognaths, polychaetes, fish, and crustacean zooplankton (copepods, euphausiids, and ostracods). Chum salmon were also feeding on heteropods, pteropods, and gelatinous forms, such as siphonophores, salps, and ctenophores. Identifiable fish prey contained in chum salmon stomachs were fish larvae and *Hemilepidotus* sp.

Coho salmon stomachs contained squid, copepods, hyperiid amphipods, pteropods, and fish. The fish identified from coho salmon stomachs included Pacific saury, Atka mackerel, three-spine sticklebacks (*Gasterosteus aculeatus*), and *Hemilepidotus* sp. In addition, in the central North Pacific, fresh Japanese anchovies were found in coho stomach contents. This is a first record of Japanese anchovy observed as far east as 180° longitude (Nagasawa and Davis, 1997a).

Chinook salmon stomachs contained squid, euphausiids, and fish. Fish prey included *Hemilepidotus* sp., Atka mackerel, and myctophids. In addition, in the central North Pacific, a chinook was found to contain two small daggertooth (*Anotopterus pharao*, FL=140 mm and 165 mm) in its stomach. Daggertooth is regarded as a predator of salmon, and generally not the other way around. Perhaps this observation points to the importance of relative predator and prey body size over prey identity in investigations of oceanic food habits.

Steelhead trout were found to consume crustacean zooplankton (copepods, euphausiids, and amphipods), pteropods, and fish. The fish prey included Atka mackerel, and three-spine sticklebacks. On several occasions, steelhead were found to contain floating debris including plastic sheet material, plastic foam, and wood in their stomach contents.

TAGGING AND TAG RECOVERY

A total of 779 salmonids were double-tagged with FAJ and FRI Petersen disk-tags and released north of 47°30'N from longline operations. These tagged fish included 85 sockeye, 404 chum, 260 pink, 11 coho, 5 chinook salmon, and 14 steelhead trout. A total of 503 salmonids were also injected with OTC including 48 sockeye, 403 chum, 25 pink, 10 coho, 3 chinook salmon, and 14 steelhead trout.

Four double-tagged pink salmon were recaptured when gillnet fishing. The four fish were recovered the next morning at locations where they were released the previous night. Recovered tags were the following: LL4415 (FAJ), LL0415 (FRI) pink salmon released at 58°30'N, 179°30'W on July 9 and recovered on July 10 (FL=450 mm, BW=1120 g, female, GW=100 g); LL4416, LL0416 pink salmon released at 58°30'N, 179°30'W on July 9 and recovered on July 10 (FL=516 mm, BW, sex, and GW were not determined because the fish was gutted before examination); LL4378, LL0378 pink salmon released at 58°30'N, 179°30'W on July 9 and recovered on July 10 (FL=427 mm, BW, sex, and GW were not determined because only the tags were recovered); and LL4623, LL0623 pink salmon released at 56°30'N, 178°30'W on July 14 and recovered on July 15 (FL=434 mm, BW=1100 g, male, GW=97 g).

Forty-five steelhead trout were caught between 41°00'N and 48°30'N that had clipped fins (53% of the steelhead trout catch). Clipped fins included adipose, dorsal, left ventral, and left pectoral fins. The snouts were collected for potential recovery of coded-wire tags.

Acknowledgments

We thank Captain Yoshiyuki Hayasaka and all the officers, and crew of the R/V *Wakatake maru* for their shipboard assistance during the cruise. Thanks also go to Dr. Yukimasa Ishida (NRIFSF) for his useful suggestions on our research. Funding for U.S. participation was provided by the Auke Bay Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service (NOAA Contract No. 50ABNF700003).

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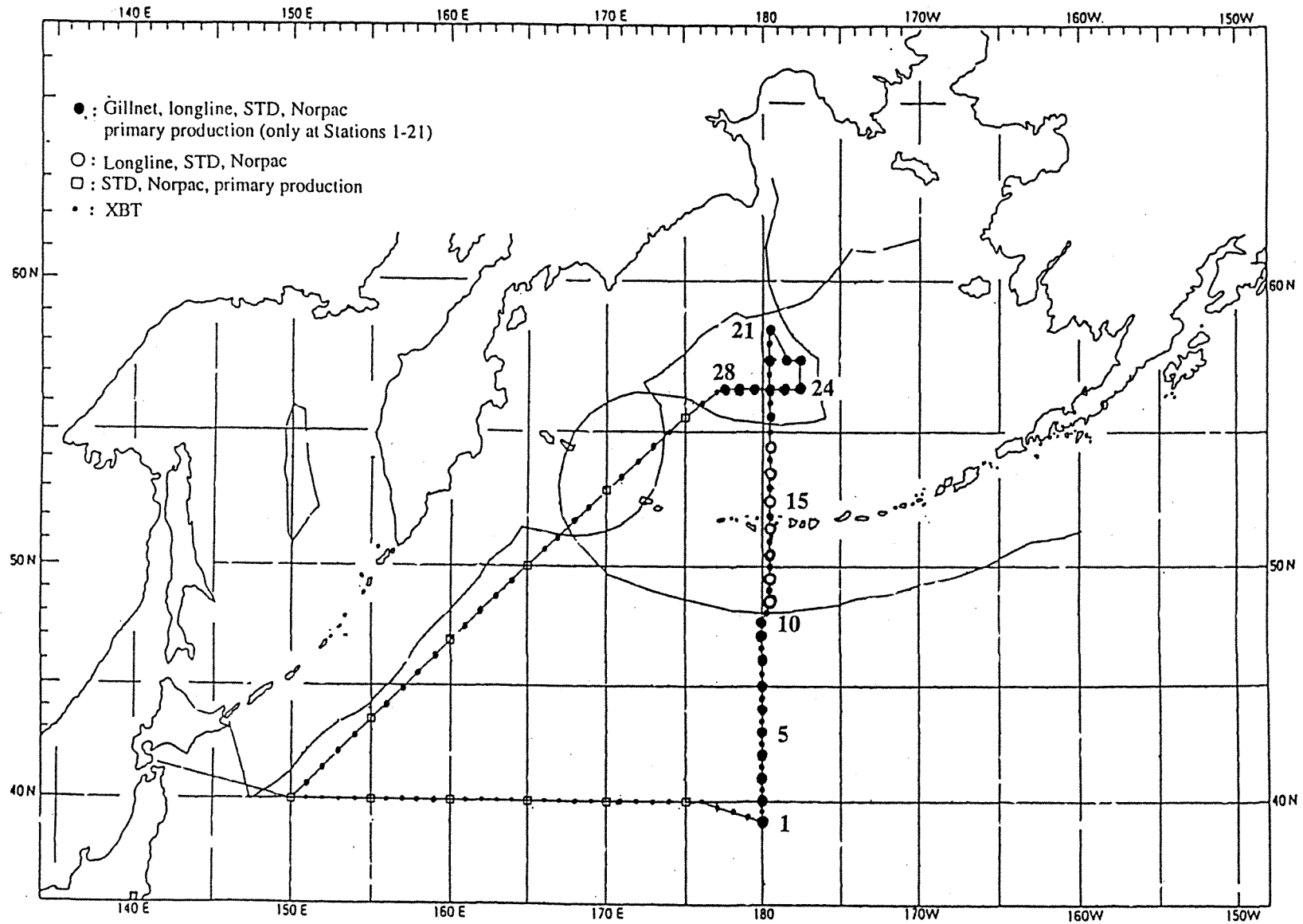


Figure 1. Cruise track of the summer 1997 salmon research cruise of the *R/V Wakatake maru*. The cruise track included 28 fishing stations along a north-south transect at 180°00' longitude (from 39°00'N to 47°30'N latitude) and at 179°30'W longitude (from 48°30'N to 58°30'N latitude) and an east-west transect at 56°30'N latitude in the central Bering Sea. In addition, there were 77 transit stations visited between fishing stations and while enroute to and returning from the fishing area.

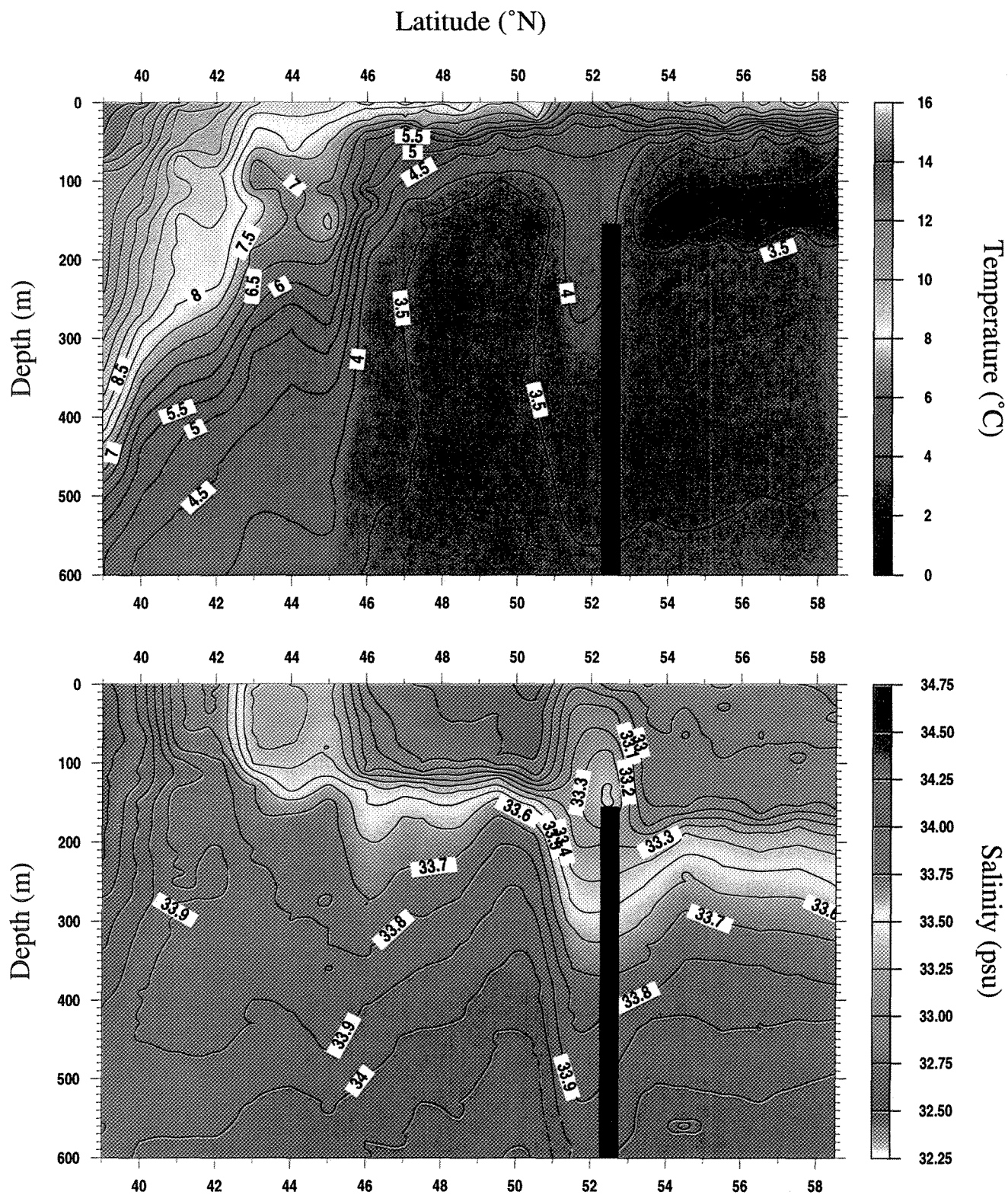


Figure 2. Vertical profile of seawater temperature (upper, °C) and salinity (lower, psu, practical salinity units) of the surface layers along a north-south transect at 180° 00' (from 39°N to 47° 30'N) and at 179° 30'W longitude (from 48° 30'N to 58° 30'N). Data were collected during fishing operations conducted by the *Wakatake Maru*, 1997. Black area is the sea bottom.

Table 1. Summary describing the size and capabilities of the (new) R/V *Wakatake maru*.

Item	Description
Ship name	R/V <i>Wakatake maru</i>
Call letters	JLOV
Home Port	Hakodate, Japan
Ship owner	Hokkaido Prefecture; Management Bureau of Training Ships
Ship Type	Combination; gillnetter, longliner
Ship Builder	Narasaki Company, Muroran, Hokkaido, Japan
Building completion date	Mar-97
Gross tons	666
Length (registered)	56 m
Breadth	10 m
Main engine	2200 horsepower; Niigata Tekkosho (manufacturer)
Fuel Capacity	410 tons (1 ton=1000 liters)
Cruising speed	13.0 knots
Full complement	74 persons (27 crew, 3 teachers, 40 students, 4 researchers)

Table 2. Description of research gear and fishing operations aboard the *R/V Wakatake maru* in 1997. Sampling stations included fishing stations (F-stations) and transit stations (T-stations) that were located between fishing stations and along a direct route going to and returning from the fishing area.

Research Item/Gear	Purpose	Specifications	Deployment	Sample/Data	Comments
A. Hydrographic					
Conductivity, Temperature, and Depth Sensor (CTD)	Collect temperature and salinity data by depth	Alec Memory STD (P-1000) sensor, made by the Alec Electronics Co. Ltd., Japan	Vertical, surface to 900 m or to the bottom	Temperature and salinity recorded at 1 m intervals and outputted to diskette and hard copy	Collected at all F-stations; T-stations at 5° longitude intervals
Expendable Bathy-Thermograph (XBT)	Collect temperature data by depth	XBT Model T-7, Tsurumi-Seiki Co., Ltd. Yokohama, Japan	Vertical, surface to 780 m	Temperature and depth recorded at 1 m intervals and outputted to diskette and hard copy	Collected at all T-stations
Salinity Reference Sample	Collect water samples for laboratory determination of salinity and to standardize CTD and XBT data	Bucket water sampler	Collection from the surface of the water	Water sample stored in brown bottles sealed with a cork	Collected at all F-stations; T-stations at 5° longitude intervals
Secchi Disk Depth	Estimate water transparency	White disk tied to a rope measured at 1 m intervals; disk diameter=30 cm	Daylight; disk lowered over the ship's side	Disk is lowered into the water and the depth is recorded when the disk disappears from view	Collected at all F-stations; T-stations at 5° longitude intervals

Table 2. Continued.

Research Item/Gear	Purpose	Specifications	Deployment	Sample/Data	Comments
B. Phytoplankton Chlorophyll-a, Biogenic Silica, Coccolithophorids, Nutrients, and Phytoplankton Species Identification	Estimate general phytoplankton biomass, abundance of biogenic silica and coccolithophorids, measure dissolved nutrient levels (phosphate, nitrate), and identify phytoplankton species	Bucket and Niskin water sampler	Water samples collected from 0, 10, 20, 30, and 50 m depths	Chlorophyll-a, coccoliths, and silica: seawater is filtered and the filter is stored frozen or dried; Coccolithophorids: 1-l seawater preserved in 2% formalin; Nutrients: 50-60 ml seawater is frozen at -50°C; Phytoplankton: 1 l seawater preserved in 5% formalin	Collected at F-stations 1-21; Chlorophyll-a, coccolith, and biogenic silica samples collected at T-stations at 5° longitude intervals; Samples analyzed later in the laboratory

Table 2. Continued.

Research Item/Gear	Purpose	Specifications	Deployment	Sample/Data	Comments
C. Zooplankton					
Micro-zooplankton	Determine abundance of major micro-zooplankton groups	Niskin water sampler	Collect water from several layers (0,10, 20, 30, 40, 50 m)	Ciliates: 300-ml seawater preserved in Bouin's solution; Piconanoplankton: 30-ml seawater preserved in glutaraldehyde solution	Collected at T-stations at 5° longitude intervals on the portion returning to Hakodate
Macro-zooplankton Norpac Net (remodeled in 1995)	Estimate biomass and identification of zooplankton in the epipelagic zone (0-150 m) and estimate biomass of zooplankton above and below the thermocline	Ring diameter: 0.45 m; Mesh size: 0.335 mm; Filtering cloth: GG54; Length of cylindrical portion of net: 0.650 m; Length of conical portion of net: 1.3 m; The design of the Norpac was improved by insertion of a cylindrical section of cloth between the net opening and the conical-shaped tail section; The remodeled design has improved filtration efficiencies over the older Norpac design (Motoda 1994)	Epipelagic tow: vertical 0-150 m; and additional vertical tows above and below the thermocline; Depression weight: 15 kg; Ship speed: 0 kts, drifting; Wire speed: 1 m/sec;	Bottled with 7% formalin; sample bottles color-coded with yellow tape	Collected at F-stations 1-21; samples from 0-150 m tows were also collected at T-stations at 5° longitude intervals; Flow meter used and calibrated on 2 occasions by repeating a 0-50 m vertical tow 5 X; Wire angle measured and added wire length recorded; Samples later analyzed in the laboratory

Table 2. Continued.

Research Item/Gear	Purpose	Specifications	Deployment	Sample/Data	Comments
C. Zooplankton (cont'd)					
Macro-zooplankton and micro-nekton Fish Larval Net	Collect fish larvae and micro-nekton (salmonid prey)	Ring diameter: 1.3 m Overall length: 4.5 m Mesh size: 2.0 mm (frontal portion), 0.335 mm (codend)	Horizontal tow at the surface; Ship speed: 2 kts; Wire speed: stationary; net towed for 10 minutes;	Sample placed in a cotton bag and stored in a bucket with 10% formalin	Collected at all F-stations; No flow meter used
	Collect micro-nekton for analysis of heavy C-N isotope ratios to describe ecosystem trophodynamics (salmonid prey)	Additional fish larval net tows	Horizontal tow at the surface	Sample frozen -50° C	Collected at stations to represent conditions in the Transition Zone, Transition Domain, Subarctic waters, and the Bering Sea

Table 2. Continued.

Research Item/Gear	Purpose	Specifications	Deployment	Sample/Data	Comments
<p>D. Salmonids</p> <p style="text-align: center;">Gillnet</p>	<p>Salmon abundance and biological data for ocean ecology and stock assessment</p>	<p>Overall length: 2.45 km (49 tans; 50m/tan); Depth approx. 7.5 m; Net configuration [research (C) or commercial (A) mesh size (mm)/amount (tans)]: North of 45°00N: A115/15, C48/3, C93/3, C157/3, C106/3, C63/3, C121/3, C72/3, C138/3, C82/3, C55/3, A115/4; 39°00N-45°00N: C29/1 and C37/1 (saury net) substituted for 2 tans of A-gear</p>	<p>Set 1600 (local time) and hauled 0400 the next morning;</p>	<p>Routine biological data: count all fish by species and mesh size and measure a maximum of 60 fish per species per mesh size for fork length, body weight, sex, gonad weight, and scale samples</p>	<p>Collected at all F-stations outside the U.S. 200-mile zone (outside EEZ; St. 1-10, 18-28); Routine scale collection: 1 scale per fish from sockeye, chum, and pink; 2 scales per fish from coho, chinook, and steelhead</p>

Table 2. Continued.

Research Item/Gear	Purpose	Specifications	Deployment	Sample/Data	Comments
<p>C. Salmonids (cont'd)</p> <p>Surface Longline</p>	<p>Capture of live fish; Fish that have recently fed</p>	<p>Overall length: approx. 3.32 km (30 hachi [baskets]); Hachi mainline length: approximately 111 m; Number of hooks per hachi: 49; Interval between branch lines: approx. 2.1 m; Fishing depth of hooks: 1.3 m; Bait: salted Japanese anchovy</p>	<p>Set 30 minutes before sunset (local) time, and hauled 30 minutes after sunset;</p>	<p>Routine biological data: count all fish by species and measure a maximum of 60 fish per species for fork length, body weight, sex, gonad weight, and a scale sample; When conducting tagging operations, viable fish were measured for fork length, a scale removed, and fish were double-tagged with JFA and FRI tags</p>	<p>Collected at all F-stations; tagging operations conducted at F-stations 11-28 where fish were tagged with two Peterson disk tags attached to the fish in front of the dorsal fin with a plastic cinch</p>

Table 3. Description of research activities conducted aboard the *R/V Wakatake maru* in 1997 related to salmonids and trophodynamics.

Subject	Species	Sample	Fishing Gear	Method	Data or Samples Collected
A. Salmonid Feeding Ecology					
Food Habits	All salmon and steelhead	Stomach contents	Longline and commercial mesh gillnet (A115)	Stomachs from esophagus to pyloric valve collected from up to 10 fish of each species per gear per station	Prey weight, % composition by prey type, % empty stomachs, collected on board ship; Occasionally, specimens of prey organisms were preserved in formalin for later species identification
Digestion Rates and Daily Ration	sockeye, chum, and pink salmon	Stomach contents	Commercial mesh gillnet (A115)	19-tans of gillnet (A115) set 8 times in one 24-hour period; stomachs removed and frozen	Prey weight and % composition of prey type determined in the laboratory; accompanying biological data
Trophodynamics	All salmon, steelhead and their prey organisms	5 g sample of muscle	Longline and gillnet	Muscle tissue removed from area immediately anterior to the dorsal fin from 5 fish per species; prey organisms collected from salmon stomach contents; stations sampled to represent conditions in the Transition Zone, Transition Domain, Subarctic waters, and the Bering Sea	Samples frozen for analysis of heavy C-N isotope ratios

Table 3. Continued.

Subject	Species	Sample	Fishing Gear	Method	Data or Samples Collected
A. Salmonid Feeding Ecology (cont'd)	small salmon small pomfret, large saury	round sample	Longline and gillnet	gill-raker size and spacing measured later in the laboratory	Samples frozen for later analysis of size and spacing of gillrakers
B. Salmonid Ocean Growth Age and Growth Validation	Sockeye, chum, pink, coho, chinook, and steelhead	Marked fish	Longline	During tagging operations salmon were double-tagged with JFA and FRI disk tags and scales were collected; chum salmon were injected with OTC (oxytetracycline) and all tagged salmon were released for recovery in inshore fisheries	Tag numbers (JFA and FRI), scale samples, and accompanying biological data; F-stations 11-28

Table 3. Continued.

Subject	Species	Sample	Fishing Gear	Method	Data or Samples Collected
C. Stock Identification					
Gel Electrophoresis	Chum	Muscle, heart, and eye	Gillnet [research-mesh (C-gear)]	Tissue samples removed from fish during collection of routine biological data	Tissue samples frozen from a maximum of 160 chum from stations in the North Pacific (8 - 13) and 320 chum from the Bering Sea (18 - 21); Accompanying biological data and scale samples
Origin-indicating Parasites	Sockeye	Visceral adhesion	Gillnet and longline	Observation during routine biological data collection	Incidence of visceral adhesion (indicator of the presence of <i>Philonema onchorhynchii</i>) recorded on biological data sheets
D. Tagging					
High Seas Coded-Wire Tag Recovery	All salmon and steel-head	Snouts	Gillnet and longline	Snouts were removed from fish lacking the adipose fin	Snouts were salted and frozen; Accompanying biological data, scales, and otolith samples

Table 3. Continued.

Subject	Species	Sample	Fishing Gear	Method	Data or Samples Collected
<p>D. Tagging (cont'd)</p> <p>High Seas Tagging</p>	All salmon and steel-head	Live fish	Longline	Fish were tagged with JFA and FRI disk tags placed in front of the dorsal fin on the same cinch; caught and released in the North Pacific and Bering Sea F-stations 11-26	Scales and fork length collected when fish tagged
<p>E. Salmonid Body Condition</p>	All salmon and steel-head	Incidence of salmon lice	Gillnet and longline	Salmon were observed for the incidence of parasites during routine biological data collection	Number and position of salmon lice (<i>Lepeophtheirus salmonis</i>) on the salmon; Accompanying biological data
<p>F. Non-salmonid Fish Catch</p>	All salmon and steel-head	Examination of slash marks	Gillnet and longline	Salmon were observed for the presence of injuries during the course of collecting routine biological data	Photographs taken of injured fish; Accompanying biological data
<p>F. Non-salmonid Fish Catch</p>	Salmon sharks	Stomach and 5-g muscle sample	Gillnet and longline	Collected a sample when shark was caught	Length and sex recorded; Stomach and muscle sample frozen; Stomach will be examined to investigate shark predation; Muscle will be analyzed to determine heavy C-N isotope ratios

Table 3. Continued.

Subject	Species	Sample	Fishing Gear	Method	Data or Samples Collected
F. Non-salmonid Fish Catch (cont'd)	Pacific Saury	Round sample	Gillnet (research-mesh 29 and 37 mm)	Small mesh size was used from 39°00N to 45°00N	Length measured; Maximum 100 fish per mesh size; Round sample frozen
	Walleye Pollock	Round sample	Gillnet and longline	Collected a sample when pollock was caught	Fork length and body weight measured; Round sample frozen; Muscle will be analyzed to determine heavy C-N isotope ratios
	Squids	Round sample	Gillnet and longline	Collected a sample when squid was caught	Mantle length recorded; Round sample frozen; Maximum 10 individuals per station (neon flying squid); Muscle will be analyzed to determine heavy C-N isotope ratios
	Pacific Pomfret	Round sample	Gillnet and longline	Collected a sample when pomfret was caught	Fork length measured; Round sample frozen; Muscle will
	All other fish by-catch	Round sample	Gillnet and longline	Collected a sample when caught	Fork length measured; Round sample frozen; Muscle will be analyzed to determine heavy C-N isotope ratios

Table 4. Salmonids, other fishes, and squid caught during the summer salmon research cruise of the *R/V Wakatake maru*, 1997, are shown for each station by gear. Location, seawater temperature (°C), and salinity (psu, practical salinity units) at the surface and at 100 m depth are listed. Catch by longline (B), salmon research-mesh gillnet (C), commercial-mesh gillnet (A), and the number of fish tagged and released are listed for each station.

Sta	Date	Location	Temperature		Salinity		Gear	Sock- eve	Chum	Pink	Coho	Chi- nook	Steel- head	Dolly Varden	Total Salmonids	Neon			Pacific Saury	Lancet Fish	Dagger Tooth	Sharks	Atka Mackerel	Walleye Pollock	Other Fishes	
			0 m	100 m	0 m	100 m										Flying Squid	Other Squids	Pacific Pomfret								
1	19-Jun-97	39°00'N 180°00'	13.40	11.37	34.33	34.33	B	0	0	0	0	0	0	0	0	0	0	0	75	0	0	0	0	0	0	1
							C	0	0	0	0	0	0	0	0	26	1	64	0	0	0	1	0	0	3	
							A	0	0	0	0	0	0	0	0	72	0	32	0	0	0	1	0	0	0	
							Total	0	0	0	0	0	0	0	0	98	1	171	0	0	0	2	0	0	4	
2	20-Jun-97	40°00'N 180°00'	13.20	10.69	34.17	34.20	B	0	0	1	1	0	0	0	2	0	1	106	0	0	0	0	0	0	0	
							C	0	4	0	1	0	0	0	5	10	1	81	10	0	0	1	0	0	1	
							A	0	0	0	2	0	0	0	2	12	0	30	0	0	0	0	0	0	1	
							Total	0	4	1	4	0	0	0	9	22	2	217	10	0	0	1	0	0	2	
3	21-Jun-97	41°00'N 180°00'	11.60	9.14	33.72	33.96	B	0	1	0	0	0	0	0	1	0	0	289	0	0	0	0	0	0	0	
							C	0	2	0	1	0	1	0	4	0	3	22	0	0	0	0	0	0		
							A	0	1	0	2	0	0	0	3	1	0	22	0	0	0	0	0	0		
							Total	0	4	0	3	0	1	0	8	1	3	333	0	0	0	0	0	0		
4	22-Jun-97	42°00'N 180°00'	11.10	8.81	33.73	33.89	B	0	0	1	11	0	0	0	12	0	4	62	0	0	0	0	0	0	0	
							C	0	1	0	36	0	0	0	37	6	31	101	13	0	0	1	0	0		
							A	0	0	0	79	0	0	0	79	8	0	102	0	0	0	0	0	0		
							Total	0	1	1	126	0	0	0	128	14	35	265	13	0	0	1	0	0		
5	23-Jun-97	43°00'N 180°00'	9.20	6.73	33.35	33.39	B	0	10	3	13	0	4	0	30	0	1	0	0	0	0	0	0	0	0	
							C	0	23	5	36	0	3	0	67	0	1	0	3	0	0	0	0	0		
							A	0	1	0	63	0	3	0	67	0	0	0	0	0	3	0	0	0		
							Total	0	34	8	112	0	10	0	164	0	2	0	3	0	3	0	3	0	0	
6	24-Jun-97	44°00'N 180°00'	9.30	7.01	33.31	33.38	B	0	8	0	10	0	0	0	18	0	0	0	0	1	0	0	0	0	0	
							C	0	9	1	25	1	3	0	39	0	19	0	0	0	0	0	0	0		
							A	0	3	0	32	0	7	0	42	0	0	0	0	0	0	0	0	0		
							Total	0	20	1	67	1	10	0	99	0	19	0	0	1	0	0	0	0		
7	25-Jun-97	45°00'N 180°00'	8.80	7.01	33.35	33.43	B	0	6	1	10	0	4	0	21	0	1	0	0	0	0	0	0	0		
							C	1	23	1	7	0	5	0	37	0	8	0	0	0	0	0	0	0		
							A	0	1	1	5	0	7	0	14	0	0	0	0	0	0	0	0	0		
							Total	1	30	3	22	0	16	0	72	0	9	0	0	0	0	0	0	0		

Table 4. Continued.

Sta	Date	Location	Temperature		Salinity		Gear	Sock-eye	Chum	Pink	Coho	Chi-nook	Steel-head	Dolly Varden	Total Salmonids	Neon		Pacific Pomfret	Pacific Saury	Lancet Fish	Dagger Tooth	Sharks	Atka Mackerel	Walleye Pollock	Other Fishes						
			0 m	100 m	0 m	100 m										Flying Squid	Other Squids														
24	13-Jul-97	56°30'N 177°30'W	8.60	3.27	32.63	32.89	B	11	122	75	1	0	0	0	209	0	0	0	0	0	0	0	0	0	0						
							Tagged	5	49	15	0	0	0	0	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
							C	64	247	396	0	0	0	0	707	0	6	0	0	0	0	0	0	0	0	0	1	2	0	0	
							A	23	27	336	0	0	0	0	386	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
							Total	98	396	807	1	0	0	0	1302	0	6	0	0	0	0	0	0	0	0	0	1	2	0	1	
25	14-Jul-97	56°30'N 178°30'W	9.10	3.25	32.87	32.93	B	20	77	103	0	2	0	0	202	0	0	0	0	0	0	0	0	0	0						
							Tagged	8	38	36	0	0	0	0	82	0	0	0	0	0	0	0	0	0	0	0	0	0			
							C	51	191	318	0	1	0	0	561	0	20	0	0	0	0	0	0	0	0	0	0	0	0		
							A	19	22	243	0	3	0	0	287	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
							Total	90	290	664	0	6	0	0	1050	0	20	0	0	0	0	0	0	0	0	0	0	0	0		
26	15-Jul-97	56°30'N 179°30'E	9.10	2.82	32.82	32.87	B	5	42	54	0	2	0	0	103	0	0	0	0	0	0	0	0	1	0						
							Tagged	2	22	27	0	0	0	0	51	0	0	0	0	0	0	0	0	0	0	0	0	0			
							C	55	195	442	0	2	0	0	694	0	5	0	0	0	0	0	0	0	0	0	0	0			
							A	8	12	253	2	1	0	0	276	0	0	0	0	0	0	0	0	0	0	0	0	0			
							Total	68	249	749	2	5	0	0	1073	0	5	0	0	0	0	0	0	0	0	0	0	1	0		
27	16-Jul-97	56°30'N 178°30'E	8.90	2.44	32.84	32.90	B	1	44	36	0	2	0	0	83	0	0	0	0	0	0	0	0	0	0						
							Tagged	1	23	17	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0	0				
							C	37	245	189	0	1	0	0	472	0	8	0	0	0	0	0	0	0	0	0	1	0			
							A	13	24	172	1	0	0	0	210	0	0	0	0	0	0	0	0	0	0	0	0	0			
							Total	51	313	397	1	3	0	0	765	0	8	0	0	0	0	0	0	0	0	0	1	0			
28****	17-Jul-97	56°30'N 177°30'E	9.00	2.77	32.86	32.92	B	9	44	31	0	1	0	0	85	0	0	0	0	0	0	0	0	0	0						
							Tagged	8	25	7	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0				
							C	43	195	140	1	1	0	0	380	0	8	0	0	0	0	0	0	0	0	0	1	0			
							A	10	11	108	1	0	0	0	130	0	0	0	0	0	0	0	0	0	0	0	0				
							Total	62	250	279	2	2	0	0	595	0	8	0	0	0	0	0	0	0	0	0	0	1	0		
TOTAL							B	200	868	869	102	39	35	0	2113	0	7	532	0	4	0	1	1	0	2						
							Tagged	85	404	260	11	5	14	0	779	0	0	0	0	0	0	0	0	0							
							C	573	1607	3878	134	42	17	1	6252	42	163	268	26	1	0	6	5	0	5						
							A	593	546	6094	233	50	33	0	7549	93	0	186	0	0	0	4	0	1	5						
							Total	1366	3021	10841	469	131	85	1	15914	135	170	986	26	5	0	11	6	1	12						

*12 hatchi (instead of 30 hatchi) were retrieved during this longline operation. The remaining 18 hatchi were not retrieved because they were lost at sea.

**Routine 12-hour soak of 49-tan gillnet (30 tans C-gear + 19 tans A-gear) was not deployed at this station. Instead, 19 tans (A-gear) were set 8 times (2-hour soak) at 3-hour intervals over a 24-hour period.

***Length of the A-gear section of gillnet was reduced from 19 to 9 tans at stations 23 to 28.

****Length of the longline was reduced from 30 to 20 hatchi.

Table 5. Mean catch (number of salmonids) per unit (30-tans, 1500 m) of effort by research-mesh gillnet (C-gear) calculated by oceanographic region for the *R/V Wakatake maru*, 1997. Research-mesh gillnet is composed of three tans each for the following mesh sizes: 48 mm, 55 mm, 63 mm, 72 mm, 82 mm, 93 mm, 106 mm, 121 mm, 138 mm, and 157 mm.

Year	Sampling Dates	No. of Sta.	Locations	Mean Temperature		Mean Salinity		Mean Catch per 30 tans C-gear							
				0 m	100 m	0 m	100 m	Sock-eye	Chum	Pink	Coho	Chi-nook	Steel-head	Dolly Varden	Total Salmonids
				Central North Pacific - Transition Zone											
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	2.5
Central North Pacific - Transition Domain															
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	36.8
Central North Pacific - Subarctic Current															
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	72.7
Bering Sea															
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	584.5

Table 6. Mean fork length (mm) and body weight (g) of salmonids caught in the research-mesh gillnet (C-gear) during fishing operations of the *R/V Wakatake maru*, 1997.

Year	Sampling Dates	Sockeye		Chum		Pink		Coho		Chinook		Steelhead							
		N	Fork Length (mm)	Body Weight (g)	N	Fork Length (mm)	Body Weight (g)	N	Fork Length (mm)	Body Weight (g)	N	Fork Length (mm)	Body Weight (g)	N	Fork Length (mm)	Body Weight (g)			
		Central North Pacific																	
1997	19-28 Jun	6	464	1108	155	385	718	83	433	937	132	507	1698	7	649	3550	18	628	2548
Bering Sea																			
1997	6-17 Jul	565	419	910	1346	402	814	1537	445	1117	3	552	1740	34	494	1671	0		