FRI-UW-9802
March 1998

**FISHERIES RESEARCH INSTITUTE
Box 357980
School of Fisheries
University of Washington
Seattle, Washington 98195-7980

Survey on Overwintering Salmonids in the Western and Central North Pacific Ocean and Bering Sea: *Kaiyo Maru*, 3 February-2 March, 1998

Nancy D. Davis

Cruise Report

to

National Marine Fisheries Service
Contract No. 50ABNF700003

**Permission to use any of the data in this report for publication should by obtained from the Fisheries Agency of Japan, National Research Institute of Far Seas Fisheries, 7-1, 5 Chome Orido, Shimizu, Shizuoka, 424, JAPAN.

Survey on Overwintering Salmonids in the Western and Central North Pacific Ocean and Bering Sea: *Kaiyo Maru*, 3 February-2 March, 1998

Abstract

A survey on overwintering salmonids (*Oncorhynchus* spp.) in the western (165°E) and central (180°) North Pacific Ocean and Bering Sea (180°) was conducted by Japanese, Russian, and U.S. scientists aboard the Japanese research vessel *Kaiyo maru* from 3 February to 2 March 1998. This was the third overwintering salmonid survey conducted on board the *Kaiyo maru*. The first two surveys were trans-Pacific cruises (Nov.-Dec. 1992 and Jan. 1996), however, this cruise was the first wintertime salmon research cruise in the central Bering Sea since 1963. The research objectives were to collect samples and data on salmon distribution and biology in February; collect data on salmon habitats such as environmental temperatures, primary production, and conditions for salmon feeding that might contribute to wintertime salmon growth reduction and mortality; and determine what differences might exist between mid-winter and summer seasons in salmon habitat conditions, especially with respect to primary production and production of salmon prey organisms.

Salmon were caught at 14 of 19 trawl stations. The total catch of salmon during the survey was 2,381 fish (49 sockeye, *O. nerka*; 1,433 chum, *O. keta*; 843 pink, *O. gorbuscha*; 24 coho, *O. kisutch*; and 32 chinook, *O. tshawytscha*). No steelhead, *O. mykiss*, were caught. The majority of the catch (66%) occurred at one station in the western North Pacific Ocean, where there were relatively large catches of chum and pink salmon. The combined results of the December 1992, January 1996, and February 1998 surveys indicate that salmon in their first ocean year (or those that have just completed their first ocean year) are distributed well offshore in winter, and that in the western North Pacific Ocean, chum and pink salmon are more abundant in offshore waters in February than in December or January. Most of the salmon catch in February 1998 was distributed in a narrow band from 42°-45°N in the western North Pacific Ocean (at 165°E), where sea surface temperatures (at 5 m) were 3.9°-5.1°C, and from 43°-46°N in the central North Pacific Ocean (at 180°), where sea surface temperatures were 5.7-6.8°C. Chinook salmon was the only species caught in the Bering Sea. Blood was collected from a total of 134 salmon for determination of steriod hormones of chum salmon and analysis of insulin-like growth factor-1 for five species of Pacific salmon.

Introduction

Interest in wintertime salmon (*Oncorhynchus* spp.) distribution, growth, and survival has increased during the 1990s, as concerns regarding carrying capacity of salmon in the North Pacific Ocean and climate change, have focused on the winter season as a critical time, when the combined effects of temperature and feeding conditions may decrease salmon growth and survival. To investigate the overwintering habitats of high-seas salmon, the *Kaiyo maru* has conducted two previous wintertime surveys in the North Pacific Ocean. In November-December 1992 and January 1996, trans-Pacific surveys with trawling operations were conducted aboard the *Kaiyo maru* in the western (157°E in 1992 and 160°E in 1996), central (179°W in 1992, 168°W in 1996), and eastern (145°W in 1992 and 1996) North Pacific Ocean (Myers 1993, 1996). Those surveys indicated that salmon were caught in relatively cool surface waters (<7.5°C), and that salmon were found in a rather narrow band of north to south distribution. In February-March 1998, the *Kaiyo maru* conducted a third survey in the western (165°E) and central (180°) North Pacific Ocean. The survey included trawl operations in the Bering Sea basin, which were the first to sample salmon in the central Bering sea since 1963. The Fisheries Agency of Japan (FAJ) invited one scientist each from Canada, Russia, and the United States to join the cruise, and Russia and the United States accepted the invitation.

The research questions to be investigated in the February-March 1998 salmon survey, as stated by the Fisheries Agency of Japan in their research plan, were the following:

" (1) Is salmon distribution in February limited to a narrow area with low sea surface temperatures, as was observed in December and January?

(2) Can a shortage of food and severe ocean conditions in winter cause salmon growth deterioration and mortality?

(3) Are there any differences between mid-winter and summer seasons in salmon habitat conditions, especially primary production and production of salmon prey organisms?" (FAJ 1997)

The purpose of this report is to present information on methods used during this survey and some preliminary results of the fishing operations. Later, under the leadership of the chief scientist, Dr. Yukimasa Ishida, FAJ will publish a final report of this survey. All data collected during the cruise belong to FAJ, and permission for use of any of the data in this report should be obtained from them.

Methods

Survey area, schedule, and personnel

The *Kaiyo maru,* a 93-m stern trawler, departed Tokyo, Japan, on 3 February 1998 and proceeded to the transect at 165°E, where we conducted fishing operations and made oceanographic observations (7-12 February; Fig. 1; Table 1). The survey along the 180° transect (Bering Sea and North Pacific) was conducted from 15 February to 22 February, and the *Kaiyo maru* returned to Japan at Shimizu Port on 2 March 1998 (Table 1).

Ship's personnel aboard the *Kaiyo maru* included 47 officers and crew (Table 1). The researchers on board included: Y. Ishida, Y. Ueno, A. Shiomoto, T. Watanabe, and T. Azumaya, National Research Institute of Far Seas Fisheries (NRIFSF, FAJ); M. Koval, Kamchatka Research Institute of Fisheries and Oceanography (KamchatNIRO), N. Davis, Fisheries Research Institute (FRI), University of Washington, and three students, T.

Murata, Hokkaido University, and Y. Shibukawa and Y. Shimizu, Tokai University (Table 2).

Hydrographic sampling

The hydrographic sampling aboard the *Kaiyo maru* followed the methods used in previous cruises (Table 3; Myers 1993, 1996). The primary oceanographic tool was the CTD octopus, which includes a deep-sea CTD sensor and rosette of niskin water collecting bottles. The CTD operation was a 0 to 1500 m cast, and water samples were collected from 23 depths. Surface water collection was done using a bucket. The variables measured by the CTD octopus included temperature, salinity, depth, DO, and fluorescence (chlorophyll-a). Analysis of water samples provided confirmation of CTD salinity, DO, and chlorophyll-a values, and information on nutrient concentrations (NO_2+NO_3, PO_4, SiO_2) at depth (Table 3).

At fishing stations, and while transiting between stations XBTs and XCTDs were used to gather oceanographic data and to intercalibrate the CTD (Table 3).

Phytoplankton sampling

Along the 165°E transect, the rate of primary production was determined in a manner similar to the experiments carried out on previous *Kaiyo maru* salmon cruises (Table 4; Myers 1993, 1996). The depth of light penetration of 100% (surface), 30%, 10%, and 1% light intensities was determined with a quantum and depth sensor, and water samples at those depths were collected using a Go-Flo sampler. Phytoplankton were incubated with ^{13}C for six hours in a water bath on deck. The water was filtered and the filters frozen at -80°C for later analysis by mass spectrophotometry. Additional water samples were collected at 0, 10, 30, 50, 100 and 200 m to determine the quantity of various phyto-pigments (Table 4).

At the 180° transect, a second incubation experiment was initiated to determine primary production (Table 4). The purpose of this experiment was to determine if the rate of production by the smaller-size phytoplankton, which characterize subtropical waters, were more affected by low water temperature than the larger-sized phytoplankton, which characterize subarctic waters. The water was collected by bucket from the surface, fractionated into 3 size groups, and incubated for 3-4 hrs with ^{13}C in a laboratory under controlled conditions of light and water temperatures. After the incubation period, the water was filtered and the filters frozen for later analysis (Table 4).

For continuous monitoring of plankton while underway, the *Kaiyo maru* has an EPSC (electronic plankton counting and sizing system) device that records time, location, water temperature, salinity, DO, chlorophyll-a, and plankton particle count every minute (Table 4; Myers 1993, 1996).

Zooplankton sampling

Zooplankton were collected using a Norpac net towed from 0-150 m and fitted with a flow meter (Table 5). Zooplankton collections during previous cruises included collection by both Norpac and bongo nets (Myers 1993, 1996), however the bongo net collection was not continued in the 1998 cruise.

Salmon sampling

Salmon were caught with the same mid-water spider net trawl, using fishing methods similar to those used in the two previous salmon cruises (Table 6; Myers 1993, 1996). The trawl was towed at the surface for one hr, and typically fished with a 50-m vertical by 70-m horizontal opening. The codend was lined with 13-mm mesh, and the trawl was capable of catching juvenile, immature, and maturing salmon.

The salmon catch was sorted by species. For up to 60 salmon per species, the fork length (FL; mm) and body weight (BW; g) were measured, a scale sample was collected, and the fish individually labeled (Table 6). As noted previously, scales from the preferred area for scale sampling (International North Pacific Fisheries Commission) were not usually present on the fish because the scales were worn off by abrasion in the net (Myers 1993, 1996). Scales were collected where they could be found, usually from areas on the body protected by covering fins, such as the pectoral fins. In cases where more than 60 fish per species were caught, as occurred at a couple of stations where chum or pink salmon were particularly abundant, the fish were counted and the total weight measured. When there was a particularly large salmon catch, two pink and two chum salmon were frozen in the round for energetic studies at FRI (Table 6).

Blood samples were collected from the caudal vein using vacutainer blood collection tubes, and centrifuged at 3000 rpm for 15 minutes. The separated serum was pipetted into cryotubes and frozen at -80°C (Table 6; Myers 1996). Two sets of salmon blood samples were collected. One set was obtained from chum salmon for determination of steriod hormones by Dr. H. Ueda's research group at Hokkaido University (Sato et al. 1997), and a second collection of samples from all salmon species was obtained for analysis of insulin-like growth factor-1 by FRI (Myers and Urawa 1997; Myers et al. 1998).

After measuring the fish and collecting scale and blood samples, small salmon were wrapped in plastic and frozen. Large salmon were frozen uncovered and later water-glazed. The fish were frozen flat on trays in the ship's freezer at -40°C. As was the procedure on previous cruises, after the salmon survey is completed, the salmon will be delivered to the NRIFSF, where a detailed dissection and organ weights and samples will be collected (Myers 1993, 1996). The detailed examination will include sex determination, gonad and liver weight, stomach content analysis, collection of heart, muscle, liver, for genetic stock identification (GSI), and otoliths for age and growth studies (Table 6).

Shipboard age determinations were made by examining scales under a microscope. Most scales were non-preferred, making freshwater age determination difficult. Therefore, only the ocean ages will be presented in this report.

The non-salmonid catch was identified and sorted by species. Up to 30 individuals of each species of fish or squid were measured for length and the total weight of the 30 individuals was measured (Table 6). If more than 30 fish per species were caught, then the remainder of the catch for that species was weighed. A subsample of each species of fish and squid was frozen for later confirmation of species identification. Jellyfish were measured for total weight. When the by-catch was particularly numerous, a few myctophids and ctenophores were frozen for energetic studies at FRI (Table 6).

Reliability and calibration of light intensity data loggers

Light intensity data loggers were tested to determine if they could be used to quantitatively measure light intensity for possible future salmon feeding studies. The FRI was lent two data loggers, called HOBOs, manufactured by Onset Computer Corp., Pocasset, Mass. Each HOBO was equipped with a water-tight plastic housing. These data loggers are small, lightweight, and do not require any cabling, which makes them well suited for quick installation on a salmon research vessel. The *Kaiyo maru* has a fully automated meteorological system that monitors a variety of weather variables, including light intensity (Table 7). The method used to test the data loggers was to turn them on for a specified time period, attach them to a structure on the upper bridge, and after the time interval had elapsed, to compare their recorded light intensities with the measurements obtained by the ship's sensor.

Daily schedule

At each trawl station CTD and Norpac data were collected (Table 8). Often, when weather permitted, there were two trawl operations per day: one at approximately 08:00 hrs (local time) and another at 15:30 hrs. Water samples for primary production experiments were collected only in the morning.

Results and Discussion

Salmon data and samples

Copies of salmonid catch and biological data forms, and a set of acetate impressions of salmon scales were provided by FAJ, and are archived at FRI.

Trawl survey

165°E transect There were several departures from the original cruise plan (Fig. 1). Fishing operations started, as planned, at 40°30'N, 165°E on 7 February 1998, but could not be continued on 8 February 1998 due to bad weather conditions (Table 9). According to the original plan, the trawl stations were 1.5° latitude apart, but when weather was good, two stations were fished per day. After completing the first trawl operation in the morning, the vessel moved north towards the next station until 15:30 hrs, when the vessel would stop and set the trawl at whatever distance the vessel had moved to the north in the intervening 5-6 hours (Table 9).

Aleutians The original cruise plan called for oceanographic observations in the Russian 200 mile-zone, but at the last minute permission was denied to conduct observations in that zone. The United States had already granted permission for trawl and oceanographic observations in the U.S. 200-mile zone in the central Aleutians (at 180°), and during the cruise we requested the U. S. National Marine Fisheries Service to amend permission in the U.S. zone to include oceanographic and trawl operations in the western Aleutians. That permission was granted, and one trawl operation was conducted near Attu Is. (Sta. 9, Table 9).

180° transect After one day in transit (14 February 1998) from Attu Is., we arrived at Sta. 10, the northernmost trawl station (58°30'N), on 15 February 1998 (Table 9). At this station, two trawl operations were conducted. The first tow used the standard towing method, i. e., at the surface for one hour. The second tow, which immediately followed the first, was at the thermocline depth, 150-210 m. The second tow was added because the surface waters were very cold (1.62°C) and it was thought the salmon might be at or just below the thermocline were water temperature increased rapidly to 3.90°C. Fishing on 17 February was canceled because of bad weather, and on 18 and 20-22 February, bad weather prevented conducting more than one trawl per day. By mid-day on 22 February, 1998, the weather deteriorated again. Strong winds and rough sea conditions caused the vessel to slow to 2 kts, heading SSW for two days, thereby eliminating the opportunity to complete the southern-most stations, 40-43°N, along 180°, as intended in the original cruise plan (Fig. 1).

Salmon catch and distribution

The total catch of salmon was 2,381 fish: 49 sockeye (*O. nerka*; 2.1% of the total catch), 1433 chum (*O. keta*; 60.2%), 843 pink (*O. gorbuscha*; 35.4%), 24 coho (*O.*

kisutch; 1.0%), and 32 chinook (*O. tshawytscha*; 1.3%) salmon (Table 9). No steelhead (*O. mykiss*) were caught. The majority of the catch (66%) occurred at one station (St. 4), where chum and pink salmon where abundant.

Most of the salmon catch was distributed in a narrow band from 42°-45°N, in the western North Pacific Ocean (at 165°E), where sea surface temperatures (at 5 m) were 5.1°-3.9°C. In the central North Pacific Ocean (at 180°), salmon were caught between 43-46°N, where sea surface temperatures were 5.7-6.8°C (Figs. 2 and 3, Table 9).

Salmon were caught between 3.2°C and 6.7°C (Fig. 2). Chinook salmon were caught at a wide range of water temperatures, and where the only salmon caught in the coldest waters (1.6-3.0°C). Coho salmon were caught in warmer waters (5.7-6.8°C). Sockeye, chum, and pink salmon were caught at sea surface temperatures between 3.0° and 6.8°C (Fig. 2).

Sockeye salmon

165°E transect Fifty-one percent of the total sockeye salmon catch was in the western North Pacific Ocean from 42°15'N-45°00'N (n=25; Table 10). Most of these fish were ocean age .2s (88%), and a few were ocean age .1s (12%). It is likely that the young (ocean age .1) sockeye salmon caught at 165°E were of Russian (Kamchatka Peninsula) origin, and that by February these young fish have moved from Kamchatkan coastal areas to the southeast as far as 42°N, 165°E. During previous *Kaiyo maru* cruises, in November-December and January, sockeye were not caught in the western North Pacific at 157°E and 160°E (Myers, 1993, 1996, Ueno et al. 1997). As surface sea temperatures cool in the Bering Sea, Okhotsk Sea, and Aleutian Islands in December and January, young Kamchatkan sockeye salmon may move quickly offshore to the south and east in February.

Aleutians Two sockeye salmon (ocean ages .2 and .3) were caught near Attu Island (Table 10). Summaries of wintertime sockeye salmon distribution (e.g., Bakkala 1971 and French et al. 1976) do not include fishing operations as far west as Attu Island.

Sockeye salmon were not caught near Amchitka Pass (St. 14, Table 9). The location of this station was slightly north of the Pass. Previous wintertime gillnet operations suggest an abundance of sockeye salmon immediately south of the Amchitka Pass area (Bakkala 1971; French et al. 1976). Bakkala (1971) suggested that older, maturing fish tended to occupy areas of stronger water currents (for example the Alaska Stream). The rapid changes in the strength of water currents, and changes in water temperatures over short distances are likely to produce complex habitats and contribute to variable salmon catches in those areas.

180° transect in the Bering Sea Sockeye salmon were not caught in the Bering Sea (Table 10). This was an unexpected result because a previous gillnet survey in January-February 1963 caught sockeye salmon in the Bering Sea as far north as 57°28'N (French and Mason 1964; French and McAlister 1970; Bakkala 1971; and French et al. 1976). In the 1963 survey, catches of sockeye were generally small, and the sockeye salmon were slightly more abundant west of 180°, at 175°E (French and McAlister 1970, Bakkala 1971, and French et al. 1976). In this early survey, the gillnet was set in the evening and retrieved the following morning, allowing the gillnet to fish throughout the night (French and Mason 1964). During the February-March 1998 trawl survey, tows were conducted only in the morning and late afternoon (Table 9). Perhaps the behavior of sockeye salmon with respect to depth and time of day could have rendered the fish more vulnerable to capture by gillnets than the surface trawl.

Sea surface temperature anomalies in the central Bering Sea during the February-March 1998 cruise were negative, indicating that temperatures were cooler than the climatic average (see internet site, http://www.fnoc.navy.mil/otis/otis_glbl_sstanomaly.gif). The mean sea surface temperature in the central Bering Sea was 0.9°C cooler in 1998 than the value recorded during the 1963 cruise when sockeye salmon were caught in the same vicinity in the Bering Sea (Table 9; French and Mason, 1964). Perhaps the cooler than average water temperatures shifted the distribution of sockeye salmon out of the area where the *Kaiyo maru* trawl operations were conducted. If sockeye abundance in the Bering Sea in winter is low, the *Kaiyo maru* fishing effort may have been too small (four stations), and the stations too widely separated (approximately 90 nautical miles) to catch sockeye salmon. Future surveys should include more intensive sampling, east to west transects, and include sampling at all periods of the day to clarify the wintertime distribution of sockeye salmon in the Bering Sea.

<u>180° transect in the central NPO</u> Forty-three percent of the total sockeye salmon catch was in the central North Pacific Ocean (n=22; Table 10). Sockeye salmon were caught between 45°00'-49°29'N. These sockeye were a mixture of ocean ages .1 (41%), .2 (55%), and .3 (4%; Table 10.) The February 1998 catch of sockeye salmon is slightly larger than the catches in November-December 1992 and January 1996 *Kaiyo maru* cruises (Myers 1993, 1996; Ueno et al. 1997). If the major Bristol Bay stock-complex of sockeye does not reach their southernmost extent until later in the winter or early spring, as suggested by Myers (1996), then the February catches may reflect the progressive southward movement of these stocks.

Chum salmon

<u>165°E transect</u> Eighty-one percent of the total chum salmon catch was in the western North Pacific Ocean (n=1161; Table 10). Chum salmon were caught between 42°15'-47°59'N. These chum salmon were all age .1 fish (100%; Table 10). The chum salmon caught along the 160°E transect by the *Kaiyo maru* in 1996 consisted of Russian (65%) and Japanese (29%) chum stocks (Urawa and Ueno 1997). In winter, young Japanese and Russian chum salmon in their first year at sea move from their summer and fall feeding areas in the Sea of Okhotsk and Kuril Islands area into the western North Pacific Ocean (Ueno et al. 1997). By December, the chum salmon may not be far enough offshore to be caught at 157°E, however, in January they are abundant at 160°E, and in February are abundant at 165°E (Myers, 1993, 1996, Ueno et al. 1997).

<u>Aleutians</u> Two chum salmon (ocean ages .2 and .3) were caught near Attu Island (Table 10). Chum salmon were not caught near Amchitka Pass (St. 14, Table 10).

<u>180° transect in the Bering Sea</u> No chum salmon were caught in the Bering Sea (St. 10-13, Table 10). Some chum salmon have been caught in the Bering Sea in winter as by-catch in mid-water and bottom trawls in the vicinity of the shelf break (200-m contour; K. Myers, peers. comm.). Perhaps the extreme low temperature of the surface mixed layer in the basin (1.62-2.81°C) in February 1998 was too cold for chum salmon. Chum salmon are abundant in the surface waters of Bering Sea basin in summer, and they are caught in mid-water trawls in the Bering Sea during the summer B-season pollock fishery (K. Myers, pers. comm.). More intensive sampling the in the Bering Sea may clarify the wintertime distribution of chum salmon in the Bering Sea.

<u>180° transect in the central NPO</u> Nineteen percent of the total chum salmon catch was in the central North Pacific Ocean (n=270; Table 10). Chum salmon were caught between 45°54'N and our southernmost station at 43°31'N. These chum salmon were a mixture of ages .1 (8%), .2 (90%), and .3 (2%; Table 10) fish. Chum salmon have been caught in the winter in the central North Pacific Ocean from December to April (French and Mason 1964; Myers 1993, 1996; Ueno et al. 1997). By late winter, chum stocks originating from widely dispersed areas including Russia, Japan, and Alaska, and from different brood years intermingle in this area (Urawa and Ueno 1997).

Pink salmon

165°E transect Ninety-four percent of the total pink salmon catch was in the western North Pacific Ocean (n=790; Table 10). Pink salmon were caught between 42°15'-46°15'N. These pink salmon were all ocean age .1 fish, completing their first and final winter at sea (100%; Table 10). It is likely that the pink salmon in this area are Russian fish that come from Sea of Okhotsk stocks (Erokhin 1991). By December, pink salmon had not yet moved east to 157°E, however, pink salmon were abundant in January at 160°E and in February at 165°E.

Pink salmon were not caught in the Aleutian Islands (Attu Island, Amchitka Pass; St. 9 and 14) or in the Bering Sea (St. 10-13; Table 10). Gillnet operations in January and February in the Bering Sea at 175°E and 180° indicated a lack of pink salmon in surface waters of the Bering Sea (French and Mason 1964). In February, perhaps the east Kamchatka pink salmon stocks (Karaginski) are located to the west within the Russian 200-mile zone and have not yet moved easterly into the central Bering Sea basin. There may be additional data on wintertime trawling operations in 1995 by researchers of TINRO-centre aboard the *Professor Levanidov*, which conducted trawl operations through the winter of 1995. However, it is unclear if the TINRO survey included operations in the Bering Sea (Mackas et al. 1997).

180° transect in the central NPO Six percent of the total pink salmon catch was in the central North Pacific Ocean (n=53; Table 10). Pink salmon were abundant in the central North Pacific Ocean catches in November-December and January *Kaiyo maru* cruises (Myers 1993, 1996). Pink salmon were caught between 45°54'N and our southernmost station at 43°31'N, at the same locations as chum salmon. This is somewhat further south than the distribution of pink salmon in January 1996 (46°-48°N; Myers 1996).

Coho salmon

Coho salmon were not caught in the western North Pacific Ocean at 165°E, in the Aleutian Islands area, or in the Bering Sea during this cruise (Table 10). In November-December 1992 *Kaiyo maru* cruise, six coho salmon were caught in the western North Pacific Ocean (at 168°E), however, no coho salmon were caught in this area during the January 1996 cruise (Myers 1993, 1996).

180° transect in the central NPO All the coho salmon caught during this cruise were caught in the central North Pacific Ocean (n=24; Table 10). Like pink salmon, coho were completing their first and final winter at sea. These coho were caught from 45°54'N to the southernmost station at 43°31'N. The location of these catches is further south than was observed in December (46°-48°N) and January (46°-50°N) in the central North Pacific (Myers 1993, 1996).

Chinook salmon

Although their abundance was relatively low in all regions, chinook salmon was the only salmon species caught in each of the four regions investigated.

165°E transect Thirty-four percent of the total chinook salmon catch was in the western North Pacific Ocean (n=11; Table 10). Chinook salmon were caught between 42°15'-46°15'N. These chinook salmon were all age .1 fish (100%; Table 10). These fish probably originated in Kamchatka, and if they are migrating to the east in the North Pacific, then by December they were not as far as east as 157°E (Myers 1993, 1996). However, in January young chinook salmon were relatively abundant at 160°E (Myers 1996). Our catches indicate movement as far east as 165°E in February.

Aleutians One chinook salmon was caught near Attu Island. This fish was ocean age .1 (St. 9, Table 10). It is likely that this chinook salmon originated in Kamchatka and perhaps some of these stocks spend the winter in the western Aleutian Islands area, and the Bering Sea. Wintertime salmon cruises in this area in the Russian 200-mile zone would help to clarify this information. Chinook salmon were not caught near Amchitka Pass (St. 14, Table 10).

180° transect in the Bering Sea Chinook was the only salmon species caught in the Bering Sea. Thirty-four percent of the total chinook salmon catch was caught at these stations, and they were a mixture of ocean age .1 (83%) and ocean age .2 (17%). Although previous winter salmon surveys did not catch any chinook salmon in the Bering Sea (French and Mason 1964), they are a by-catch in commercial groundfish trawl operations in the eastern Bering Sea in winter (K. Myers, pers. comm.). The depths where chinook salmon are caught may vary seasonally because in coastal areas chinook move into deeper waters in the winter (Erickson and Pikitch 1994). Salmon may find a warmer water refuge and better feeding conditions at depth near the shelf break. We did not conduct trawl operations on the shelf break at Bower or Petrel Bank, although we were in the area. Sampling within the Russian and U.S. 200-mile zone in the wintertime, east to west transects, trawling along the shelf break and at various depths would be useful to determine the wintertime chinook distribution in the Bering Sea.

180° transect in the central NPO Twenty-five percent of the total chinook salmon catch was caught in the North Pacific Ocean (n=8; Table 10). Chinook salmon were caught between 45°00'N and 49°29'N, but were not abundant. These chinook were a mixture of ages .1 (63%), .2 (25%), and .3 (12%; Table 10) fish. Chinook salmon were not abundant in the central North Pacific Ocean in December or January cruises of the *Kaiyo maru* (Myers, 1993, 1996; Nagasawa et al. 1994; Ueno et al. 1997).

Blood plasma for growth studies

Blood was collected from a total of 134 salmon, of which 39 chum salmon samples were collected for researchers at Hokkaido University and 20 sockeye, 30 chum, 27 pink, 18 coho, and 26 chinook salmon samples were collected for FRI (Table 11).

Non-salmonid catch

The non-salmonid catch included fish, squid, and jellyfish (Table 12). Myctophids were tentatively identified as *Tarletonbeania taylori*, *Diaphus theta*, and *Stenobrachius leucopsarus*. Other fishes included three-spine sticklebacks, *Gasterosteus aculeatus* , the prowfish, *Zaprora silenus*, and the lumpfish, *Aptocyclus ventricosus*. In addition, larval forms of leptocephalus and Stichaeidae were caught. The squids were tentatively identified as *Gonotopsis borealis*, *Berryteuthis anonychus*, *Gonatus middendorfii*, *Moroteuthis robustus*, and unidentified Gonatidae. Jellyfish was not identified because of damage by the trawl. No marine mammals or birds were caught by the trawl during the survey.

Reliability and calibration of light intensity data loggers

The HOBO data loggers were found to be unreliable. In four attempts to have them record continuously outside in the weather on the upper deck for periods of 30 hrs to 6 days, only once did one HOBO record light intensities for the full period for which it was set (i. e., 2 days). These failures may be fixed by replacing the batteries. The manufacturer states in their manual that the battery might last two years, but they should be replaced yearly. These HOBOs were purchased two months before this experiment, and no extra batteries were brought on this cruise. In a phone conversation with the manufacturer, they have suggested installing new batteries to determine if the reliability problem can be solved easily. If replacement of the batteries does not make the HOBOs operational, then the loggers will have to returned to Onset Computer Corp. for testing, repair, or possible replacement.

A scatterplot with the light intensities recorded by the HOBO and the ship's light sensor were plotted to compare the relative sensitivities of the two sensors (Fig. 4). Results indicate the HOBO is more sensitive than the ship's sensor at low light levels, and that the ship's sensor is more sensitive than the HOBO at high light levels. The light measuring capabilities of the HOBO would be satisfactory for use in recording ambient high-seas light levels for salmon feeding experiments, however, the failure of two data loggers to perform reliably makes them unsuitable for field work if the source of the problem is not corrected.

Acknowledgments

I thank Captain K. Yamanaka, and the officers and crew of the *Kaiyo maru* for their hard work and kind help during this cruise. I thank Y. Ishida, Y. Ueno, A. Shiomoto, and M. Koval for their help in collecting samples and for providing scientific cooperation and discussions throughout this cruise. Y. Ishida, K. Nagasawa, K. Todokoro, and Y. Ueno were helpful in organizing samples for shipment from Japan, and I appreciated their hospitality in Shimizu. I appreciate the suggestions of K. W. Myers, (FRI) for improvement of this report. Funding for the U.S. portion of this work was provided by the Auke Bay Laboratory, Alaska Fisheries Science Center, U.S. National Marine Fisheries Service (NOAA Contract No. 50ABNF700003).

References

Bakkala, R. G. 1971. Distribution and migration of immature sockeye salmon. Int. N. Pac. Fish. Comm. Bull. 27:1-70.

Erickson, D. L., and E. K. Pikitch. 1994. Incidental catch of chinook salmon in commercial bottom trawls off the U.S. west coast. N. Amer. J. Fish. Manage. 14:550-563.

Erokhin, V. G. 1991. Distribution and biological composition of pink salmon, *O. gorbuscha*, in the ocean. J. of Ichthyol. 31:138-145.

Fisheries Agency of Japan. 1997. Research plan of the *Kaiyo maru* cruise in 1998 (February 3-March 4, 1998); survey on overwintering salmonids in the North Pacific Ocean. Tokyo, Japan. 14 p.

Fisheries Agency of Japan. 1998. Preliminary report of the February 1998 *Kaiyo maru* cruise (February 3-March 4, 1998); survey on overwintering salmonids in the North Pacific Ocean. 101 p. (Shipboard summary report , in Japanese).

French, R., H. Bilton, M. Osako, and A. Hartt. 1976. Offshore distribution and origin of sockeye salmon (*Oncorhynchus nerka*) in offshore waters of the North Pacific Ocean. Int. N. Pac. Fish. Comm. Bull. 34:1-113.

French, R., and J. E. Mason. 1964. Salmon distribution and abundance on the high seas-winter season 1962 and 1963. *In* Report on the investigations by the United States for the INPFC-1963. Annual Report 1963. Int. N. Pac. Fish. Comm., Vancouver, pp. 131-141.

French, R. R., and W. B. McAlister. 1970. Winter distribution of salmon in relation to currents and water masses in the Northeastern Pacific Ocean and migrations of sockeye salmon. Trans. Amer. Fish. Soc. 99:649-663.

Mackas D., Y. Ueno, V. Karpenko, and N. D. Davis. 1997. Ocean salmon survey methods, 1995-1997. N. Pac. Anadr. Fish. Comm. Doc. 256. 37 p.

Motoda, S. 1994. [Devices of simple plankton apparatus VIII.] Bulletin of Plankton Society of Japan 40(2):139-150. (In Japanese with English summary.)

Myers, K. W. 1993. Japan, U.S.A., and Canada cooperative survey on overwintering salmonids in the North Pacific Ocean: *Kaiyo maru*, cruise report 25 November-24 December 1992. FRI-UW-9301. Fisheries Research Institute, Univ. Washington, Seattle. 15 p. + appendices.

Myers, K. W. 1996. Survey on overwintering salmonids in the North Pacific Ocean: *Kaiyo maru*, 5 January-29 January 1996. FRI-UW-9607. Fisheries Research Institute, Univ. Washington, Seattle. 31 p. + appendices.

Myers, K. W., N. D. Davis, W. W. Dickhoff, and S. Urawa. 1998. Blood plasma levels of insulin-like growth factor-I in Pacific salmon in offshore waters in winter. N. Pac. Anadr. Fish. Comm. Bull 1:129-137.

Myers, K. W., and S. Urawa. 1997. Report on blood plasma levels of insulin-like growth factor-1 in Pacific salmon caught during the January 1996 *Kaiyo maru* cruise. Salmon Report Series 43:115-118.

Nagasawa, K., Y. Ueno, K. W. Myers, and D. W. Welch. 1994. Japan-U.S.-Canada cooperative survey on overwintering salmonids in the North Pacific Ocean aboard the Japanese research vessel *Kaiyo maru*, November 25 to December 24, 1992. Salmon Rep. Ser. 37:109-133.

Sato, A., M. Fukaya, K. Orito, Y. Ishida, M. Kaeriyama, S. Urawa, K. W. Myers, and H. Ueda. 1997. Serum steroid hormone profiles of 5 species of Pacific salmon during overwintering in the North Pacific Ocean. Salmon Report Series 43:105-114.

Ueno, Y., Y. Ishida, K. Nagasawa, and T. Watanabe. 1997. Winter distribution of Pacific salmon. Salmon Report Series 43:41-60. (In Japanese with English summary.)

Urawa, S., and Y. Ueno. 1997. Genetic stock identification of chum salmon (*Oncorhynchus keta*) in the North Pacific Ocean in the winter of 1996. Salmon Report Series 43:97-103.

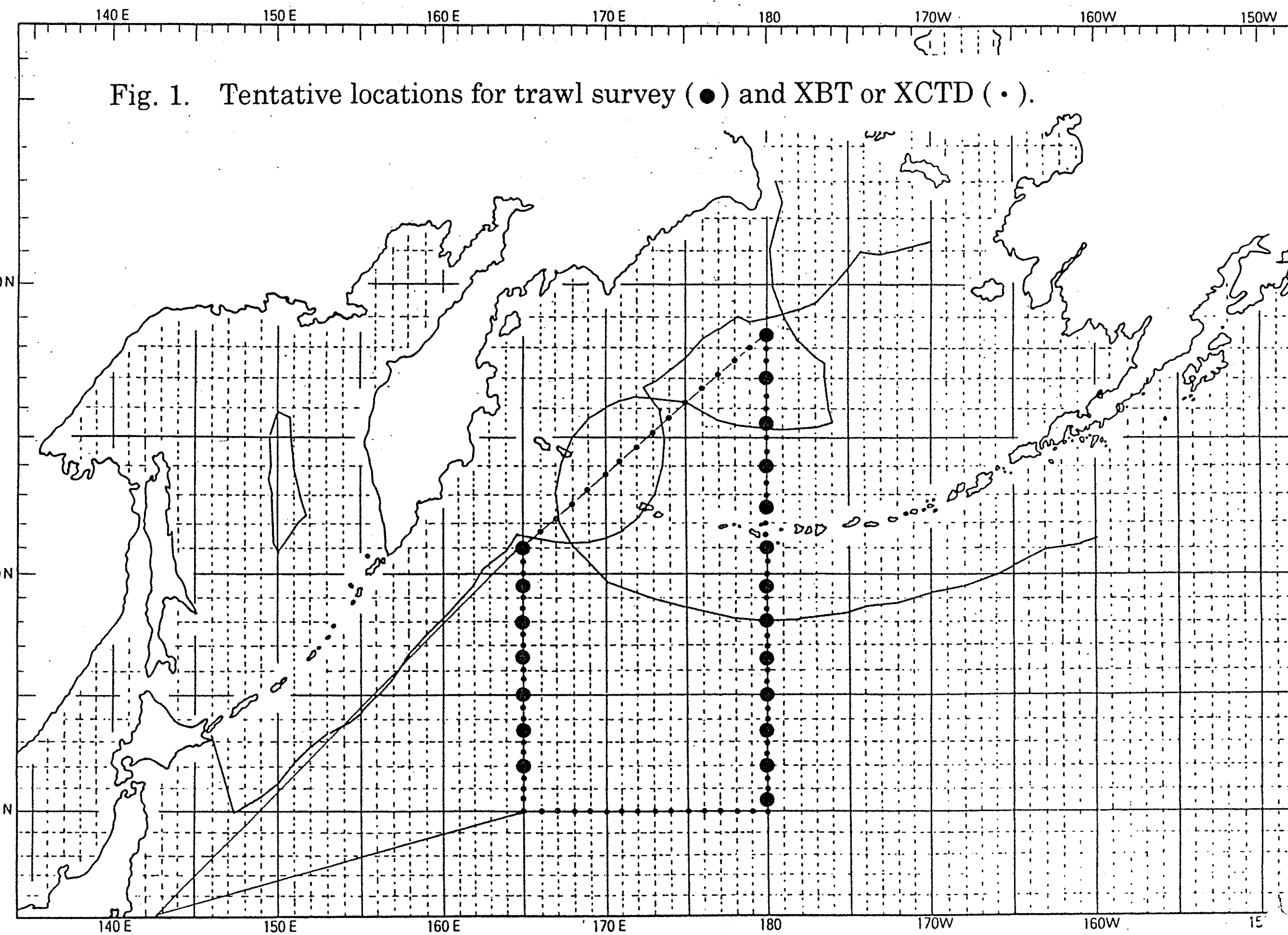

Figure 1. Planned location of trawl and CTD stations for the salmon cruise of the *Kaiyo maru*, February-March 1998 (Fisheries Agency of Japan 1997).

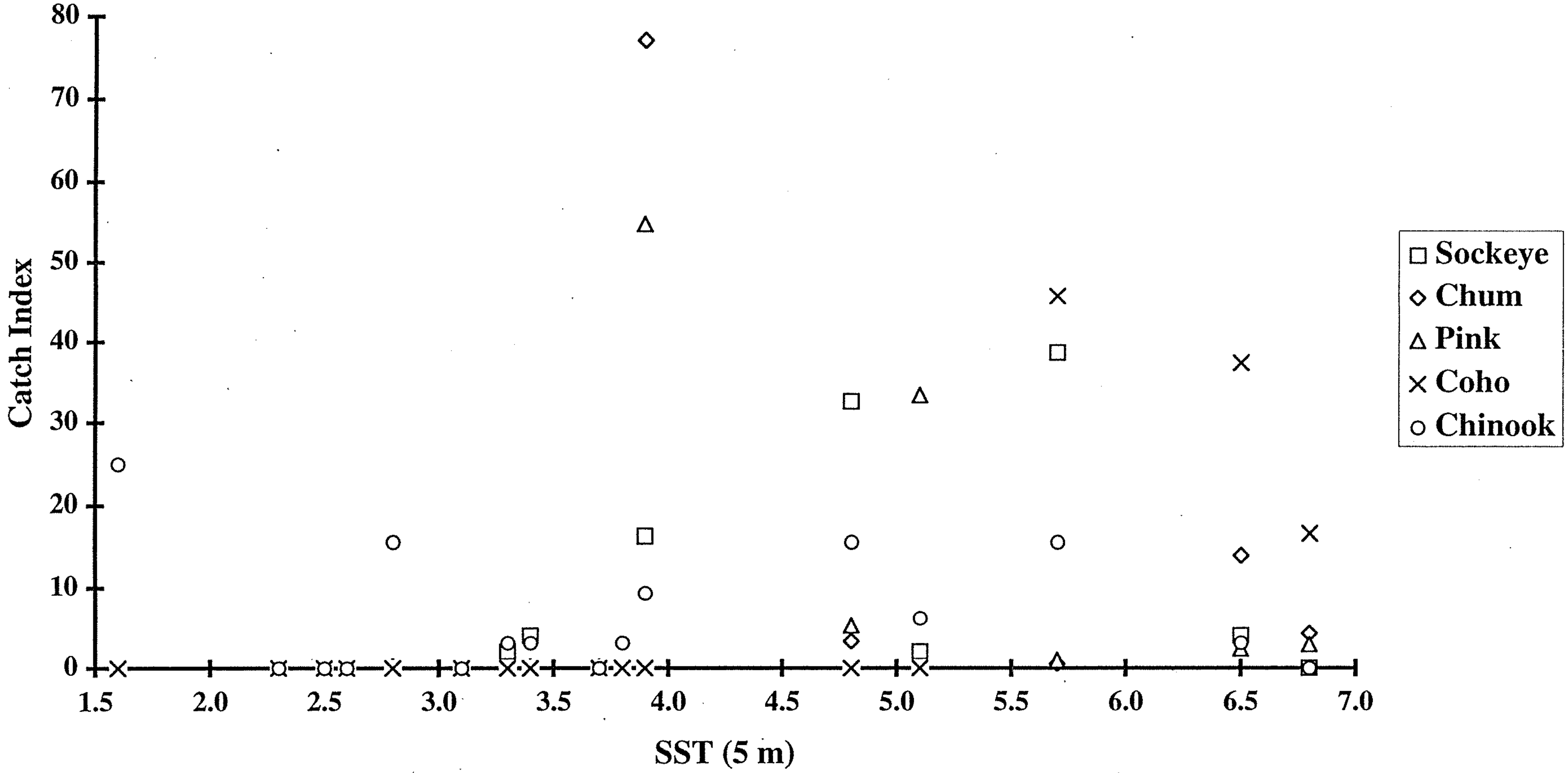

Figure 2. Scatterplot of the sea surface temperatures (at 5 m depth) and salmon catch by the *Kaiyo maru*, February-March 1998. The catch index is the percentage of the total catch of each species that occurred at a particular temperature.

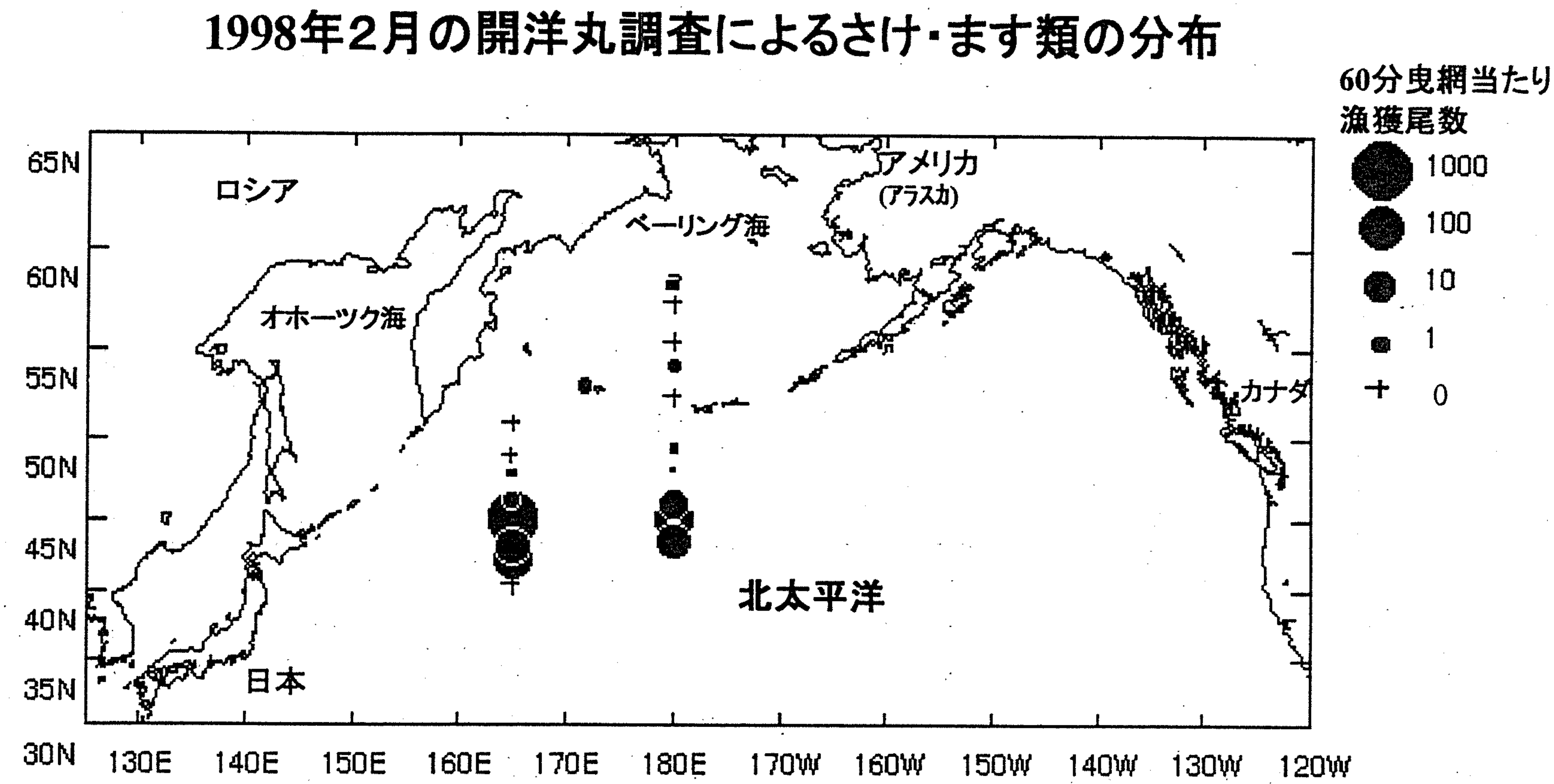

Figure 3. Total salmon catch distribution (number of fish) at trawl stations sampled by the *Kaiyo maru* in February 1998. The cross indicates a trawl location and no catch (Fisheries Agency of Japan 1998).

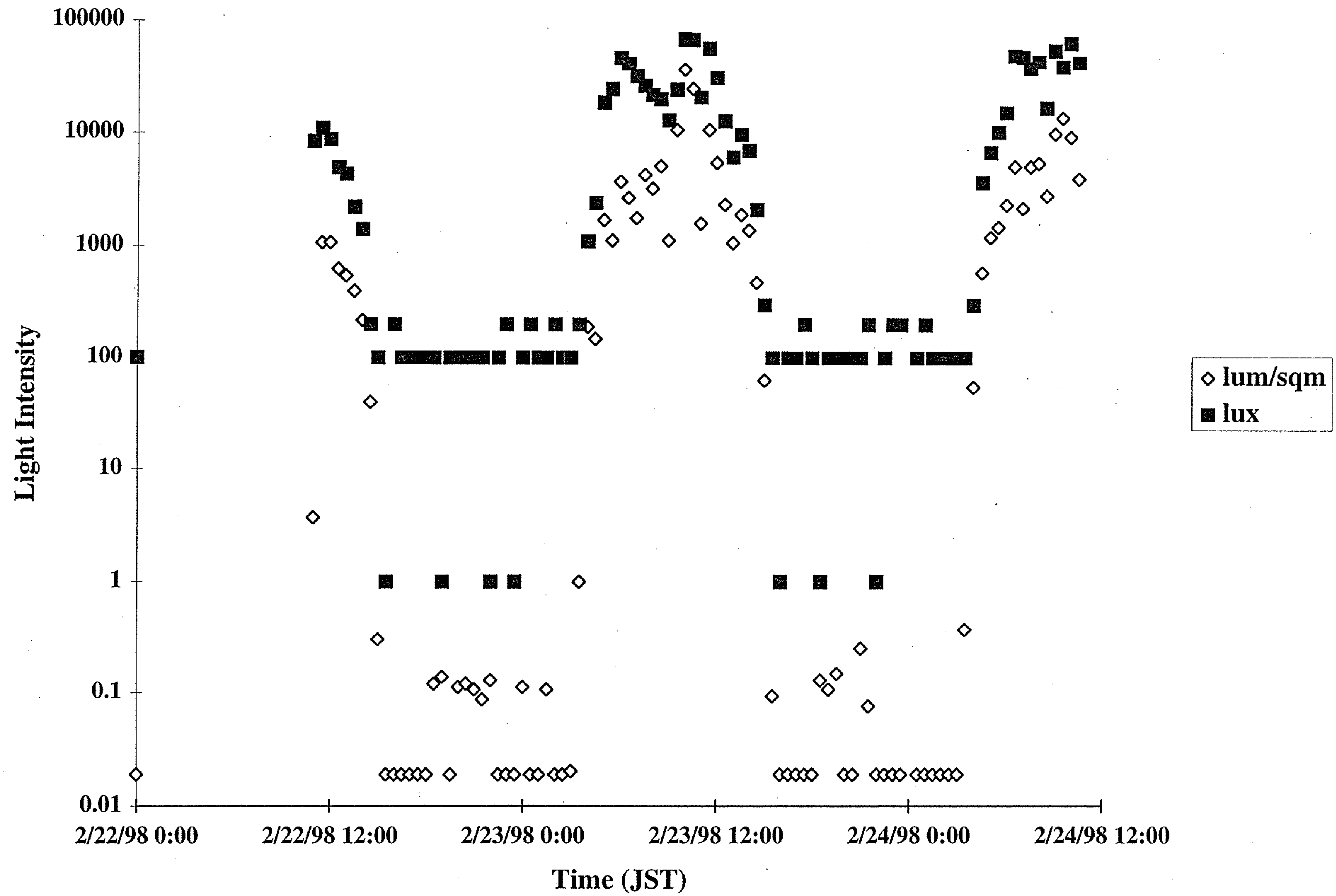

Figure 4. Scatterplot of the light intensities recorded by the radiometer (lux) onboard the *Kaiyo maru* and the intensities recorded by the HOBO data logger (Onset Corp; lumen/m^2) for 22-24 February 1998.

Table 1. Description of the *Kaiyo maru*, geographical area of operation, and research objectives for the overwintering salmon survey, February-March 1998.

Item	February-March 1998 Cruise
Ship name	*R/V Kaiyo maru*
Signal letters	JNZL
Gross tonnage	2,630 t 2,942 t (international)
Year built	1991 (date of delivery)
Ship type	93-m stern trawler
Ship owner	Fisheries Agency of Japan Ministry of Agriculture, Forestry, and Fisheries
Ship's complement	Captain and crew: 47 Scientists: 10
Survey area	2 transects: at 165°E: 40°30'-51°00'N; at 180°: 40°30'-58°30'N; one additional trawl station near Attu Is. (53°01'N, 171°42'E) added when moving northeast between 165°E and 180°
Ship's schedule	Feb. 3, 1998: depart Tokyo Port (Harumi Pier) 10:00 hrs Feb. 7-12: oceanographic observations and salmon trawling at 40°30'-51°00'N, 165°E (WNPO) Feb. 13: oceanographic observations and one trawl operation in the western Aleutians near Attu Is. Feb. 15-16: oceanographic observations and salmon trawling at 58°30'-54°09'N, 180°00' (BS) Feb. 18: oceanographic observations and one trawl operation in the central Aleutians near Amchitka Pass Feb. 19-22: oceanographic observations and salmon trawling at 49°29'-43°31'N, 180°00' (CNPO) Mar. 2: arrival in Shimizu Port, Japan, 09:00 hrs
Research objectives	Third in a cruise series (Dec. 1992, Jan. 1996, Feb. 1998) concerned with overwintering of salmon on the high-seas. Specific objectives: (1) determine if salmon distribution in February is limited to a narrow area with low sea surface temperature, as was observed in the previous December (1992), and January (1996) cruises; (2) clarify if shortage of food and severe ocean conditions in winter cause reduced growth and mortality; (3) determine the levels of primary production and salmon prey organisms in wintertime salmon habitats

Table 2. Researchers on board the *Kaiyo maru* during the overwintering salmon survey, February-March 1998.

Name	**Affiliation**	**Ship-board Task**
Yukimasa Ishida	National Research Institute of Far Seas Fisheries (Salmon Section), Japan	Chief scientist, general management
Yasuhiro Ueno	National Research Institute of Far Seas Fisheries (Salmon Section), Japan	Salmon research
Akihiro Shiomoto	National Research Institute of Far Seas Fisheries (Biological Oceanography), Japan	Primary production
Tomowo Watanabe	National Research Institute of Far Seas Fisheries (Physical Oceanography), Japan	Physical oceanography
Tomonori Azumaya	National Research Institute of Far Seas Fisheries (Post-Doc, Salmon Section), Japan	Physical oceanography
Maxim V. Koval	Kamchatka Research Institute of Fisheries and Oceanography (KamchatNIRO), Russia	Zooplankton and salmon ecology
Nancy D. Davis	Fisheries Research Institute, University of Washington, USA	Salmon biology
Takao Murata	Hokkaido University (graduate student, oceanography), Japan	Primary production
Yoshiko Shibukawa	Tokai University (undergraduate student, biology), Shimizu, Japan	Salmon biology
Yumiko Shimizu	Tokai University (undergraduate student, biology), Shimizu, Japan	Salmon biology

Table 3. Description of hydrographic sampling during the *Kaiyo maru* overwintering salmon survey, February-March 1998.

Item	**February-March 1998 Cruise**
Instrument type	Deep Sea CTD octopus: temperature, salinity, depth, DO, and chlorophyll-a measured at 0-1500 m. Accuracy: 0.002 °C temperature, 0.003 S/m conductivity, ±0.015% FS. Bucket sample for 0 m; rosette sampling (2.5 liter Niskin bottles) for 10, 20, 30, 50, 75, 100, 125, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500 m water samples; in stormy conditions XCTD and XBT were used (0-750 m; Tsurumi-Seiki Co., Yokohama).
Water analysis	Salinity confirmation by auto-salinometer analysis; DO measurements by titration method NO_2+NO_3, PO_4, SiO_2, by Auto-Analyzer II (within 24 hrs); chlorophyll-a (0-300 m) by fluorometric analysis (within 24 hrs)
Sub-surface current velocities	ADCP (acoustic doppler current profiler) frequency: 75 kHz, maximum measurement depth: 800 m

Table 4. Description of the phytoplankton sampling during the *Kaiyo maru* overwintering salmon survey, February-March 1998.

Item	**February-March 1998 Cruise**
Primary production (experiment at 165°E)	A quantum and depth sensor was lowered at 5-m intervals to determine the 100% (surface), 30%, 10%, and 1% light-level depths, and water samples were collected at these depths. A surface water sample was collected using a bucket. A (30-l) Go-Flo water sampler used to collect water at the 30%, 10%, 1% light-level depths. The 100%, 30%, 10%, and 1% light-level depth samples were put into (1-l) polycarbonite bottles into which ^{13}C-$NaHCO_3$ was added, and incubated in one black bottle (respiration) and two light bottles (photosynthesis). Bottles were incubated on deck in a water bath for about 6 hrs. After incubation, the water was filtered and frozen at -80°C until later analysis in a laboratory by mass spectrophotometry. Various phytoplankton pigments were measured (chlorophyll-a, -b, -c, etc.) from 0, 10, 30, 50, 100, and 200-m water depths. These water samples were filtered and frozen for later analysis.
Primary production (experiment at 180°)	To determine if production by smaller-size phytoplankton was affected more by low water temperature than larger-size phytoplankton, surface water samples were separated into three phytoplankton size groups (< 2 μm, 2-10 μm, and 10-200 μm) and incubated at two temperatures (low ambient temperature, 3-6°C, and high temperature, 27°C). The incubation method was the same as above, except the experiments were conducted inside under controlled conditions of light and water temperature. The incubation experiment was conducted for 3-4 hours.
Continuous monitoring	EPSC (electronic plankton counting and sizing system); time, latitude, longitude, surface water temp, salinity, DO, fluorescence (chlorophyll-a) and plankton count (particles; ppm), and flow (liter/min), monitored every min

Table 5. Description of zooplankton sampling during the *Kaiyo maru* overwintering salmon survey, February-March 1998.

Item	**February-March 1998 Cruise**
Zooplankton	Remodeled Norpac (Motoda 1994) GG54 filtering cloth, 0.315 mm mesh size with attached flow meter; vertical tow 0-150 m sample preserved in 10% formalin (seawater)
Continuous monitoring	EPCS (electronic plankton counting and sizing system). See Table 4.

Table 6. Description of the salmon sampling methods on board the *Kaiyo maru* during the overwintering salmon survey, February-March 1998.

Item	**February-March 1998 Cruise**
Gear type	Mid-water spider net trawl; catches juvenile, immature, and maturing salmon
Gear description	Net length=222 m overall including a 20-m codend; headrope=63 m; footrope=63 m; warp=approx. 400 m; 9-m^2 doors each weighing 1450 kg; typically fished with approx. 50-m vertical opening and 70-m horizontal opening
Codend mesh size	Codend outer mesh=95 mm; codend liner mesh=13 mm
Usual setting time	Day time (0800 and 1530)
Usual set duration	1 hr
Towing speed	5.8 kts
Usual towing or setting depth	0-50 m except at St 10 where there was also one tow at the thermocline (150-210 m)
Number of stations	19
Variables measured on salmon (ship-board)	Sorted to species; up to 60 fish/species were measured for fork length (FL) and body weight (BW), a scale sample collected, and each fish individually labeled. Blood was collected from a subsample of each species, centrifuged at 3000 rpm for 15 min and the serum frozen at -80°C. Salmon were frozen in the round at -40°C. If > 60 fish/species were caught, the fish were counted and weighed. A sample of 2 chum and 2 pink salmon were frozen in the round for energetic studies at FRI.
Variables measured on salmon (at Shimizu)	Liver wt (energetic studies), sex, gonad weight, stomach contents (weight and identification into categories as % volume), otoliths (age and growth), heart, muscle, liver (GSI), and parasites (stock ID).
Handling of non-salmonid catch	Identified and sorted by species; up to 30 fish or squid/species measured for length (SL or ML) and the total weight of the 30 individuals measured. If more than 30 fish/species was caught, then the rest was weighed. A subsample was labeled and frozen for later confirmation of species identification. Total weight was measured for jellyfish. A small sample of myctophids and ctenophores were frozen for energetic studies at FRI.

Table 7. Description of other conditions monitored on board the *Kaiyo maru* during the overwintering salmon survey, February-March 1998.

Item	February-March 1998 Cruise
Meteorology	Fully automated meteorological equipment collects data on time, latitude, longitude (GPS), average and maximum wind speed and direction (every 10 min), air temperature, humidity, dew point, air pressure, light intensity (radiometer; in lux), water temperature and wave height. Every 10 min., output is recorded on paper and diskette

Table 8. Description of a typical day's schedule when weather conditions permitted visiting two stations and making two trawl operations in one day. Some research operations were done simultaneously with others. This example is 9 February 1998, stations 2 and 3.

Time	Item
05:45	researchers meet for stand-by and update
05:57-07:19	CTD and rosette
06:04	Sunrise
06:12-06:15	XCTD
06:24-06:35	Norpac net
06:59-07:08	shallow water quantum and depth measurement
06:38-07:34	Go-Flo water collection
07:49-09:59	setting, towing, and retrieval of trawl
10:00-15:25	transit to station 3
15:27-15:29	XBT
15:31-17:32	setting, towing, retrieval of trawl
16:23	Sunset
17:49-19:02	CTD
18:00-18:06	XCTD
18:07-18:17	Norpac net

Table 9. Catch of salmon in numbers by station, date, location, water temperature and salinity, and species. Thermocline depth estimated from CTD data. Trawl start time is the local time when the crew began to set the net and the trawl end time is the time when the crew completed retrieval of the net onto the deck. Trawl tow duration is hour. LT=local time, sock=sockeye, chin=chinook, and sthd=steelhead.

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

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

Table 10. Salmon ocean age composition by region, including physical characteristics for those stations were salmon were caught, *Kaiyo maru*, February-March 1998.

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

Table 11. List of salmon blood samples collected during the *Kaiyo maru* overwintering salmon survey, February-March 1998, for measurement of insulin-like growth factor-1. N=121.

Sample No.	Sheet No. (Fish No.)	Species	Date of catch	Latitude	Longitude	Ocean Age	F L (mm)	B W (g)
S-01	3 (5)	sockeye	Feb 9-98	42°15N	165°00E	2	394	700
S-02	4 (1)	sockeye	Feb 9-98	43°08N	164°59E	2	394	680
S-03	4 (11)	sockeye	Feb 9-98	43°08N	164°59E	2	404	700
S-04	14 (1)	sockeye	Feb 10-98	45°00N	165°00E	2	406	915
S-05	14 (2)	sockeye	Feb 10-98	45°00N	165°00E	2	367	500
S-06	14 (7)	sockeye	Feb 10-98	45°00N	165°00E	1	251	150
S-07	14 (8)	sockeye	Feb 10-98	45°00N	165°00E	1	241	155
S-08*	17 (1)	sockeye	Feb 13-98	53°01N	171°42E	3	530	1740
S-09	17 (2)	sockeye	Feb 13-98	53°01N	171°42E	2	382	580
S-10	21 (1)	sockeye	Feb 19-98	49°29N	179°59W	3	545	1840
S-11	23 (1)	sockeye	Feb 20-98	45°54N	179°56W	1	304	295
S-12	23 (2)	sockeye	Feb 20-98	45°54N	179°56W	1	306	280
S-13	23 (4)	sockeye	Feb 20-98	45°54N	179°56W	1	304	290
S-14	23 (6)	sockeye	Feb 20-98	45°54N	179°56W	1	280	225
S-15	23 (13)	sockeye	Feb 20-98	45°54N	179°56W	2	374	590
S-16	23 (15)	sockeye	Feb 20-98	45°54N	179°56W	2	376	600
S-17	23 (18)	sockeye	Feb 20-98	45°54N	179°56W	2	430	800
S-18	23 (19)	sockeye	Feb 20-98	45°54N	179°56W	2	464	1090
S-19	32 (1)	sockeye	Feb 21-98	45°00N	179°58W	1	344	460
S-20	32 (2)	sockeye	Feb 21-98	45°00N	179°58W	1	359	480
Ch-01 to Ch-04 no sample								
Ch-05	5 (15)	chum	Feb 9-98	43°08N	164°59E	1	266	175
Ch-06	5 (22)	chum	Feb 9-98	43°08N	164°59E	1	262	185
Ch-07 no sample								
Ch-08	12 (15)	chum	Feb 10-98	45°00N	165°00E	1	246	155
Ch-09 no sample								
Ch-10	12 (29)	chum	Feb 10-98	45°00N	165°00E	1	244	145
Ch-11	14 (10)	chum	Feb 10-98	45°00N	165°00E	2	389	590
Ch-12	14 (11)	chum	Feb 10-98	45°00N	165°00E	2	384	570
Ch-13	15 (1)	chum	Feb 10-98	46°15N	165°00E	2	448	800
Ch-14	15 (2)	chum	Feb 10-98	46°15N	165°00E	2	476	1060
Ch-15 no sample								
Ch-16	16 (1)	chum	Feb 11-98	47°59N	164°59E	3	498	1380
Ch-17	16 (2)	chum	Feb 11-98	47°59N	164°59E	3	446	1020
Ch-18	17 (3)	chum	Feb 13-98	53°01N	171°42E	2	360	480
Ch-19	17 (4)	chum	Feb 13-98	53°01N	171°42E	3	438	820
Ch-20 no sample								
Ch-21	24 (2)	chum	Feb 20-98	45°54N	179°56W	2	351	390
Ch-22	24 (3)	chum	Feb 20-98	45°54N	179°56W	2	364	510

Table 11. Continued.

Sample No.	Sheet No. (Fish No.)	Species	Date of catch	Latitude	Longitude	Ocean Age	F L (mm)	B W (g)
Ch-23 to Ch-24 no sample								
Ch-25	28 (1)	chum	Feb 21-98	45°00N	179°58W	2	360	460
Ch-26	28 (2)	chum	Feb 21-98	45°00N	179°58W	2	350	430
Ch-27	28 (5)	chum	Feb 21-98	45°00N	179°58W	2	358	480
Ch-28	28 (6)	chum	Feb 21-98	45°00N	179°58W	2	370	500
Ch-29	28 (7)	chum	Feb 21-98	45°00N	179°58W	2	342	400
Ch-30 no sample								
Ch-31	28 (13)	chum	Feb 21-98	45°00N	179°58W	2	386	500
Ch-32	28 (15)	chum	Feb 21-98	45°00N	179°58W	2	382	590
Ch-33	28 (19)	chum	Feb 21-98	45°00N	179°58W	2	394	570
Ch-34	28 (20)	chum	Feb 21-98	45°00N	179°58W	2	262	180
Ch-35	no sample							
Ch-36	33 (3)	chum	Feb 22-98	43°31N	180°00	2	364	420
Ch-37	33 (9)	chum	Feb 22-98	43°31N	180°00	2	410	620
Ch-38	33 (23)	chum	Feb 22-98	43°31N	180°00	3	450	820
Ch-39	33 (26)	chum	Feb 22-98	43°31N	180°00	2	452	840
Ch-40	34 (2)	chum	Feb 22-98	43°31N	180°00	2	380	500
Ch-41 no sample								
Ch-42	34 (14)	chum	Feb 22-98	43°31N	180°00	3	470	1120
Ch-43	34 (24)	chum	Feb 22-98	43°31N	180°00	2	364	485
P-01	1 (1)	pink	Feb 9-98	42°15N	165°00E	1	278	185
P-02	2 (14)	pink	Feb 9-98	42°15N	165°00E	1	300	230
P-03	7 (1)	pink	Feb 9-98	43°08N	164°59E	1	296	265
P-04	7 (7)	pink	Feb 9-98	43°08N	164°59E	1	306	270
P-05	10 (1)	pink	Feb 10-98	45°00N	165°00E	1	306	265
P-06	10 (7)	pink	Feb 10-98	45°00N	165°00E	1	284	196
P-07	15 (5)	pink	Feb 10-98	46°15N	165°00E	1	314	280
P-08	25 (1)	pink	Feb 20-98	45°54N	179°56W	1	271	185
P-09	25 (2)	pink	Feb 20-98	45°54N	179°56W	1	260	150
P-10	25 (3)	pink	Feb 20-98	45°54N	179°56W	1	278	200
P-11	25 (7)	pink	Feb 20-98	45°54N	179°56W	1	328	290
P-12	25 (8)	pink	Feb 20-98	45°54N	179°56W	1	322	305
P-13	31 (1)	pink	Feb 21-98	45°00N	179°58W	1	279	170
P-14	31 (2)	pink	Feb 21-98	45°00N	179°58W	1	269	175
P-15	31 (3)	pink	Feb 21-98	45°00N	179°58W	1	300	250
P-16	31 (4)	pink	Feb 21-98	45°00N	179°58W	1	284	210
P-17	31 (5)	pink	Feb 21-98	45°00N	179°58W	1	279	188
P-18	31 (6)	pink	Feb 21-98	45°00N	179°58W	1	310	220
P-19	31 (7)	pink	Feb 21-98	45°00N	179°58W	1	276	195
P-20	31 (8)	pink	Feb 21-98	45°00N	179°58W	1	290	220
P-21	no sample							

Table 11. Continued.

Sample No.	Sheet No. (Fish No.)	Species	Date of catch	Latitude	Longitude	Ocean Age	F L (mm)	B W (g)
P-22	36 (9)	pink	Feb 22-98	43°31N	180°00	1	322	320
P-23	36 (10)	pink	Feb 22-98	43°31N	180°00	1	280	205
P-24	36 (15)	pink	Feb 22-98	43°31N	180°00	1	301	250
P-25	36 (16)	pink	Feb 22-98	43°31N	180°00	1	238	105
P-26	36 (17)	pink	Feb 22-98	43°31N	180°00	1	291	200
P-27	36 (27)	pink	Feb 22-98	43°31N	180°00	1	314	275
P-28	36 (28)	pink	Feb 22-98	43°31N	180°00	1	310	275
Co-01	26 (1)	coho	Feb 20-98	45°54N	179°56W	1	334	440
Co-02	26 (2)	coho	Feb 20-98	45°54N	179°56W	1	312	393
Co-03	26 (3)	coho	Feb 20-98	45°54N	179°56W	1	339	479
Co-04	26 (4)	coho	Feb 20-98	45°54N	179°56W	1	324	440
Co-05	26 (5)	coho	Feb 20-98	45°54N	179°56W	1	339	465
Co-06	26 (7)	coho	Feb 20-98	45°54N	179°56W	1	346	500
Co-07	32 (3)	coho	Feb 21-98	45°00N	179°58W	1	306	340
Co-08	32 (4)	coho	Feb 21-98	45°00N	179°58W	1	312	340
Co-09	32 (5)	coho	Feb 21-98	45°00N	179°58W	1	342	446
Co-10	32 (6)	coho	Feb 21-98	45°00N	179°58W	1	308	330
Co-11	32 (7)	coho	Feb 21-98	45°00N	179°58W	1	350	500
Co-12	32 (8)	coho	Feb 21-98	45°00N	179°58W	1	327	390
Co-13	32 (9)	coho	Feb 21-98	45°00N	179°58W	1	306	320
Co-14	32 (10)	coho	Feb 21-98	45°00N	179°58W	1	343	480
Co-15	36 (1)	coho	Feb 22-98	43°31N	180°00	1	324	370
Co-16	36 (2)	coho	Feb 22-98	43°31N	180°00	1	327	425
Co-17	36 (3)	coho	Feb 22-98	43°31N	180°00	1	374	660
Co-18	36 (4)	coho	Feb 22-98	43°31N	180°00	1	347	450
K-01	3 (3)	chinook	Feb 9-98	42°15N	165°00E	1	312	390
K-02	9 (1)	chinook	Feb 9-98	43°08N	164°59E	1	292	305
K-03	9 (5)	chinook	Feb 9-98	43°08N	164°59E	1	312	370
K-04	14 (12)	chinook	Feb 10-98	45°00N	165°00E	1	272	255
K-05	14 (13)	chinook	Feb 10-98	45°00N	165°00E	1	268	258
K-06	15 (4)	chinook	Feb 10-98	46°15N	165°00E	1	292	320
K-07	17 (5)	chinook	Feb 13-98	53°01N	171°42E	1	303	360
K-08	18 (1)	chinook	Feb 15-98	58°30N	179°59E	1	316	375
K-09	18 (2)	chinook	Feb 15-98	58°30N	179°59E	1	278	250
K-10	18 (3)	chinook	Feb 15-98	58°30N	179°59E	1	304	305
K-11	18 (4)	chinook	Feb 15-98	58°30N	179°59E	1	314	365
K-12	18 (5)	chinook	Feb 15-98	58°30N	179°59E	1	380	580
K-13	19 (1)	chinook	Feb 15-98	58°21N	179°47E	2	378	700
K-14	19 (2)	chinook	Feb 15-98	58°21N	179°47E	1	321	420
K-15	19 (3)	chinook	Feb 15-98	58°21N	179°47E	1	305	355

Table 11. Continued.

Sample No.	Sheet No. (Fish No.)	Species	Date of catch	Latitude	Longitude	Ocean Age	F L (mm)	B W (g)
K-16	20 (1)	chinook	Feb 16-98	54°09N	179°58W	1	260	200
K-17	20 (3)	chinook	Feb 16-98	54°09N	179°58W	1	286	285
K-18	20 (4)	chinook	Feb 16-98	54°09N	179°58W	1	246	170
K-19	21 (2)	chinook	Feb 19-98	49°29N	179°59W	3	590	2600
K-20	22 (1)	chinook	Feb 19-98	48°11N	179°59W	2	415	840
K-21	27 (1)	chinook	Feb 20-98	45°54N	179°56W	1	270	250
K-22	27 (2)	chinook	Feb 20-98	45°54N	179°56W	1	294	330
K-23	27 (3)	chinook	Feb 20-98	45°54N	179°56W	1	304	365
K-24	27 (4)	chinook	Feb 20-98	45°54N	179°56W	1	278	292
K-25	27 (5)	chinook	Feb 20-98	45°54N	179°56W	1	286	314
K-26	32 (14)	chinook	Feb 21-98	45°00N	179°58W	2	458	1140

*old blood, fish may have been caught in the previous day's trawl operation.

Table 12. Non-salmonids caught during the trawl operations of the *Kaiyo maru*, February-March 1998.

Sta	Date	Location	Non-salmonid catch
1	7-Feb-98	40°30'N 165°00'E	leptocephalus
2	9-Feb-98	42°15'N 165°00'E	no non-salmonid catch
3	9-Feb-98	43°08'N 164°59'E	*Tarletonbeania taylori* *Diaphus theta* *Stenobrachius leucopsarus* *Gonatopsis borealis* Gonatidae
4	10-Feb-98	45°00'N 165°00'E	no non-salmonid catch
5	10-Feb-98	46°15'N 165°00'E	*Diaphus theta* *Gasterosteus aculeatus* leptocephalus, elopiforms *Berryteuthis anonychus* *Gonatus middendorffi*
6	11-Feb-98	47°59'N 164°59'E	*Gasterosteus aculeatus* *Berryteuthis anonychus* *Gonatus middendorffi* Jellyfish
7	11-Feb-98	49°15'N 165°00'E	*Moroteuthis robustus* *Berryteuthis anonychus* *Gonatus middendorffi* *Zaprora silenus* (prowfish) *Gasterosteus aculeatus* Jellyfish leptocephalus, elopiforms
8	12-Feb-98	51°00'N 165°00'E	Stichaeidae larvae and juveniles *Berryteuthis anonychus* Jellyfish
9	13-Feb-98	53°01'N 171°42'E	*Zaprora silenus* *Aptocyclus ventricosus* (lumpfish) *Berryteuthis anonychus* Stichaeidae jellyfish

Table 12. Continued.

Sta	Date	Location	Non-salmonid catch
10a	15-Feb-98	58°30'N 179°59'E	Gonatidae *Gonatus middendorffi* jellyfish
10b	15-Feb-98	58°21'N 179°47'E	*Aptocyclus ventricosus* *Gonatus middendorffi* Gonatidae
11	15-Feb-98	57°27'N 179°59'E	Gonatidae jellyfish
12	16-Feb-98	55°30'N 179°58'W	*Berryteuthis anonychus* Stichaeidae Jellyfish
13	16-Feb-98	54°09'N 179°58'W	Gonatidae Jellyfish
14	18-Feb-98	52°30'N 179°56'E	Gonatidae Jellyfish
15	19-Feb-98	49°29'N 179°59'W	Gonatidae Jellyfish
16	19-Feb-98	48°11'N 179°59'W	Gonatidae *Gonatus middendorffi* large pelagic unid squid (*Moroteuthis robustus*?)
17	20-Feb-98	45°54N 179°56W	Gonatidae Jellyfish Salpa (Thalacea)
18	21-Feb-98	45°00N 179°58W	Gonatidae
19	22-Feb-98	43°31N 180°00W	Gonatidae