

**International Salmon Research Aboard the R/V *Wakatake maru* in  
the Central North Pacific Ocean and Bering Sea during the  
Summer of 2008**

**Masa-aki Fukuwaka,**

*Hokkaido National Fisheries Research Institute, Fisheries Research Agency  
116 Katsurakoi, Kushiro 085-0802, Japan*

**Nancy Davis, Margaret Atcheson,**

*School of Aquatic and Fishery Sciences, University of Washington  
Box 355020, Seattle, WA 98195-5020, USA*

**Yuzo Yamamoto,**

*Field Science Center for Northern Biosphere, Hokkaido University  
North 9 West 9, Kita-ku Sapporo, 060-0809, Japan*

**and Kanako Toge**

*Graduate School of Fisheries Science, Hokkaido University  
3-1-1 Minato-cho, Hakodate 041-8611, Japan*

Submitted to the  
**NORTH PACIFIC ANADROMOUS FISH COMMISSION**  
by  
**JAPAN**

**October 2008**

**THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:**

Fukuwaka, M., N. Davis, M. Atcheson, Y. Yamamoto, and K. Toge. 2008. International salmon research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea during the summer of 2008. NPAFC Doc. 1115. 19 pp. Hokkaido National Fisheries Research Institute, Fisheries Research Agency. (Available at <http://www.npafc.org>).

# International Salmon Research Aboard the R/V *Wakatake maru* in the Central North Pacific Ocean and Bering Sea during the Summer of 2008

## Abstract

An annual high-seas salmonid research cruise was conducted in the central North Pacific Ocean and Bering Sea from June 6 to July 18, 2008 onboard the Japanese research vessel, *Wakatake maru*, to investigate salmon stock condition. Research cruise activities included collection of data on oceanography, primary production, zooplankton, salmonids, and other organisms. Average sea surface temperature in the central North Pacific Ocean in 2008 was 9.2°C, which was slightly warmer by 0.1°C than the average temperature in 2007. The Subarctic Boundary was located between 40°N and 41°N, which was similar to its location in seven of the previous ten years. In the central Bering Sea, sea surface temperature in 2008 was 6.6°C, which was 0.4°C cooler than in 2007. At 29 experimental fishing stations, a total of 7,175 salmonids was caught by longline and gillnet: 756 fish in the central North Pacific and 6,419 fish in the central Bering Sea. In the central North Pacific, chum salmon was the most abundant species (53.8% of the salmonid catch), followed by coho (31.3%), pink (10.3%), steelhead (3.2%), chinook (0.8%), sockeye (0.4%), and one masu salmon (0.1%) was also caught. In the Bering Sea, chum salmon was the most abundant species (75.7% of the salmonid catch), followed by sockeye (13.2%), pink (9.8%), chinook salmon (1.3%), and Dolly Varden (0.03%). A total of 1,516 salmonids was disk tagged during the survey, which included 2 sockeye, 132 chum, 11 pink, 70 coho, and 1 chinook salmon, and 8 steelhead released in the central North Pacific and 50 sockeye, 1,189 chum, 33 pink, 18 chinook salmon, and 2 Dolly Varden released in the Bering Sea. Nineteen water temperature and swimming-depth recording data storage tags were placed on chinook salmon. Snouts from seven adipose fin-clipped steelhead and one adipose fin-clipped coho salmon were collected for later potential retrieval of coded-wire tags. A PIT-tagged steelhead was detected, which identified it as a summer-run hatchery-reared fish originating from the Snake River, USA. Other sampling and salmonid research activities included food habits analysis (all salmonids and seabirds), genetics (steelhead and chinook salmon), stable isotopes (steelhead, coho salmon, and their prey), endocrinological sampling (sockeye, chum, and pink salmon), zooplankton sampling, and seabird collection and observation.

## Introduction

The main objective of this research cruise is to monitor the stock condition of salmon (*Oncorhynchus* spp.) in the central North Pacific Ocean and Bering Sea. A recent decrease in body size and increase in age of chum salmon (*O. keta*) at maturity has been reported (Kaeriyama 1989; Ishida et al. 1993; Helle and Hoffman 1995; Bigler et al. 1996). A scale pattern analysis showed that Japanese chum salmon suffered growth reduction after the second year of ocean life (Kaeriyama 1998). Urawa (2000) suggested this reduction occurs in the Bering Sea, where chum salmon density increases in summer. To investigate these issues, a survey has been conducted annually in the central North Pacific Ocean and Bering Sea during summer. Routine observations have included collection of physical oceanographic data, estimates of primary production, and investigations into the relationships among zooplankton, salmonids, and higher trophic levels. This document summarizes the R/V *Wakatake maru* cruise conducted in these waters during June and July, 2008.

## Methods

### *Research Vessel and Survey Areas*

The *Wakatake maru* (666 gross tons) began the cruise when she departed Kushiro on June 6, 2008 and completed it when she returned to Kushiro on July 18, 2008. There were 29 experimental fishing stations during the cruise (Fig. 1). Nineteen fishing stations were located in the vicinity of 180° longitude from 41°N to 58°30'N latitude. In addition, 10 fishing stations were located in international waters of the central Bering Sea. Oceanographic data were collected at each fishing station and additional oceanographic data were collected enroute to and from the fishing area (Table 1).

### *Physical Oceanography*

Seawater temperature and salinity data have been collected in the same manner since 1999 (Kawana et al. 1999, Urawa et al. 2000, Fukuwaka et al. 2001, Tanaka et al. 2002, Fukuwaka et al. 2003, Morita et al. 2004, Fukuwaka et al. 2005, Fukuwaka and Watanabe 2006, Fukuwaka et al. 2007). An expendable bathythermograph (XBT), which recorded data at 1-m increments from the surface to 780 m, was used at 1°-longitude intervals on the outbound, eastward transit at 40°N, and at 1°-longitude intervals on the return leg from the Bering Sea to Kushiro (n = 58; Table 1). The conductivity, temperature, and depth sensor (CTD) was used at 5°-longitude intervals along the eastward transit, along the westward return leg, and at fishing stations (n = 43). The CTD records data in 1-m intervals from the surface to approximately 1000 m. Four ARGO floats were released at two stations along the eastward transit and at two stations at 180° longitude (Table 1) at the request of the Institute of Observational Research for Global Change, Japan Agency for Marine-Earth Science and Technology. These floats are free-drifting profilers, which record water temperature and salinity in the upper 2000 m of the ocean. When the ARGO float surfaces periodically, it relays temperature-salinity profiles and, from locational information, provides information on current velocity via satellite. ARGO float temperature-salinity profiles are available at this website: [http://www.jamstec.go.jp/J-ARGO/index\\_e.html](http://www.jamstec.go.jp/J-ARGO/index_e.html).

### *Primary Production*

Surface seawater was collected with a bucket to sample chlorophyll at fishing stations and at 5°-longitude intervals when transiting to and returning from the fishing area (n = 33; Table 1). Water (100 ml) was filtered through a glass fiber filter (Whatman GF/F) using a vacuum pump (100-150 mm Hg). Filters containing chlorophyll-a were saturated with 6 ml of N-dimethylformamide and stored in the freezer.

### *Zooplankton Collection*

Macro-zooplankton were sampled with a remodeled NORPAC net (0.45 m ring diameter, 1.93 m net length, 0.33 mm mesh size) at 29 fishing stations and six transit stations located at intervals of 5° longitude from 150°E to 160°E (Table 1). The net was towed vertically from 150 m to the surface. A calibrated flow meter was attached to the opening of the net in a slightly off-center position. Samples were fixed in 5% borax-buffered formalin in seawater. Samples collected by NORPAC net were collected at approximately midnight during fishing operations, or whenever the ship arrived on station for those located enroute to and from the fishing transect (Fig. 1)

Large macro-zooplankton were collected at 29 fishing stations using an Ocean Research Institute (ORI) net (1.60 m diameter, 7.5 m in overall length, 0.67 mm mesh size) and a BONGO net (2 rings, 0.7 m diameter, 4.1 m in overall length, 0.335 mm mesh size; Table 1). The ORI net was towed along side of the vessel at the surface at a speed of 1.5-2 knots for 10 min around 23:00 hrs. Immediately following the ORI net tow, the BONGO net was towed obliquely at the stern of the vessel from 100 m to the surface at a speed of approximately 1.5-2 knots. After the ORI and BONGO net tows were completed, the NORPAC net was towed, which completed the nightly zooplankton sampling.

### *Fishing Operations*

A gillnet and longline were used for experimental fishing operations to collect salmonids and other pelagic fish. The gillnet was used at 8 stations in the central North Pacific Ocean and 14 stations in the central Bering Sea, outside of the U.S. EEZ (Fig. 1, Table 1). The gillnet was set at 16:00 in the afternoon (Local Mean Time [LMT], GMT + 12) and retrieved at 04:00 the following morning. The gillnet configuration consisted of a variable-mesh research gillnet (C-gear: 3 tans each of 48, 55, 63, 72, 82, 93, 106, 121, 138, and 157 mm mesh size, one tan is 50 m long) combined with panels of a commercial-mesh gillnet (A-gear: 19 tans of 115 mm mesh size, one tan is 50 m long). The longline was used at 29 fishing stations, where it was set 30 minutes before sunset and hauled 30 minutes after sunset (LMT). The longline comprised 30 hachi (overall length 3.32 km; 1 hachi is 110.68 m long with 49 hooks) and it was baited with salted Japanese anchovy (*Engraulis japonicus*).

### *Fish Examination*

Salmonids were processed soon after removal from the fishing gear. For each mesh size, the catch was sorted and counted by species. Biological data were collected using a two-tiered sampling scheme, namely a routine and an abbreviated scheme. The routine scheme consisted of determining fork length (FL, mm), body weight (BW, g), sex, and gonad weight (GW, g), and collecting scale samples. The routine sampling scheme was used on a maximum of 60 individuals per species per mesh size from the research gillnet and commercial gillnet (total number of meshes = 11) and from a maximum of 60 individuals per species from longline mortalities. One scale (pink salmon *O. gorbuscha*), two scales (sockeye *O. nerka*, chum, coho *O. kisutch*, chinook salmon *O. tshawytscha* and steelhead *O. mykiss*), and a scrape scale sample (chinook salmon and steelhead) were collected. Scales were collected from the INPFC-preferred (International North Pacific Fisheries Commission) area on the body for age determination (Davis et al. 1990). The presence of external injuries on salmon and visceral adhesions in sockeye salmon and other species were recorded (Nagasawa et al. 1997). An abbreviated sampling scheme was used for all other salmonids caught in the research gillnet (number of meshes = 10) over and above the 60 individuals by species by mesh sampled by the routine scheme just described. The abbreviated sampling scheme consisted of determining fork length, body weight, and sex. All salmonids were inspected for the presence of clipped fins. If the fish had a clipped adipose fin, the snout was removed, salted, and frozen for later potential recovery of the coded-wire tag (CWT) by researchers at NOAA NMFS, Auke Bay Laboratories (ABL).

All non-salmonid catches were identified and counted by mesh size. Body length was determined for non-salmonid fish, squid, and other organisms, and a few were frozen for taxonomic and ecological studies. Neon flying squid (*Ommastrephes bartramii*) samples were sent to the National Research Institute of Far Seas Fisheries, Yokohama, and birds were sent to the Graduate School of Fisheries Science, Hokkaido University, Hakodate (HU), for further examination.

### *Disk Tags and Data Storage Tags*

Live salmonids caught in a healthy condition were briefly placed in a recovery tank immediately after removal from the longline. Fish were tagged with three disk tags; one issued by the Fisheries Agency of Japan (FAJ), one issued by the University of Washington (UW) and one issued by the NPAFC. The three disk tags were placed on one plastic cinch strap and applied to the fish anterior to the dorsal fin. The fork length was measured and two scales were collected before the fish was released to the sea.

Data storage tags (DST; Lotek model LAT 140), which record water temperature and the fish's swimming depth, were placed externally on chinook salmon immediately anterior to the dorsal fin using metal pins. On these chinook salmon, disk tags were placed on the metal pins on the opposite side of the fish to function as backing plates for the DST.

### *Other Sampling and Research*

Salmonid stomach samples were collected for two different studies. In one study, stomachs were examined for the purposes of examining interannual and interspecific differences in salmon diets. For this study, stomach samples were collected from all species of salmon and steelhead trout. These samples were collected from a maximum of 10 fish per species from longline mortalities and from each of five mesh sizes of the research-mesh gillnet (48, 63, 82, 106, and 138 mm) and from the commercial-mesh gillnet (115 mm). Stomach samples were weighed to the nearest gram before and after removal of the contents, and the weight of the stomach contents obtained by subtraction. The stomach contents were examined on board using a binocular microscope and separated into several prey categories as described by Ueno et al. (1998). The percent volume in each prey category was estimated by eye. A second study of salmon stomach contents was conducted to examine the relationship between salmon and seabird diets, and the availability of prey in zooplankton samples. This study required stomach samples be collected from sockeye, chum, and pink salmon caught in five mesh sizes of the research-mesh gillnet (55, 72, 93, 121, and 157 mm). Samples were fixed in 10% borax-buffered formalin in seawater and stored for later examination at HU.

For genetic analysis of steelhead and chinook salmon, the axillary process was collected and stored in alcohol. These samples were obtained from mortalities from fishing gear and occasionally fin clips were removed from live fish during the tagging procedure.

Stable isotope samples were obtained from dorsal muscle of steelhead and coho salmon. To establish isotopic levels in steelhead prey, samples of their fish and zooplankton prey were collected from stomach contents and from ORI net samples when the ORI net collections were large enough to require subsampling. Genetic and stable isotope samples were sent to the School of Aquatic and Fishery Sciences, University of Washington, Seattle (UW).

For an endocrinological study, blood, olfactory epithelia, and brain were collected from recently sacrificed sockeye, chum, and pink salmon caught on the longline. Blood was collected from the caudal vasculature, and centrifuged at 3000 rpm for 15 min to obtain plasma samples. After blood collection, olfactory epithelia and the brain were removed, trimmed, and separated into seven components including the olfactory bulb, telencephalon, optic tectum, hypothalamus, pituitary, cerebellum, and medulla. Part of the brain and olfactory epithelia were immediately frozen in liquid nitrogen after removal from the fish. The blood, olfactory epithelia, and brain components were preserved by freezing at approximately -20°C for later biochemical analysis at HU.

The feasibility of detecting passive integrated transponder (PIT) tags was tested using a hand-held PIT tag detector (Destron-Fearing Pocket Reader EX) protected in a waterproof bag. Steelhead, chinook and coho salmon, and seabirds caught in the gillnet were scanned to determine if they carried an internally embedded PIT tag. Steelhead and coho salmon were also scanned for the presence of a PIT tag during the disk-tagging procedure.

## **Results**

### *Physical Oceanography*

The position of oceanographic domains was identified along the 180° transect according to the seawater characteristics described by Dodimead et al. (1963) and Favorite et al. (1976; Figs. 2, 3). Stations 1 and 2 were located in the Transition Zone, an area characterized by relatively saline waters (> 34.0 psu) (Fig. 3). The vertical 34.0 psu isohaline, which characterizes the Subarctic Boundary and separates subtropical and subarctic waters, was located between 40°N (St. 2) and 41°N (St. 3). The position of the Subarctic Boundary in 2008 was the same position observed during cruises in 1997, 1998, 2000, 2003-2005, and 2007, however the Boundary was located 1° latitude south of its 2008 position in 1991-1996, 1999, and 2001-2002 (Davis et al. 1996, Nagasawa et al. 1997; Ueno et al. 1998, Kawana et al. 1999, Urawa et al. 2000, Fukuwaka et al. 2001; Tanaka et al. 2002, Fukuwaka et al. 2003, Morita et al. 2004, Fukuwaka et al. 2005, Fukuwaka et al. 2007). The most northerly

location of the Subarctic Boundary was observed in 2006 when the Boundary was located between 43°N and 44°N (Fukuwaka and Watanabe 2006). The southern limit of the Transition Domain is the Subarctic Boundary and the northern limit is delineated by cold water (< 4°C) below 100 m depth in the central North Pacific. The Transition Domain was located between 41°N and 46°N (between St. 3 and 8; Fig. 2). The Subarctic Current, an eastward-flowing surface current of cool, dilute waters can be identified by cold water (near 3.5°C) at approximately 125 m. This current was located between 46°N (St. 8) and 49°30'N (St. 12). Further to the north, the westward-flowing Alaska Current, identified by warm (> 4°C) and dilute (< 33.6 psu) freshwater run-off at depths less than 100 m, was located in the vicinity of 50°30'N (St. 13).

Station 14 was located in Amchitka Pass in the Aleutian Islands, one of several locations where North Pacific waters enter the Bering Sea. Station 15 (52°30'N, 180°00') was located on the relatively shallow (~300 m depth) Bowers Bank and stations north of 52°30'N (St. 16 through St. 31) were located in the central Bering Sea basin. The basin is characterized by a cold, saline surface layer (depth to approximately 200 m), which is produced by cooling and mixing during the previous winter. This year, superficial warming of the sea surface during the summer produced a shallow seasonal thermocline at approximately 20 m (Fig. 2).

In 2008, average sea surface temperature in the central North Pacific was 9.2°C, which was 0.1°C slightly warmer than the average temperature in 2007 (St. 3-13; 2008 mean = 9.2°C, 2007 mean = 9.1°C). In the central Bering Sea, average sea surface temperature in 2008 was 6.6°C, which was 0.4°C cooler than in 2007 (St. 14-31; 2008 mean = 6.6°C, 2007 mean = 7.0°C).

#### *Salmonid Catches*

A total of 7,175 salmonids was caught by longline and gillnet: 756 fish in the central North Pacific Ocean (St. 3-13) and 6,419 fish in the central Bering Sea (St. 14-31; Table 2). In the central North Pacific, chum salmon was the most abundant species (53.8% of the salmonid catch), followed by coho (31.3%), pink (10.3%), steelhead (3.2%), chinook (0.8%), sockeye (0.4%), and one masu salmon (0.1%) was also caught. In the Bering Sea, chum salmon was the most abundant species (75.7% of the salmonid catch), followed by sockeye (13.2%), pink (9.8%), chinook salmon (1.3%), and Dolly Varden (0.03%).

#### *Non-Salmonid Catches*

Pacific saury (*Cololabis saira*: n = 607), Pacific pomfret (*Brama japonica*: n = 250), and Atka mackerel (*Pleurogrammus monopterygius*: n = 240) were particularly abundant in the catch (Table 2). In addition, 141 neon flying squid, 43 boreal clubhook squid (*Onychoteuthis borealijaponicus*), 34 eight-armed squid (*Gonatopsis borealis*), 29 smalleye squaretail (*Tetragonurus cuvieri*), 28 spiny dogfish (*Squalus acanthias*), one salmon shark (*Lamna ditropis*), two Pacific lamprey (*Entosphenus tridentatus*), one daggertooth (*Anotopterus nikparini*), 14 other fishes from a mixture of species, 68 seabirds, and one Dall's porpoise (*Phocoenoides dalli*) were caught.

#### *Trends in Mean Fish Size at Age*

Preliminary data on mean length (FL, mm) at age for salmon caught in research mesh gillnet (C-gear) were plotted for the period 1991 to 2008 for the central North Pacific and Bering Sea. Size data for sockeye salmon in the central North Pacific had been available from ocean age-1 and -2 fish regularly since 1998, however, no size data was available in 2008 (Fig. 4). In the Bering Sea, trends indicate that since 2001 the size of ocean age -1 sockeye and ocean age -1 chum salmon has increased. The size of ocean age-3 sockeye and ocean age-3 and -4 chum salmon has been stable since 2004. Generally, the size of pink salmon in the central North Pacific has increased since 1999. In 2008, pink salmon were not abundant in the catch, however, pink salmon body size in catches in the Bering Sea was lower than last year, when the catch of pink salmon was large (Fig. 5). The size of maturing coho salmon in the central North Pacific has generally decreased since 2001. Size of ocean age-1, chinook salmon in the Bering Sea has remained relatively stable since 2001, while

ocean age-2 and -3 chinook salmon has been variable since that time (Fig. 6). In the central North Pacific, the mean size of ocean age-1, -2 and -3 steelhead has increased since 2006.

#### *Disk and Data Storage Tags*

A total of 1,516 salmonids was disk tagged during the survey. In the central North Pacific (St. 3-13), 224 disk tags were placed on fish, including 2 sockeye, 132 chum, 11 pink, 70 coho, 1 chinook salmon, and 8 steelhead. In the Bering Sea (St. 14-30), 1292 disk tags were placed on salmon including 50 sockeye, 1,189 chum, 33 pink, 18 chinook salmon, and 2 Dolly Varden. There was a high seas recovery of a disk-tagged chum salmon in the morning gillnet operation after it was tagged the preceding evening during the longline operation at the same station (Table 3.) One Lotek DST was placed on chinook salmon in the central North Pacific Ocean and 18 more DSTs were placed on chinook salmon in the Bering Sea. These chinook salmon ranged in size from 363 to 772 mm FL.

#### *Other Sampling and Research*

A total of 18 fin clipped or tagged salmonids (steelhead, coho, and chum salmon) was caught by longline and gillnet (Table 3). Snouts from seven adipose fin-clipped steelhead and one adipose fin-clipped coho salmon were collected for later potential retrieval of CWTs. Six adipose fin-clipped steelhead, one PIT-tagged steelhead, and one dorsal fin-clipped chum salmon were tagged with high seas disk tags and released. The PIT-tagged steelhead was detected from among 329 fish (237 coho, 68 chinook salmon and 24 steelhead) and 68 seabirds (shorttailed shearwater, common murre, northern fulmar, and puffins) that were scanned. The PIT tag code identified the fish came from the Snake River, USA, and was a summer-run fish of hatchery origin. The steelhead was PIT tagged as a smolt at the Lower Granite Dam fish bypass facility on April 23, 2006, and the next day was placed on a barge and transported down the Columbia River, where it was released within 5 km of the river mouth. Information about this recovery is available from the PTAGIS website (<http://www.ptagis.org/ptagis>).

For food habits analyses, a total of 1,125 samples of salmon stomach samples was collected. This total included samples collected from 145 sockeye, 350 chum, 150 pink, 85 coho, 68 chinook, 1 masu salmon, and 15 steelhead, which were examined on board the ship. In addition, stomach samples from 90 sockeye, 112 chum, and 109 pink salmon were fixed in 10% formalin for later examination in the laboratory.

Samples for genetic, stable isotope, and endocrine studies were obtained. Genetic samples were collected from 21 steelhead and 68 chinook salmon. Samples for stable isotope analysis were obtained from 15 steelhead, 24 coho salmon, and 14 steelhead prey groups. Plasma, brain, and olfactory nerve samples were collected from four sockeye, 59 chum, and four pink salmon for endocrinological analysis.

### **Acknowledgements**

We thank Captain Yuichi Murata and the officers, crew, teacher, and students aboard the R/V *Wakatake maru* for their cooperation in research and sample collections during the cruise. We thank Dave Marvin, Carter Stein, and Ryan Day of the Pacific States Marine Fisheries Commission for the loan of the PIT tag detector and for help with the PTAGIS database. Support for the U.S. authors was provided by the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative Project 712 <http://www.aykssi.org/>, Alaska Sustainable Salmon Fund, and by a grant from the Washington Sea Grant Program, University of Washington, pursuant to National Oceanic and Atmospheric Administration Award No. NA07OAR4170007, Project No. R/F-160. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its sub-agencies.

## References

- Bigler, B.S., D.W. Welch, and J.H. Helle. 1996. A review of size trends among North Pacific salmon (*Oncorhynchus* spp.). *Can. J. Fish. Aquat. Sci.*, 53: 455-465.
- Davis, N.D., K.W. Myers, R.V. Walker, and C. Harris. 1990. The Fisheries Research Institute's high-seas salmonids tagging program and methodology for scale pattern analysis. *Am. Fish. Soc. Symp.*, 7: 863-879.
- Davis, N.D., M. Takahashi, and Y. Ishida. 1996. The 1996 Japan-U.S. cooperative high-seas salmon cruise of the *Wakatake maru* and a summary of 1991-1996 results. (NPAFC Doc. 194) FRI-UW-9617. *Fish. Res. Inst., Univ. of Washington, Seattle; Nat. Res. Inst. Far Seas Fish., Shimizu.* 45 p.
- Dodimead, A.J., F. Favorite, and T. Hirano. 1963. Salmon of the North Pacific Ocean. Part II. Review of oceanography of the Subarctic Pacific region. *Int. North Pac. Fish. Comm. Bull.*, 13: 195 p.
- Favorite, F., A.J. Dodimead, and K. Nasu. 1976. Oceanography of the Subarctic Pacific Region, 1960-1971. *Int. North Pac. Fish. Comm. Bull.*, 31: 187 p.
- Fukuwaka, M., and N. Watanabe. 2006. International salmon research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea during the summer of 2006. (NPAFC Doc. 959). 17 p. Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro 085-0802, Japan.
- Fukuwaka, M., N. Davis, A. Urano, T. Onuma, M. Akita, and S. Tsuchiya. 2001. International salmon research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea during the summer of 2001. (NPAFC Doc. 546). 18 p. Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro 085-0802, Japan.
- Fukuwaka, M., S. Urawa, K. Hirasawa, N. Davis, and R. V. Walker. 2003. Recoveries of high-seas tags in Japan in 2002, and tag releases and recoveries of fin-clipped salmon from Japanese research vessel surveys in the North Pacific Ocean in the fall of 2002 and the summer of 2003. (NPAFC Doc. 715). Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro 085-0802. 11 p.
- Fukuwaka, M., N. Davis, N. Ambers, R. Yamashita, M. Bando, Y. HIRAMA, and K. Honma. 2005. International salmon research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea during the summer of 2005. (NPAFC Doc. 890). 26 p. Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro 085-0802, Japan.
- Fukuwaka, M., N. Davis, M. Kuwaki, S. Imai, and K. Toge. 2007. International salmon research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea during the summer of 2007. NPAFC Doc. 1046. 19 pp. Hokkaido National Fisheries Research Institute, Fisheries Research Agency (Available at <http://www.npafc.org>).
- Helle, J.H., and M.S. Hoffman. 1995. Size decline and older age at maturity of two chum salmon (*Oncorhynchus keta*) stocks in western North America, 1972-1992. *In* R. J. Beamish [ed.] *Climate change and northern fish populations.* *Can. Spec. Publ. Fish. Aquat. Sci.*, 121:245-260.
- Ishida, Y., S. Ito, M. Kaeriyama, S. McKinnell, and K. Nagasawa. 1993. Recent changes in age and size of chum salmon (*Oncorhynchus keta*) in the North Pacific Ocean and possible causes. *Can. J. Fish. Aquat. Sci.*, 50: 290-295.
- Kaeriyama, M. 1989. Aspects of salmon ranching in Japan. *Physiol. Ecol. Japan, Spec. Vol. 1:* 625-638.
- Kaeriyama, M. 1998. Dynamics of chum salmon, *Oncorhynchus keta*, populations released from Hokkaido, Japan. *N. Pac. Anadr. Fish Comm. Bull.*, 1: 90-102.
- Kawana, M., K. Umeda, G. Kawakami, Y. Matsushita. 1999. High-seas salmonid research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea in the summer of 1999. (NPAFC Doc. 418) National Salmon Resources Center, Fisheries



- Agency of Japan, Sapporo. 28 p.
- Morita, K., N. Davis, A. Urano, M. Abe, and Y. Ito. 2004. The 2004 Japan-U.S. cooperative high-seas salmon research cruise of the R/V *Wakatake maru*. (NPAFC Doc. 787). Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro 085-0802, Japan. 20 p.
- 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. 266) Nat. Res. Inst. Far Seas Fish., Fisheries Agency of Japan, Shimizu. 32 p.
- Tanaka, H., N. Davis, T. Onuma, M. Yamada, Y. Yamamoto, and S. Tsuchiya. 2002. International salmon research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea during the summer of 2002. (NPAFC Doc. 622). Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro 085-0802, Japan. 21 p.
- Ueno, Y., N.D. Davis, M. Sasaki, and I. Tokuhiko. 1998. Japan-U.S. cooperative high-seas salmonid research aboard the R/V *Wakatake maru* from June 9 to July 25, 1998. (NPAFC Doc. 326) Nat. Res. Inst. Far Seas Fish., Fisheries Agency of Japan, Shimizu. 55 p.
- Urawa, S. 2000. Ocean migration route of Japanese chum salmon with a reference to future salmon research. National Salmon Resources Center Newsletter, 5: 3-9. (In Japanese.)
- Urawa, S., K. Yamaya, N. Davis, H. Tanaka, and S. Tsuchiya. 2000. International salmon research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea during the summer of 2000. (NPAFC Doc. 484). 21 p. National Salmon Resources Center, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062-0922, Japan.

**Table 1.** Research activities conducted at each station during the *Wakatake maru* cruise in 2008.

NO	ST	Date	Latitude	Longitude	XBT	CTD	Primary	NORPAC	ORI	BONGO	Gillnet	Longline	Remarks
1	T-1	2008 6 7 40 0	150 0	E	○	○	○	○					flowmeter calibration
2	T-2	2008 6 7 40 0	151 0	E	○								
3	T-3	2008 6 7 40 0	152 0	E	○								
4	T-4	2008 6 8 40 0	153 0	E	○								
5	T-5	2008 6 8 40 0	154 0	E	○								
6	T-6	2008 6 8 40 0	155 0	E	○	○	○	○					
7	T-7	2008 6 8 40 0	156 0	E	○								
8	T-8	2008 6 8 40 0	157 0	E	○								
9	T-9	2008 6 8 40 0	158 0	E	○								
10	T-10	2008 6 9 40 0	159 0	E	○								
11	T-11	2008 6 9 40 0	160 0	E	○	○	○	○					
12	T-12	2008 6 9 40 0	161 0	E	○								
13	T-13	2008 6 9 40 0	162 0	E	○								
14	T-14	2008 6 9 40 0	163 0	E	○								
15	T-15	2008 6 9 40 0	164 0	E	○								
16	T-16	2008 6 10 40 0	165 0	E	○	○	○						
17	T-17	2008 6 10 40 0	166 0	E	○								
18	T-18	2008 6 10 40 0	167 0	E	○								
19	T-19	2008 6 10 40 0	168 0	E	○								ARGO Float cast
20	T-20	2008 6 10 40 0	169 0	E	○								
21	T-21	2008 6 10 40 0	170 0	E	○	○	○						
22	T-22	2008 6 11 40 0	171 0	E	○								
23	T-23	2008 6 11 40 0	172 0	E	○								ARGO Float cast
24	T-24	2008 6 11 40 0	173 0	E	○								
25	T-25	2008 6 11 40 0	174 0	E	○								
26	T-26	2008 6 11 40 0	175 0	E	○	○	○						
27	T-27	2008 6 11 40 0	176 0	E	○								
28	T-28	2008 6 11 39 45	177 0	E	○								
29	T-29	2008 6 12 39 30	178 0	E	○								
30	T-30	2008 6 12 39 15	179 0	E	○								
31	ST-1	2008 6 12 39 0	180 0		○	○	○						
32	ST-2	2008 6 12 40 0	180 0			○	○						ARGO Float cast
33	ST-3	2008 6 13 41 0	180 0			○	○	○	○	○	○	○	ARGO Float cast
34	ST-4	2008 6 14 42 0	180 0			○	○	○	○	○	○	○	
35	ST-5	2008 6 15 43 0	180 0			○	○	○	○	○	○	○	
36	ST-6	2008 6 16 44 0	180 0			○	○	○	○	○	○	○	
37	ST-7	2008 6 17 45 0	180 0			○	○	○	○	○	○	○	
38	ST-8	2008 6 18 46 0	180 0			○	○	○	○	○	○	○	
39	ST-9	2008 6 19 47 0	180 0			○	○	○	○	○	○	○	
40	ST-10	2008 6 20 47 30	180 0			○	○	○	○	○	○	○	
41	ST-11	2008 6 21 48 30	180 0			○	○	○	○	○	○	○	
42	ST-12	2008 6 22 49 30	180 0			○	○	○	○	○	○	○	
43	ST-13	2008 6 23 50 30	180 0			○	○	○	○	○	○	○	
44	ST-14	2008 6 24 51 30	180 0			○	○	○	○	○	○	○	
45	ST-15	2008 6 25 52 30	180 0			○	○	○	○	○	○	○	
46	ST-16	2008 6 26 53 30	180 0			○	○	○	○	○	○	○	
47	ST-17	2008 6 27 54 30	180 0			○	○	○	○	○	○	○	
48	ST-18	2008 6 28 55 30	180 0			○	○	○	○	○	○	○	
49	ST-19	2008 6 29 56 30	180 0			○	○	○	○	○	○	○	
50	ST-20	2008 6 30 57 30	180 0			○	○	○	○	○	○	○	
51	ST-21	2008 7 1 58 30	180 0			○	○	○	○	○	○	○	
52	ST-22	2008 7 2 57 30	179 0	W		○		○	○	○	○	○	
53	ST-23	2008 7 3 57 30	178 0	W		○		○	○	○	○	○	
54	ST-24	2008 7 4 56 30	178 0	W		○		○	○	○	○	○	
55	ST-25	2008 7 5 56 30	179 0	W		○		○	○	○	○	○	
56	ST-26	2008 7 6 56 30	179 0	E		○		○	○	○	○	○	
57	ST-27	2008 7 7 56 30	178 0	E		○		○	○	○	○	○	
58	ST-28	2008 7 8 56 30	177 0	E		○		○	○	○	○	○	
59	ST-29	2008 7 9 57 30	177 0	E		○		○	○	○	○	○	
60	ST-30	2008 7 10 57 30	176 0	E		○		○	○	○	○	○	
61	ST-31	2008 7 11 56 30	176 0	E		○		○	○	○	○	○	
62	T-50	2008 7 12 56 0	176 0	E	○								
63	T-51	2008 7 12 55 30	175 0	E	○	○	○						
64	T-52	2008 7 12 55 0	174 0	E	○								
65	T-53	2008 7 12 54 30	173 0	E	○								
66	T-54	2008 7 12 54 0	172 0	E	○								
67	T-55	2008 7 13 53 30	171 0	E	○								
68	T-56	2008 7 13 53 0	170 0	E	○	○	○						
69	T-57	2008 7 13 52 20	169 0	E	○								
70	T-58	2008 7 13 51 40	168 0	E	○								

**Table 1.** (continued)

NO	ST	Date		Latitude		Longitude		XBT	CTD	Primary	NORPAC	ORI	BONGO	Gillnet	Longline	Remarks
71	T-59	2008	7	13	51	10	167	0	E	○						
72	T-60	2008	7	13	50	40	166	0	E	○						
73	T-61	2008	7	14	50	0	165	0	E	○	○					
74	T-62	2008	7	14	49	20	164	0	E	○						
75	T-63	2008	7	14	48	40	163	0	E	○						
76	T-64	2008	7	14	48	0	162	0	E	○						
77	T-65	2008	7	14	47	30	161	0	E	○						
78	T-66	2008	7	14	46	50	160	0	E	○	○	○				
79	T-67	2008	7	15	46	10	159	0	E	○						
80	T-68	2008	7	15	45	30	158	0	E	○						
81	T-69	2008	7	15	44	50	157	0	E	○						
82	T-70	2008	7	15	44	10	156	0	E	○						
83	T-71	2008	7	15	43	30	155	0	E	○	○	○				
84	T-72	2008	7	16	42	50	154	0	E	○						
85	T-73	2008	7	16	42	10	153	0	E	○						
86	T-74	2008	7	16	41	20	152	0	E	○						
87	T-75	2008	7	16	40	40	151	0	E	○						
88	T-76	2008	7	17	40	0	150	0	E	○	○	○				flowmeter calibration

**Table 2.** Salmonids, other fishes, and squid catches at each station with sea surface temperature (SST, °C) during the summer research cruise of the *Wakatake maru*, 2008. B-gear, surface longline; C-gear, salmon research gillnet (mesh sizes = 48, 55, 63, 72, 82, 93, 106, 121, 138 and 157 mm); A-gear, commercial gillnet (mesh size = 115 mm). The number of fish tagged with disk tags and released is listed for each station.

St	Date	Lat	Long	SST	Gear	No. unit	Sock-eye	Chum	Pink	Coho	Chi-nook	Masu	Steel-head	Dolly Varden	Salmo-nid total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamprey	Salmon shark	Spiny dogfish	Dagg tooth	Pacific saury	Pacific pom-fret	Atka-macke-rel	Square tail	Other fishes	Dall's Sea-birds	porpoise				
3	6/14/08	4100	18000	11.7	B	30	0	3	0	1	0	0	2	0	6	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0			
					C	30	0	2	0	2	0	0	0	0	0	4	58	0	1	0	0	0	1	0	0	68	0	2	1	0	0	0	
					A	19	0	0	0	2	0	0	0	0	0	2	83	0	0	0	0	0	0	0	0	51	0	0	0	0	0	0	0
					Total		0	5	0	5	0	0	2	0	12	141	0	1	0	0	1	0	0	0	0	146	0	2	1	0	0	0	
					Rel.		0	2	0	1	0	0	2	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	6/15/08	4200	18000	11.9	B	30	0	2	0	4	0	0	1	0	7	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0			
					C	30	0	2	0	9	0	0	0	0	11	0	0	12	0	0	0	1	8	30	0	25	1	0	0	0	0		
					A	19	0	0	0	12	0	0	1	0	13	0	0	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0
					Total		0	4	0	25	0	0	2	0	31	0	0	12	0	0	0	1	8	72	0	25	1	0	0	0	0	0	
					Rel.		0	1	0	2	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	6/16/08	4300	18000	10.3	B	30	0	5	0	9	0	0	0	0	14	0	0	0	0	0	0	0	0	7	0	0	0	1	0	0			
					C	30	0	10	0	8	0	0	0	0	18	0	5	16	0	0	0	0	144	16	0	2	0	0	0	0	0		
					A	19	0	1	0	4	0	0	0	0	5	0	0	1	0	0	0	3	0	3	0	0	0	0	0	0	0	0	
					Total		0	16	0	21	0	0	0	0	37	0	5	17	0	0	0	3	144	26	0	2	1	0	0	0	0	0	
					Rel.		0	4	0	8	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	6/17/08	4400	18000	10.6	B	30	0	17	1	40	0	0	1	0	59	0	0	1	0	0	0	0	0	4	0	0	0	0	0	0			
					C	30	0	61	3	32	1	0	2	0	99	0	1	8	0	0	0	5	455	0	0	0	0	0	0	0	0	0	0
					A	19	0	3	0	22	0	0	0	0	25	0	0	0	0	0	0	9	0	2	0	0	0	0	0	0	0	0	0
					Total		0	81	4	94	1	0	3	0	183	0	1	9	0	0	0	14	455	6	0	0	0	0	0	0	0	0	0
					Rel.		0	11	1	29	0	0	1	0	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	6/18/08	4500	18000	9.9	B	30	0	3	1	10	0	0	3	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
					C	30	0	22	6	5	0	0	1	0	34	0	5	3	0	0	0	1	0	0	0	0	0	0	0	0	3	0	
					A	19	0	1	6	3	0	1	2	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					Total		0	26	13	18	0	1	6	0	64	0	5	3	0	0	0	1	0	0	0	0	0	0	0	0	3	0	
					Rel.		0	3	1	9	0	0	2	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	6/19/08	4600	18000	8.6	B	30	0	1	0	8	0	0	0	0	9	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0			
					C	30	0	50	10	10	1	0	1	0	72	0	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	
					A	19	0	6	3	10	0	0	4	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					Total		0	57	13	28	1	0	5	0	104	0	13	1	0	0	0	3	0	0	0	0	0	0	0	0	0	1	
					Rel.		0	1	0	6	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

**Table 2.** (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sock-eye	Chum	Pink	Coho	Chi-nook	Masu	Steel-head	Dolly Varden	Salmon total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamp-ey	Salmon shark	Spiny dog-fish	Dagg tooth	Pacific saury	Pacific pom fret	Atka macke-rel	Square-tail	Other fishes	Sea-porpoise	Dall's birds				
9		4700	18000	8.0		30	0	47	4	9	0	0	2	0	62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
						30	0	34	11	8	0	0	1	0	54	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
						19	1	1	14	5	2	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
							1	36	25	21	2	0	1	0	86	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
						0	42	3	7	0	0	2	0	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
10		4730	18000	7.8		30	0	8	0	6	1	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
						30	0	56	7	9	1	0	1	0	74	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	
						19	0	0	4	6	0	0	2	0	12	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
							0	64	11	21	2	0	3	0	101	0	1	0	0	1	0	3	0	0	0	0	0	0	0	0	0	1	0
						0	7	0	5	1	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
11		4830	18000	7.7		30	0	17	3	2	0	0	0	0	22	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0			
							0	16	3	2	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12		4930	18000	7.4		30	2	39	5	1	0	0	0	0	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
							2	34	3	1	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13		5030	18000	7.3		30	0	16	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
							0	11	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	6/24/08	5130	18000	4.8	B	30	0	23	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0			
					Rel.		0	20	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
15	6/25/08	5230	18000	5.9	B	30	8	137	2	0	0	0	0	0	147	0	0	0	0	0	0	0	0	0	22	0	1	0	0				
					Rel.		7	104	0	0	0	0	0	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
16	6/26/08	5330	18000	6.7	B	30	0	103	1	0	0	0	0	0	104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
					Rel.		0	76	1	0	0	0	0	77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
17	6/27/08	5430	18000	6.9	B	30	0	20	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
					Rel.		0	15	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
18	6/29/08	5530	18000	7.0	B	30	1	44	7	0	0	0	0	0	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	48	67	69	0	2	0	0	0	186	0	5	0	0	0	0	0	0	0	0	0	8	0	0	2	0		
					A	19	18	95	45	0	0	0	0	0	158	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0		
					Total		67	206	121	0	2	0	0	0	396	0	5	0	0	0	0	0	0	0	0	0	0	8	0	1	2	0	
	Rel.		1	36	6	0	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0					

**Table 2.** (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sock-eye	Chum	Pink	Coho	Chi-nook	Mas u	Steel-head	Dolly Varden	Salmonid total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamprey	Salmon shark	Spiny dogfish	Dagger tooth saury	Pacific pommacke-fret	Atka rel	Square-tail	Other fishes	Sea-porpoise	Dall's birds				
19	6/30/08	5630	18000	6.9	B	30	1	98	1	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	36	82	62	0	0	0	0	180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	
					A	19	12	149	48	0	0	0	0	209	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
					Total		49	329	111	0	0	0	0	489	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
					Rel.		1	86	0	0	0	0	0	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	7/01/08	5730	18000	7.3	B	30	5	62	4	0	11	0	0	0	82	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	31	58	45	0	5	0	0	139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	
					A	19	17	113	21	0	1	0	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	
					Total		53	233	70	0	17	0	0	373	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	0
					Rel.		5	41	4	0	9	0	0	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	7/02/08	5830	18000	6.5	B	30	0	31	6	0	1	0	0	2	40	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	19	51	18	0	2	0	0	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
					A	19	16	106	25	0	0	0	0	147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	
					Total		35	188	48	0	3	0	0	276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
					Rel.		0	24	5	0	1	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	7/03/08	5730	17900W	6.9	B	30	2	72	11	0	2	0	0	0	87	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	26	85	31	0	1	0	0	143	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	
					A	19	16	160	38	0	2	0	0	216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	
					Total		44	317	80	0	5	0	0	446	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	0
					Rel.		2	59	6	0	2	0	0	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	7/04/08	5730	17800W	7.1	B	30	3	171	2	0	6	0	0	0	182	0	0	0	0	0	0	0	0	2	0	0	0	0				
					C	30	17	131	39	0	24	0	0	211	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		
					A	19	19	176	34	0	13	0	0	242	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					Total		39	478	75	0	43	0	0	635	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	
					Rel.		1	129	1	0	6	0	0	137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	7/05/08	5630	17800W	7.2	B	30	3	39	5	0	0	0	0	0	47	0	0	0	0	0	0	0	0	0	0	0	1	0				
					C	30	25	74	8	0	1	0	0	108	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0		
					A	19	15	84	16	0	0	0	0	115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0		
					Total		43	197	29	0	1	0	0	270	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	6	0	
					Rel.		2	33	3	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

**Table 2.** (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sock-eye	Chum	Pink	Coho	Chi-nook	Masu	Steel-head	Dolly Varden	Salmonid total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamprey	Salmon shark	Spiny dogfish	Dagger tooth saury	Pacific pommacke-fret	Atka macke-rel	Square-tail	Other fishes	Sea-porpoise	Dall's birds				
25	7/06/08	5630	17900W	7.3	B	30	5	75	4	0	0	0	0	0	84	0	0	0	0	0	0	0	0	0	0	0	0	1	0			
					C	30	22	105	3	0	2	0	0	0	0	0	132	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0
					A	19	7	77	6	0	1	0	0	0	0	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
					Total		34	257	13	0	3	0	0	0	0	0	307	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0
					Rel.		4	59	3	0	0	0	0	0	0	0	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	7/07/08	5630	17900E	7.3	B	30	8	187	0	0	0	0	0	0	195	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
					C	30	35	201	9	0	1	0	0	0	0	0	246	0	0	0	0	0	0	0	0	0	4	0	2	0	0	
					A	19	23	123	7	0	0	0	0	0	0	0	153	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
					Total		66	511	16	0	1	0	0	0	0	0	594	0	0	0	0	0	0	0	0	0	0	4	0	2	1	0
					Rel.		6	136	0	0	0	0	0	0	0	0	142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	7/08/08	5630	17800E	8.1	B	30	3	133	1	0	0	0	0	0	137	0	0	0	0	0	0	0	0	0	1	0	0	0	0			
					C	30	53	240	3	0	0	0	0	0	0	0	296	0	0	0	0	0	0	0	0	0	5	0	0	9	0	
					A	19	23	90	7	0	0	0	0	0	0	0	120	0	0	0	0	0	0	0	0	0	0	0	0	6	0	
					Total		79	463	11	0	0	0	0	0	0	0	553	0	0	0	0	0	0	0	0	0	0	6	0	0	15	0
					Rel.		3	105	1	0	0	0	0	0	0	0	109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	7/09/08	5630	17700E	7.6	B	30	3	116	1	0	0	0	0	0	120	0	0	0	0	0	0	0	0	0	1	0	0	0	0			
					C	30	33	116	1	0	1	0	0	0	0	0	151	0	1	0	0	0	0	0	0	0	14	0	0	1	0	
					A	19	21	129	7	0	0	0	0	0	0	0	157	0	0	0	2	0	0	2	0	0	0	0	0	0	0	
					Total		57	361	9	0	1	0	0	0	0	0	428	0	1	0	2	0	0	2	0	0	15	0	0	1	0	
					Rel.		2	88	1	0	0	0	0	0	0	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29	7/10/08	5730	17700E	8.1	B	30	8	49	3	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	1	0	1	0	0			
					C	30	69	126	3	0	0	0	0	0	0	0	198	0	0	0	0	0	0	0	0	0	20	0	0	1	0	
					A	19	19	111	6	0	1	0	0	0	0	0	137	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
					Total		96	286	12	0	1	0	0	0	0	0	395	0	0	0	0	0	0	0	0	0	0	21	0	1	2	0
					Rel.		7	36	2	0	0	0	0	0	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
30	7/11/08	5730	17600E	8.5	B	30	10	206	0	0	0	0	0	0	216	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
					C	30	71	177	8	0	2	0	0	0	0	0	258	0	1	0	0	0	0	0	0	0	0	0	0	2	0	
					A	19	29	90	8	0	2	0	0	0	0	0	129	0	0	0	0	0	0	0	0	0	0	0	1	1	0	
					Total		110	473	16	0	4	0	0	0	0	0	603	0	1	0	0	0	0	0	0	0	0	0	0	1	3	0
					Rel.		9	142	0	0	0	0	0	0	0	0	151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

**Table 2.** (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sock-eye	Chum	Pink	Coho	Chi-nook	Masu	Steel-head	Dolly Varden	Salmonid total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamprey	Salmon shark	Spiny dogfish	Dagger tooth saury	Pacific pommacke-fret	Atka rel	Square-tail	Other fishes	Sea-porpoise	Dall's birds					
31	7/12/08	5630	17600E	8.4	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	51	198	7	0	0	0	0	0	0	0	256	0	1	0	0	0	0	0	0	0	156	0	0	0	0	0	
					A	19	18	79	6	0	0	0	0	0	0	0	0	103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					Total		69	277	13	0	0	0	0	0	0	0	0	359	0	1	0	0	0	0	0	0	0	156	0	0	0	0	0
					Rel.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total					B	840	62	1724	62	90	21	0	9	2	1970	0	0	1	0	0	3	0	0	43	29	0	3	2	0				
					C	660	536	1948	343	83	44	0	6	0	2960	58	34	41	0	1	9	1	607	114	211	29	8	34	1				
					A	418	254	1594	301	64	22	1	9	0	2245	83	0	1	2	0	16	0	0	93	0	0	0	3	32	0			
					Total	1948	852	5266	706	237	87	1	24	2	7175	141	34	43	2	1	28	1	607	250	240	29	14	68	1				
					Rel.		52	1321	44	70	19	0	8	2	1516	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

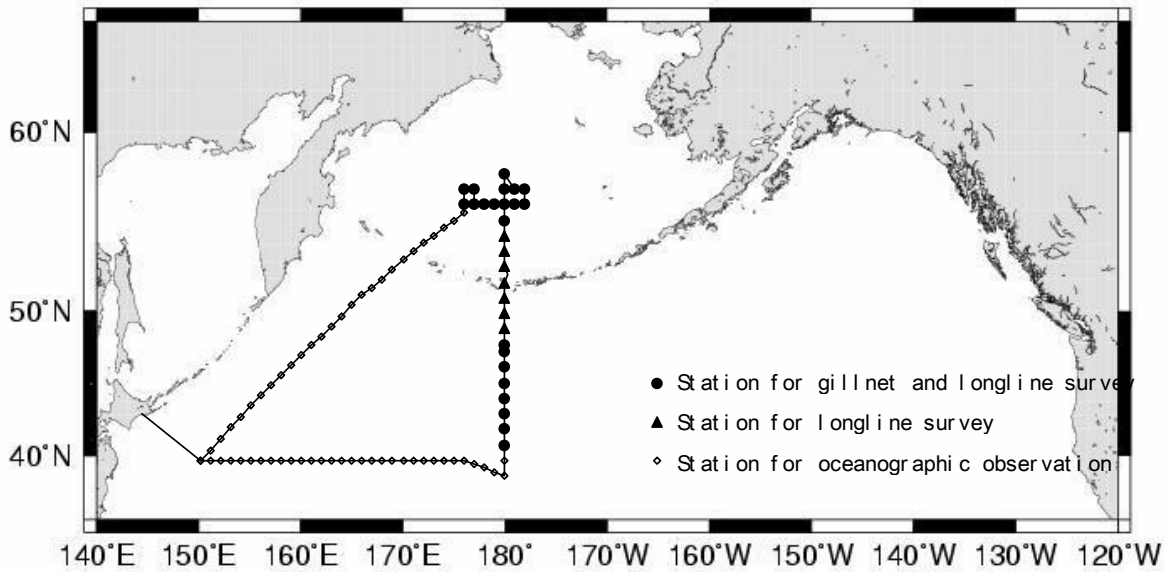


**Table 3.** Salmonids missing fins or tagged fish recovered in the catch of the *Wakatake maru*, summer, 2008. Gear: A = commercial-mesh gillnet; C = research-mesh gillnet followed by mesh size (mm); and B = surface longline. Clipped fin: Ad = adipose fin, RV = right ventral fin, LV = left ventral fin, D = dorsal fin, PIT = passive integrated transponder, – = no data.

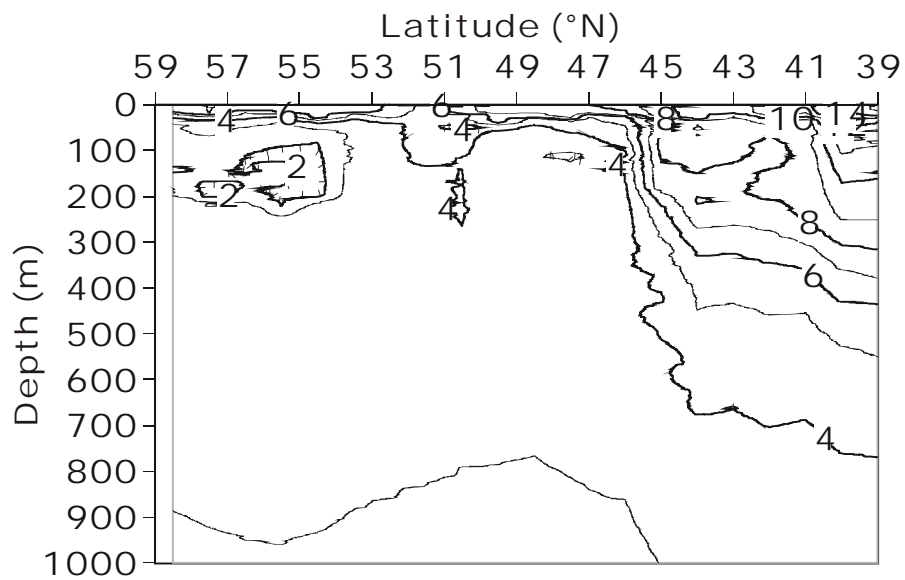
Date	Location		Gear	Species	Fork length (mm)	Body weight (g)	Sex	Gonad weight (g)	Age	Clipped fin / tag #	Sample #	Tag # of releases
	Lat.	Long.										
6/13/08	41°03'N	179°59'W	B	steelhead	829	-	-	-	x.3	Ad	1-3-1#1	LL6001, MM3001, NA0001
*6/14/08	42°04'N	179°57'W	B	steelhead	776	-	-	-	1.2	PIT tag #985120030555799	1-4-1#8	LL6008, MM3008, NA0008
6/15/08	42°00'N	180°00'	A115	steelhead	793	4760	M	1	1.2	Ad	13-10	
6/16/08	44°03'N	179°56'W	B	steelhead	529	-	-	-	x.1	Ad	1-6-2#19	LL6049, MM3049, NA0049
6/17/08	44°00'N	180°00'	C106	steelhead	560	1790	M	1	1.1	Ad	31-11	
6/17/08	45°02'N	179°55'W	B	steelhead	544	-	-	-	x.1	Ad	1-7-1#9	LL6069, MM3069, NA0069
6/17/08	45°02'N	179°55'W	B	steelhead	517	-	-	-	x.1	Ad	1-7-1#14	LL6074, MM3074, NA0074
6/18/08	45°00'N	180°00'	A115	steelhead	600	2030	M	5	1.1	Ad	39-10	
6/19/08	46°00'N	180°00'	A115	steelhead	705	3330	F	25	1.2	Ad	49-1	
6/19/08	46°00'N	180°00'	A115	steelhead	555	1600	F	12	1.1	Ad	49-2	
6/19/08	46°00'N	180°00'	C157	steelhead	847	6700	F	37	1.3	Ad	50-1	
6/19/08	47°05'N	179°54'W	B	coho	541	1780	F	26	3.1	Ad	51-7	
6/19/08	47°05'N	179°54'W	B	steelhead	518	-	-	-	1.1	Ad	1-9-3#18	LL6138, MM3138, NA0138
6/19/08	47°05'N	179°54'W	B	steelhead	814	-	-	-	1.2	Ad	1-9-3#19	LL6139, MM3139, NA0139
6/20/08	47°00'N	180°00'	C106	steelhead	549	1600	M	1	1.1	Ad, LV	55-14	
7/01/08	57°30'N	180°00'	C121	chum	662	3300	F	71	0.4	RV	-	
7/02/08	57°27'N	179°12'W	B	chum	535	-	-	-	0.3	D	-	LL6714, MM3714, NA0714
**7/09/08	56°30'N	177°00'E	A115	chum	457	1010	M	1	0.2	Disk tag #NA1240	-	

\* PIT tag hexadecimal code=3D9.1BF260EE97. The steelhead is a summer-run hatchery-reared steelhead PIT tagged as a smolt at the Lower Granite Dam on the Snake River, USA. For recovery details go to <http://www.ptagis.org/ptagis>

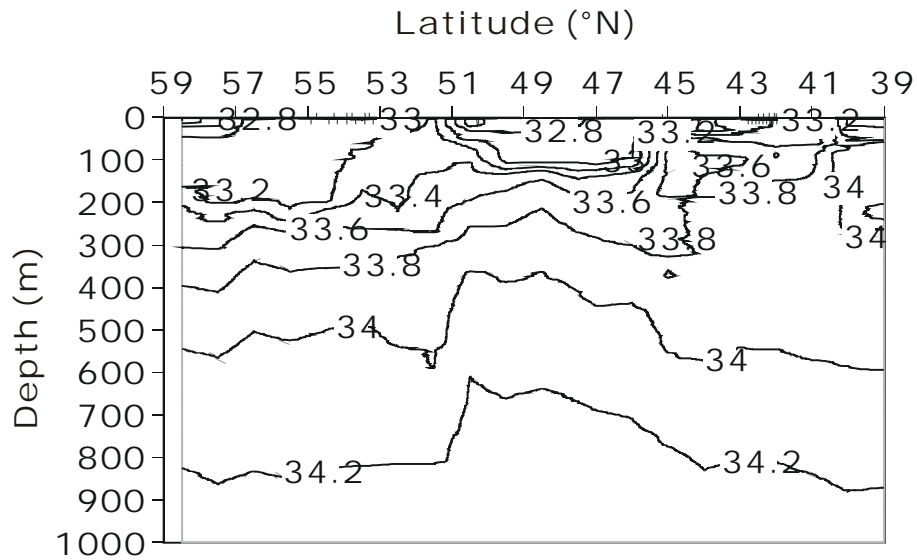
\*\* High-seas disk-tag recovery of a chum salmon tagged the previous evening (July 8, 2008) by the *Wakatake maru* at 56°32'N 177°06'E



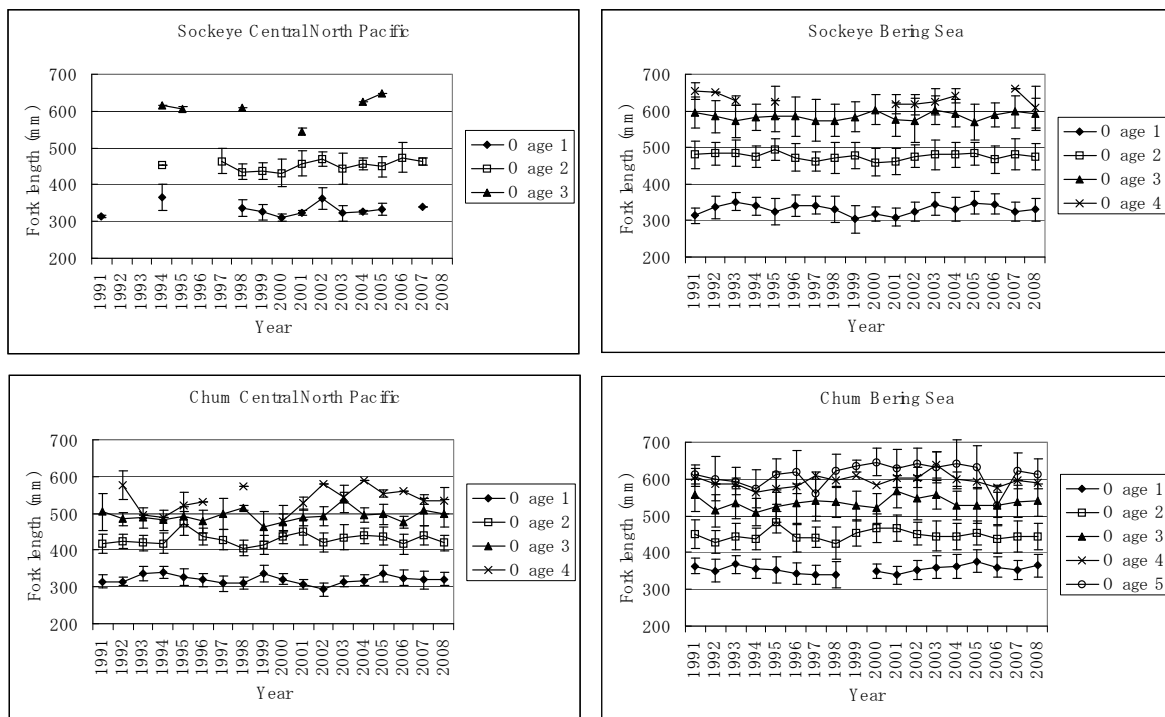
**Fig. 1.** Survey area of the R/V *Wakatake maru* salmon research cruise, summer 2008.



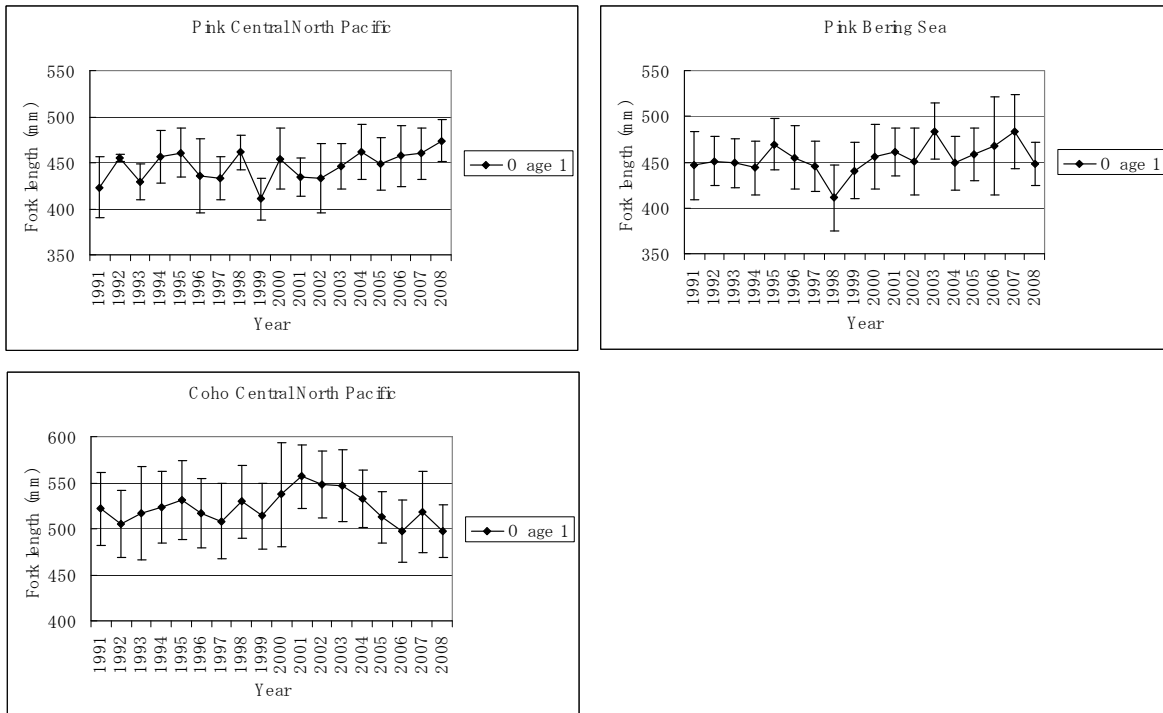
**Fig. 2.** Vertical section of water temperature ( $^{\circ}\text{C}$ ) along the  $180^{\circ}$  transect of the *Wakatake maru* cruise, 2008.



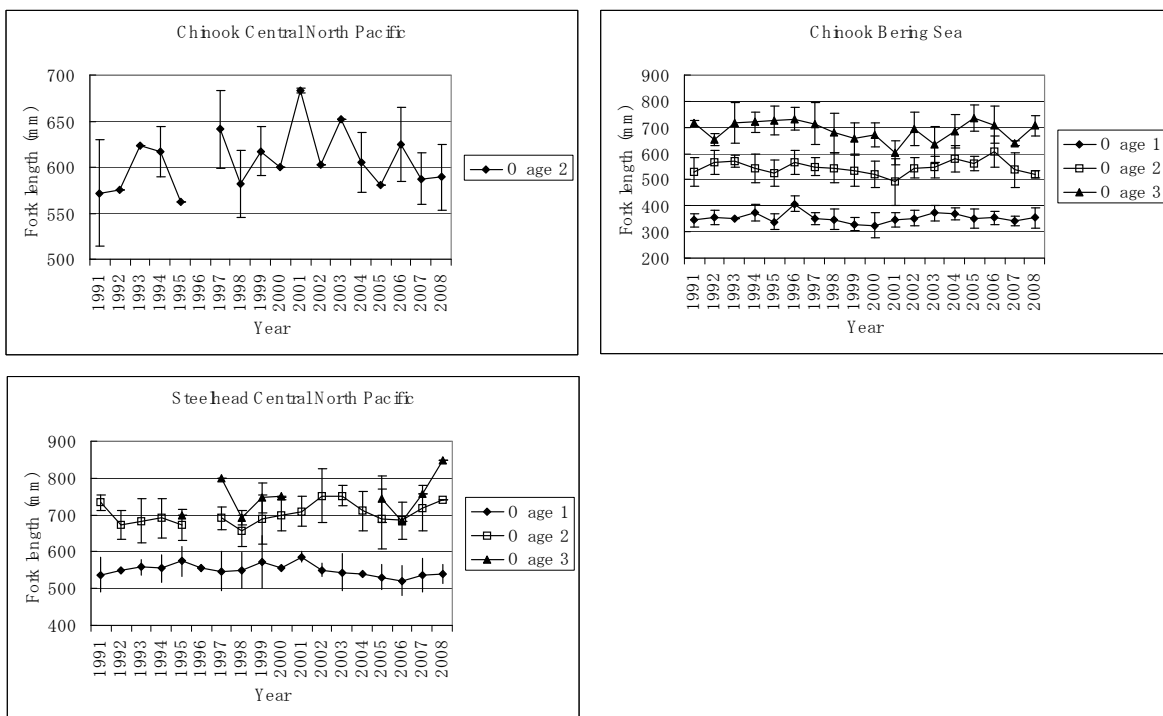
**Fig. 3.** Vertical section of salinity (psu) along the 180° transect of the *Wakatake maru* cruise, 2008.



**Fig. 4.** Mean fork length (+/- one standard deviation) at ocean age by year for sockeye and chum salmon caught in the research-mesh gillnet (C-gear), 1991-2008. Fish were caught in the central North Pacific and Bering Sea.



**Fig. 5.** Mean fork length ( $\pm$  one standard deviation) at ocean age by year for pink and coho salmon caught in the research-mesh gillnet (C-gear), 1991-2008. Fish were caught in the central North Pacific and Bering Sea.



**Fig. 6.** Mean fork length ( $\pm$  one standard deviation) at ocean age by year for chinook salmon and steelhead caught in the research-mesh gillnet (C-gear), 1991-2008. Fish were caught in the central North Pacific and Bering Sea.