

NPAFC

Doc. 716

Rev. _____

**International Salmon Research Aboard the R/V *Wakatake maru* in
the Central North Pacific Ocean and Bering Sea during the
Summer of 2003**

Masa-aki Fukuwaka

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

Nancy Davis

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

Takeshi Onuma and Aya Jodo

*Division of Biological Sciences, Graduate School of Science
Hokkaido University, Sapporo 060-0810, Japan*

Masaya Nomura

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

and

Sadamasa Tsuchiya

*Japan Marine Fishery Resource Research Center,
3-27 Kioi-cho, Chiyoda-ku, Tokyo 102-0094, Japan*

Submitted to the

NORTH PACIFIC ANADROMOUS FISH COMMISSION

by

JAPAN

October 2003

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:

Fukuwaka, M, N. Davis, T. Onuma, A. Jodo, M. Nomura, and S. Tsuchiya. 2003. International salmon research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea during the summer of 2003. (NPAFC Doc. 716). 21 p. Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro 085-0802, Japan.

International Salmon Research Aboard the R/V *Wakatake maru* in the Central North Pacific Ocean and Bering Sea during the Summer of 2003

Abstract

An annual high-seas salmonid research cruise was conducted in the central North Pacific Ocean and Bering Sea from June 7 to July 22, 2003 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 temperatures in the North Pacific were 0.4°C cooler than in 2002. However, in the Bering Sea, sea surface temperatures in 2003 were 0.5°C warmer than in 2002. A total of 12,725 salmonids was caught by longline and gillnet: 1,108 fish in the central North Pacific Ocean (St. 3-14) and 11,617 fish in the central Bering Sea (St. 15-31). In the North Pacific Ocean, pink salmon was the most abundant species (48.6% of the salmonid catch), followed by chum (25.0%), coho (20.2%), sockeye (4.2%), steelhead trout (1.4%), and chinook salmon (0.6%). In the Bering Sea, pink salmon was the most abundant species (76.4% of the salmonid catch), followed by chum (17.9%), sockeye (4.3%), chinook (1.3%), and coho salmon (0.1%). A total of 846 stomach samples was examined onboard the research vessel. Brain, pituitary, gonad, and blood samples were obtained from 140 chum salmon for endocrine studies. A total of 834 salmonids (579 pink, 166 chum, 30 coho, 29 chinook, 26 sockeye salmon, and 4 steelhead trout) were tagged with disk tags and released to the North Pacific Ocean and Bering Sea. These fish included 40 chum, 21 sockeye, 19 chinook, and 60 pink salmon, which were released carrying one of two different archival tags.

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) estimated that 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, salmonid, and higher trophic levels. This document summarizes the R/V *Wakatake maru* cruise conducted in these waters during June and July 2003.

Methods

Research Vessel and Survey Areas

The *Wakatake maru* (666 gross tons) departed Kushiro on June 7, 2003 and returned to Hakodate on July 22, 2003. 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 between stations. 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). 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°-latitude intervals between fishing stations (n = 51). The conductivity, temperature, and depth sensor (CTD) was used at 5°-longitude intervals along the eastward transit and at fishing stations (n = 39). The XCTD (expendable CTD) was used at 1°-longitude intervals on the return leg from the Bering Sea (n = 27). The CTD and XCTD record data in 1-m intervals from the surface to approximately 1000 m.

Primary Production

Chlorophyll samples were collected at 19 fishing stations (St. 3-21) along a south to north transect and at 12 transit stations located at an interval of 5° longitude (Fig. 1). A bucket was used to collect a surface water sample of which 100-ml was filtered through a 25-mm glass-fiber filter (Whatman GF/F) using a vacuum pump (100-120 mm Hg). Filters containing chlorophyll-a were soaked 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 6 transit stations located at intervals of 5° longitude from 150°E to 160°E. 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 position slightly off-center. Samples were fixed in 5% borax-buffered formalin in seawater.

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). 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. Samples were fixed in 10% borax-buffered formalin in seawater. When the ORI net collected more sample material than the capacity of the sample bottle, then the total volume was measured and a subsample was retained.

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). At eight fishing stations (St. 3-10) in the central North Pacific, the number of tans of A-gear was reduced from 19 to 17 tans, and two tans of smaller mesh size (F-gear: one tan each of 29 and 37 mm mesh size, one tan is 25 m long) were substituted in order to collect Pacific saury (*Cololabis saira*). 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 from a maximum of 60 individuals of each species from each mesh size (gillnet operation, mesh sizes = 11 or

13) and from a maximum of 60 individuals per species from longline mortalities. The biological data included fork length (FL, mm), body weight (BW, g), sex, and gonad weight (GW, g). One scale (pink salmon *O. gorbuscha*), two scales (sockeye *O. nerka*, chum, coho *O. kisutch*, and chinook salmon *O. tshawytscha*), or a scrape scale sample (steelhead *O. mykiss*) 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 were recorded (Nagasawa et al. 1997). 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 a coded-wire tag.

All non-salmonid catches were identified and counted by mesh size. Body lengths were measured for non-salmonid fish, squid, and other organisms, and a few were frozen for taxonomic and ecological studies. Frozen Pacific saury were sent to the Hokkaido Fisheries Experimental Station, Kushiro, neon flying squid (*Ommastrephes bartramii*) were sent to the National Research Institute of Far Seas Fisheries, Shimizu, and dead birds were sent to the Graduate School of Fisheries Science, Hokkaido University, Hakodate, for further examination. Salmon shark (*Lamna ditropis*) was measured for body length, and sexual maturity examined. Blood, cartilage, gonads, and DNA samples collected from salmon shark were sent to the School of Aquatic and Fishery Sciences, University of Washington, Seattle, for further analysis.

Salmonid Stomach Content Examination

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 a variety of research-mesh sizes and from the commercial mesh gillnet (C- and A-gear). These samples were examined while onboard the vessel. The 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 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.

Disk Tagging

Live salmon caught in a healthy condition were put into a recovery tank soon after removal from the longline. Fish were tagged with two disk tags issued by the Fisheries Agency of Japan (FAJ) and University of Washington (UW). Both 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.

Archival Tagging

Two types of externally-attached archival tags were used. One tag is manufactured by Lotek Marine Technologies, Newfoundland, Canada (model LTD 1100-300; size = 8mm x 16mm x 27mm; weight in air = 5 grams; number of records = 32,768) and records temperature and depth data. The sampling interval of the LTD tag depends on total recording time, which is referred as Time Extension Recording. The logger begins recording at a base sampling interval of 1 sample every 14.063 seconds. When its memory is full, the logger doubles its sampling interval and continues recording, overwriting every other sample in memory, and when its memory is filled at that sampling interval it doubles its sampling interval again. The process can repeat almost indefinitely. Another tag is a Thermonchron iButton data storage device, manufactured by Dallas Semiconductor, Inc., and repackaged for fish tagging by AlphaMach, Inc. (model iB4; size = 8 mm x 16 mm x 24 mm; weight in air = 3.8 grams; number of records = 2048). The iB4 records temperature data only. These types of tags were attached externally in the dorsal musculature of the fish anterior to the dorsal fin

with nickel pins.

Large-bodied sockeye, chum, and chinook salmon were selected for tagging with the Lotek LTD because they were likely to be maturing fish. Ibutton tags set to record at a 4.25 hour intervals were placed on immature sockeye, chum, and chinook salmon. Ibutton tags set to record at 1.5 hour intervals were placed on maturing sockeye, chum, chinook, and pink salmon.

Other Sampling and Research

The brain, pituitary, gonad, liver, and blood samples of chum salmon were collected for (1) molecular endocrine analysis of the spawning migration, including the role of salmon gonadotropin-releasing hormone (sGnRH) and (2) analysis of endocrinological changes of the fish during its spawning migration from the Bering Sea to Japan. Fish caught in a healthy condition were placed in a recovery tank soon after detachment from a longline hook. After removal from the tank, chum salmon length and weight were measured and a scale sample collected. Blood samples were collected from the caudal vasculature and centrifuged to obtain plasma samples for analyzing levels of steroid hormones. These samples were stored at -20°C . The gonad and liver were dissected out and weighed to calculate gonadosomatic index (GSI, gonad weight/body weight $\times 100$) and hepatosomatic index (HSI, liver weight/body weight $\times 100$). The brain and pituitary were hemisected and frozen in liquid nitrogen for determination of the level of mRNAs encoding hypothalamic hormones and pituitary hormones. In some fish, the olfactory nerve, olfactory epithelium, olfactory bulb, telencephalon, optic tectum, hypothalamus, cerebellum, and medulla oblongata were collected to investigate genes related to the homing migration. Several parts of the gonads and liver were frozen in liquid nitrogen to measure GnRH content, and to determine levels of mRNA encoding insulin-like growth factor I. Additional gonad samples were fixed in Bouin's solution and stored in 70% ethanol for histological analyses. All tissue samples were stored at -50°C .

In the central North Pacific Ocean and Bering Sea, a small number of other samples were collected. These samples included the collection of round samples of salmon, which might be a hybrid between chum and pink salmon, or unusual diseased fish. In addition, muscle samples were collected from a few of each salmonid species in order to establish a DNA baseline, so the salmonid species can be identified in various fish products.

The vertical distribution of zooplankton was examined at St 5, 9, 13, 17, 21, and 28. Video images of zooplankton in the water column were recorded at the surface, and at 10-m intervals to 50-m depth for 3 minutes at each depth. The video camera was manufactured by the Towa Electronics Factory, Hakodate, Japan. Images of zooplankton captured on video may be analyzed at Hokkaido University.

Results

Physical Oceanography

The position of oceanographic domains were identified along the 180° transect according to the seawater characteristics described by Dodimead et al. (1963) and Favorite et al. (1976). Stations 1 and 2 were located in the Transition Zone, an area characterized by relatively saline waters (> 34.0 psu). A vertical 34.0 psu isohaline characterizes the Subarctic Boundary, which separates subtropical and subarctic waters. The Boundary was located between 40°N (St. 2) and 41°N (St. 3). In 2003, the Subarctic Boundary was located at the same latitude that it was observed in 1997, 1998, and 2000, however, the Boundary was located 1° latitude south of its position in 1991-1996 and 2001 and 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). The southern limit of the Transition Domain is the Subarctic Boundary and

northern limit is delineated by cold water ($< 4^{\circ}\text{C}$) below 100 m depth in the central North Pacific. The Transition Domain was located between 40°N and 46°N (between St. 2 and St. 8). 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 $47^{\circ}30'\text{N}$ (St. 10). Further to the north, at $49^{\circ}30'\text{N}$ to $50^{\circ}30'\text{N}$ (Stations 12-13), the westward-flowing Alaska Current was observed. Fed by freshwater run-off, this current has warm ($> 4^{\circ}\text{C}$) and dilute (< 33.6 psu) waters at depths less than 100 m.

Station 14 was located in Amchitka Pass in the Aleutian Islands, one of several locations where North Pacific waters enter the Bering Sea. Stations north of $52^{\circ}00'\text{N}$ (St. 15 through St. 30) were located in the Bering Sea. The central Bering Sea 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 10 to 20 m.

In 2003, average sea surface temperatures in the North Pacific were 0.4°C cooler than in 2002 (St. 1-13; 2002 mean = 9.2°C , 2002 mean = 9.6°C). In the Bering Sea, sea surface temperatures in 2003 (St. 14-28; mean = 7.3°C) were 0.5°C warmer than in 2002 (mean = 6.8°C ; Tanaka et al. 2002).

Salmonid Catches

A total of 12,725 salmonids was caught by longline and gillnet: 1,108 fish in the central North Pacific Ocean (St. 3-14) and 11,617 fish in the central Bering Sea (St. 15-31; Table 2). In the North Pacific Ocean, pink salmon was the most abundant species (48.6% of the salmonid catch), followed by chum (25.0%), coho (20.2%), sockeye (4.2%), steelhead trout (1.4%) and chinook salmon (0.6%). In the Bering Sea, pink salmon was the most abundant species (76.4% of the salmonid catch), followed by chum (17.9%), sockeye (4.3%), chinook (1.3%), and coho salmon (0.1%). Abundance and body size variation by species are compared across years by Fukuwaka et al. (2003a).

Snout Recovery from Adipose Fin-clipped Salmonids

Three fin-clipped steelhead trout were caught in the central North Pacific Ocean. The snouts were salted and sent to the Auke Bay Laboratory, Juneau, AK, for dissection and potential recovery of coded-wire tags.

Non-salmonid Catches

Pacific saury ($n=1204$), Pacific pomfret (*Brama japonica*: $n=269$), and Atka mackerel (*Pleurogrammus monopterygius*: $n=126$) were particularly abundant in the catch (Table 2). In addition, 111 squids, two longnose lancetfish (*Alepisaurus ferox*), two walleye pollock (*Theragra chalcogramma*), one spiny dogfish (*Squalus acanthias*), and two salmon sharks were caught. Other non-salmonid fishes included in the catch were two Pacific lamprey (*Entosphenus tridentatus*), daggertooth (*Anotopterus pharao*), and black rockfish (*Sebastes melanops*).

Salmonid Stomach Content Examination

A total of 846 stomach samples was examined onboard the *Wakatake maru*. This total includes samples collected from 190 sockeye, 266 chum, 234 pink, 61 coho, and 83 chinook salmon, and 12 steelhead trout.

Common salmon prey organisms included squid (subadult *Berryteuthis anonychus*, and juveniles of several unidentified species), fish, including juvenile Atka mackerel, post-larval halibut (*Hippoglossus stenolepis*), *Atheresthes* sp., bathymasterids, irish lords (*Hemilepidotus* spp.), and adult northern lampfish (*Stenobranchius leucopsarus*). Common zooplankton prey included hyperiid amphipods (*Themisto pacifica*, *Primno abyssalis*, *Hyperia medusarum*, and

Phronima sedentaria), the euphausiid, *Thysanoessa longipes*, pteropods (*Limacina* and *Clione*), and copepods (*Neocalanus cristatus* CV). Chum salmon had the most varied diet and were observed to also feed on ctenophores (*Beroe* sp.) medusae, (*Aglantha digitale*), and *Oikopleura* sp.

Disk Tagging

A total of 834 tagged salmonids were released to the North Pacific Ocean (n = 145) and Bering Sea (n = 689; Table 2). The releases included 579 pink, 166 chum, 30 coho, 29 chinook, 26 sockeye salmon, and 4 steelhead trout. The tag release information is compiled in Fukuwaka et al. (2003b).

Archival Tagging

Archival tags were attached to a total of 140 salmonids with disk tags (Table 3). In the central North Pacific Ocean, 4 sockeye and 1 chinook were released with a LTD tag. In the Bering Sea, 14 maturing sockeye and 10 maturing chum salmon of Japanese or western Alaskan origins were tagged with a LTD tag, and 3 sockeye, 30 chum, 60 pink, and 18 chinook salmon were released carrying an iB4 archival tag.

Other Sampling and Research

Brain and pituitary samples were collected from a total of 140 chum salmon at fifteen stations (St. 14 – 28). Olfactory nerve and epithelium were collected from 24 chum salmon at St. 14 – 26 in the Bering Sea. Gonad, blood, and liver samples were collected from 116 chum salmon (gonad and liver) and 140 chum salmon (blood), respectively.

Based on external characteristics, 52 potential hybrids of chum and pink salmon were selected and kept as round samples. In addition, 43 chum and 50 pink salmon round samples were collected to compare morphological and genetic characteristics with the potential hybrids. Round samples were kept frozen and will be analyzed by scientists at the National Salmon Resources Center and Hokkaido University.

Other sampling and research included the collection of three round samples of pink salmon that appeared to be diseased for later pathological analysis, and collection of muscle samples from 21 sockeye, 21 chum, 20 pink, 22 coho, 20 chinook salmon, and 8 steelhead trout that will be used to establish a DNA baseline from which specific salmonid identification can be determined in various fish products.

Acknowledgements

We thank Captain Yuichi Murata and the officers, crew, teacher, and students of the R/V *Wakatake maru* for their cooperation in research and sample collections during the cruise.

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. *Amer. 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. Inter. 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. Inter. North Pac. Fish. Comm. Bull., 31: 187 p.
- 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, T. Azumaya, and T. Nagasawa. 2003a. Pacific salmon stock assessment in the North Pacific Ocean, 2001. (NPAFC Doc. 714). Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro 085-0802, Japan. 13 p.
- 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.
- 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.
- 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). 21 p. Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro 085-0802, Japan.
- Ueno, Y., N. D. Davis, M. Sasaki, and I. Tokuhira. 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 2003.

NO	ST	Date			Latitude		Longitude			XBT	XCTD	CTD	Primary	NORPAC	ORI	Gillnets	Longline	Remarks
		Year	Month	Day	North	East	North	East	North									
1	T-1	2003	6	8	40	0	150	0	E	○		○		○				
2	T-2	2003	6	8	40	0	151	0	E	○		○						
3	T-3	2003	6	9	40	0	152	0	E	○								
4	T-4	2003	6	9	40	0	153	0	E	○								
5	T-5	2003	6	9	40	0	154	0	E	○								
6	T-6	2003	6	9	40	0	155	0	E	○		○	○	○				
7	T-7	2003	6	9	40	0	156	0	E	○								
8	T-8	2003	6	9	40	0	157	0	E	○								
9	T-9	2003	6	10	40	0	158	0	E	○								
10	T-10	2003	6	10	40	0	159	0	E	○								
11	T-11	2003	6	10	40	0	160	0	E	○		○	○	○				
12	T-12	2003	6	10	40	0	161	0	E	○								
13	T-13	2003	6	10	40	0	162	0	E	○								
14	T-14	2003	6	10	40	0	163	0	E	○								
15	T-15	2003	6	11	40	0	164	0	E	○								
16	T-16	2003	6	11	40	0	165	0	E	○		○	○					
17	T-17	2003	6	11	40	0	166	0	E	○								
18	T-18	2003	6	11	40	0	167	0	E	○								
19	T-19	2003	6	11	40	0	168	0	E	○								
20	T-20	2003	6	11	40	0	169	0	E	○								
21	T-21	2003	6	12	40	0	170	0	E	○	○		○					
22	T-22	2003	6	12	40	0	171	0	E	○								
23	T-23	2003	6	12	40	0	172	0	E	○								
24	T-24	2003	6	12	40	0	173	0	E	○								
25	T-25	2003	6	12	40	0	174	0	E	○								
26	T-26	2003	6	13	40	0	175	0	E	○		○	○					
27	T-27	2003	6	13	40	0	176	0	E	○								
28	T-28	2003	6	13	39	45	177	0	E	○								
29	T-29	2003	6	13	39	30	178	0	E	○								
30	T-30	2003	6	13	39	15	179	0	E	○								
31	ST-1	2003	6	13	39	0	180	0		○		○						
32	T-31	2003	6	14	39	30	180	0		○								
33	ST-2	2003	6	14	40	0	180	0			○	○						
34	T-32	2003	6	14	40	30	180	0		○								
35	ST-3	2003	6	14	41	0	180	0			○	○	○	○	○	○		
36	T-33	2003	6	15	41	30	180	0		○								
37	ST-4	2003	6	15	42	0	180	0			○	○	○	○	○	○		
38	T-34	2003	6	16	42	30	180	0		○								
39	ST-5	2003	6	16	43	0	180	0			○	○	○	○	○	○		
40	T-35	2003	6	17	43	30	180	0		○								
41	ST-6	2003	6	17	44	0	180	0			○	○	○	○	○	○		
42	T-36	2003	6	18	44	30	180	0		○								
43	ST-7	2003	6	18	45	0	180	0			○	○	○	○	○	○		
44	T-37	2003	6	19	45	30	180	0		○								
45	ST-8	2003	6	19	46	0	180	0			○	○	○	○	○	○		
46	T-38	2003	6	20	46	30	180	0		○								
47	ST-9	2003	6	20	47	0	180	0			○	○	○	○	○	○		
48	ST-10	2003	6	21	47	30	180	0			○	○	○	○	○	○		
49	T-39	2003	6	22	48	0	180	0		○								
50	ST-11	2003	6	22	48	30	180	0			○	○	○	○	○	○		
51	T-40	2003	6	23	49	0	180	0		○								
52	ST-12	2003	6	23	49	30	180	0			○	○	○	○	○	○		
53	T-41	2003	6	24	50	0	180	0		○								
54	ST-13	2003	6	24	50	30	180	0			○	○	○	○	○	○		
55	T-42	2003	6	25	51	0	180	0		○								
56	ST-14	2003	6	25	51	30	179	55	W		○	○	○	○	○	○		
57	T-43	2003	6	26	52	0	179	40	W	○								
58	ST-15	2003	6	26	52	30	180	0			○	○	○	○	○	○		
59	T-44	2003	6	27	53	0	180	0		○								
60	ST-16	2003	6	27	53	30	180	0			○	○	○	○	○	○		
61	T-45	2003	6	28	54	0	180	0		○								
62	ST-17	2003	6	28	54	30	180	0			○	○	○	○	○	○		
63	T-46	2003	6	29	55	0	180	0		○								
64	ST-18	2003	6	29	55	30	180	0			○	○	○	○	○	○		
65	T-47	2003	6	30	56	0	180	0		○								
66	ST-19	2003	6	30	56	30	180	0			○	○	○	○	○	○		
67	T-48	2003	7	1	57	0	180	0		○								
68	ST-20	2003	7	1	57	30	180	0			○	○	○	○	○	○		
69	T-49	2003	7	2	58	0	180	0		○								
70	ST-21	2003	7	2	58	30	180	0			○	○	○	○	○	○		

Table 1. (continued)

NO	ST	Date			Latitude		Longitude			XBT	XCTD	CTD	Primary	NORPAC	ORI	Gillnets	Longline	Remarks
71	ST-22	2003	7	3	57	30	179	0	W			○		○	○	○	○	
72	ST-23	2003	7	4	57	30	178	0	W			○		○	○	○	○	
73	ST-24	2003	7	5	56	30	178	0	W			○		○	○	○	○	
74	ST-25	2003	7	6	56	30	179	0	W			○		○	○	○	○	
75	ST-26	2003	7	7	56	30	179	0	E			○		○	○	○	○	
76	ST-27	2003	7	8	56	30	178	0	E			○		○	○	○	○	
77	ST-28	2003	7	9	56	30	177	0	E			○		○	○	○	○	
78	ST-29	2003	7	10	57	30	177	0	E			○		○	○	○	○	
79	ST-30	2003	7	11	57	30	176	0	E			○		○	○	○	○	
80	ST-31	2003	7	12	56	30	176	0	E			○		○	○	○	○	
80	T-50	2003	7	13	56	0	176	0	E		○							
81	T-51	2003	7	13	55	30	175	0	E		○		○					
82	T-52	2003	7	13	55	0	174	0	E		○							
83	T-53	2003	7	13	54	30	173	0	E		○							
84	T-54	2003	7	13	54	0	172	0	E		○							
85	T-55	2003	7	14	53	30	171	0	E		○							
86	T-56	2003	7	14	53	0	170	0	E		○		○					
87	T-57	2003	7	14	52	20	169	0	E		○							
88	T-58	2003	7	14	51	40	168	0	E		○							
89	T-59	2003	7	14	51	10	167	0	E		○							
90	T-60	2003	7	14	50	40	166	0	E		○							
91	T-61	2003	7	15	50	0	165	0	E		○		○					
92	T-62	2003	7	15	49	20	164	0	E		○							
93	T-63	2003	7	15	48	40	163	0	E		○							
94	T-64	2003	7	15	48	0	162	0	E		○							
95	T-65	2003	7	15	47	30	161	0	E		○							
96	T-66	2003	7	15	46	50	160	0	E		○		○					
97	T-67	2003	7	16	46	10	159	0	E		○							
98	T-68	2003	7	16	45	30	158	0	E		○							
99	T-69	2003	7	16	44	50	157	0	E		○							
100	T-70	2003	7	16	44	10	156	0	E		○							
101	T-71	2003	7	17	43	30	155	0	E		○		○					
102	T-72	2003	7	17	42	50	154	0	E		○							
103	T-73	2003	7	17	42	10	153	0	E		○							
104	T-74	2003	7	17	41	20	152	0	E		○							
105	T-75	2003	7	17	40	40	151	0	E		○							

Table 2. Salmonids, other fishes, and squid catches at each station with sea surface temperature (SST, °C) during the summer research cruise of *Makatake maru*, 2003. B-gear, surface longline; C-gear, salmon research gillnet (meshes=48, 55, 63, 72, 82, 93, 106, 121, 138 and 157 mm); F-gear, small mesh research gillnet (meshes=29 and 37 mm); A-gear, commercial gillnet (mesh=115 mm). The number of fish tagged with disk tags and released is listed for each station.

St	Date	Lat	Long	SST	Gear	No. Soek unit eye	Chum	Pink	Coho	Chino		Salmonid Steel total	Squids	Pacific pomfret	Pacific saury	Pacific Lanacet fish	Sharks	Atka mackerel	Walleye pollock	Other fishes	Sea birds	Dall's porpoi se					
										ok	ok																
3	20030614	4100N	18000	11.9	B	30	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0				
					C	30	0	0	0	0	0	0	0	0	0	25	18	1	0	0	0	0	0	0	0		
					F	2	0	0	0	0	0	0	0	0	0	0	0	932	0	0	0	0	0	0	0	0	
					A	17	0	2	0	0	0	0	0	0	0	2	1	24	0	0	0	0	0	0	0	1	0
					Total		0	2	0	0	0	0	0	0	0	2	26	47	933	0	0	0	0	0	0	1	0
					Releases		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	20030615	4200N	18000	11.8	B	30	0	5	0	2	0	0	7	4	15	0	0	0	0	0	0	0	0				
					C	30	0	22	0	0	0	0	0	0	22	12	49	5	0	0	0	0	0	0	0		
					F	2	0	0	0	0	0	0	0	0	0	0	0	259	0	0	0	0	0	0	0	0	
					A	17	0	4	0	0	2	0	0	0	0	6	0	29	1	0	0	0	0	0	0	0	
					Total		0	31	0	4	0	0	0	0	0	35	16	93	265	0	0	0	0	0	0	0	0
					Releases		0	5	0	2	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
5	20030616	4300N	18000	8.4	B	30	0	3	0	25	0	3	31	1	42	0	0	0	0	0	0	0	0				
					C	30	0	5	1	39	0	1	46	6	61	0	0	0	0	0	0	0	0	0	5	0	
					F	2	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	
					A	17	0	3	0	71	1	2	77	0	34	0	0	0	0	0	0	0	0	0	0	4	0
					Total		0	11	1	135	1	6	154	7	137	6	0	0	0	0	0	0	0	0	0	9	0
					Releases		0	2	0	16	0	3	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	20030617	4400N	18000	8.1	B	30	0	1	0	12	0	0	13	0	0	0	0	0	0	0	0	0	0				
					C	30	0	3	2	26	0	3	34	6	0	0	0	0	0	0	0	0	0	0	2	0	
					F	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					A	17	0	2	2	33	2	3	42	0	0	0	0	0	0	0	0	0	0	0	0	0	
					Total		0	6	4	71	2	6	89	6	0	0	0	0	0	0	0	0	0	0	0	2	0
					Releases		0	1	0	9	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	20030618	4500N	18000	7.3	B	30	0	1	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0				
					C	30	0	59	6	1	0	0	66	5	0	0	0	0	0	0	0	0	0	0	0		
					F	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
					A	17	0	0	5	5	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0		
					Total		0	60	11	7	0	1	79	5	0	0	0	0	0	0	0	0	0	0	0	0	
					Releases		0	1	0	1	0	0	2	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	Chino ok	Steel total	Salmonid	Squids	Pacific pomfret	Pacific saury	Lancet fish	Sharks	Atka mackerel	Walleye pollock	Other fishes	Sea birds	Dall's porpoi se			
																								30	12	5
8	20030619	4600N	18000	6.5	B	30	0	5	3	0	0	1	9	0	0	0	1	0	0	0	0	0	0			
					C	30	12	38	41	2	0	2	95	5	0	0	0	0	0	0	0	0	0	0	0	
					A	19	1	34	59	1	0	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0
					Total	13	13	77	103	3	0	3	199	5	0	0	1	0	0	0	1	0	0	0	0	0
Releases																										
9	20030620	4700N	18000	6.6	B	30	1	11	4	0	1	0	17	0	0	0	0	0	0	0	0	0				
					C	30	9	21	53	2	1	0	86	11	0	0	0	0	0	0	0	0	0	0	0	
					A	19	2	21	63	0	1	0	87	1	0	0	1	0	0	0	0	0	0	0	0	0
					Total	12	12	53	120	2	3	0	190	12	0	0	1	0	0	0	0	1	0	0	0	0
Releases																										
10	20030621	4730N	18000	7	B	30	0	2	5	0	0	0	7	0	0	0	0	0	0	0	0	0				
					C	30	13	4	145	1	0	0	163	3	0	0	1	0	0	0	0	0	0	0	0	
					A	19	1	20	57	1	1	0	80	0	0	0	0	0	0	0	0	0	0	0	0	0
					Total	14	14	26	207	2	1	0	250	3	0	0	1	0	0	0	1	0	0	0	0	0
Releases																										
11	20030622	4830N	18000	6.6	B	30	1	0	18	0	0	0	19	0	0	0	0	0	0	0	0	0				
					Releases	1	1	0	13	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	
12	20030623	4930N	18000	7.2	B	30	3	3	12	0	0	0	18	0	0	0	0	0	0	0	0	0				
					Releases	3	3	3	8	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0		
					Total	14	14	26	207	2	1	0	250	3	0	0	1	0	0	0	1	0	0	0	0	0
13	20030624	5030N	18000	7.1	B	30	1	2	8	0	0	0	11	0	0	0	0	0	0	0	0	0				
					Releases	0	0	2	6	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	
14	20030625	5130N	18000	5.2	B	30	2	6	54	0	0	0	62	0	0	0	0	0	0	0	47	0				
					Releases	2	2	2	38	0	0	0	42	0	0	0	0	0	0	0	0	0	0	0		
					Total	13	13	26	207	2	1	0	250	3	0	0	1	0	0	0	1	0	0	0	0	
15	20030626	5230N	18000	5.9	B	30	2	4	113	0	0	0	119	0	0	0	0	0	0	0	14	0				
					Releases	1	1	1	94	0	0	0	96	0	0	0	0	0	0	0	0	0	0	0		
					Total	13	13	26	207	2	1	0	250	3	0	0	1	0	0	0	1	0	0	0	0	
16	20030627	5330N	18000	6.7	B	30	2	32	45	0	0	0	79	0	0	0	0	0	0	56	0	0				
					Releases	2	2	18	36	0	0	0	56	0	0	0	0	0	0	0	0	0	0	0		
					Total	13	13	26	207	2	1	0	250	3	0	0	1	0	0	0	1	0	0	0	0	
17	20030628	5430N	18000	6.5	B	30	3	55	77	0	0	0	135	0	0	0	0	0	0	0	0	0				
					Releases	2	2	29	49	0	0	0	80	0	0	0	0	0	0	0	0	0	0	0		

Table 2. (continued)

St	Date	Lat	Long	SST	Gear	No. sock unit eye	Chum	Pink	Coho	Chino	Steel	Salmonid total	Squids	pomfret	Pacific saury	Pacific fish	Lancet fish	Sharks	Atka mackerel	Walleye pollock	Other fishes	Sea birds	Dall's porpoi se							
																								Releases	Releases	Releases	Releases	Releases	Releases	Releases
18	20030629	5530N	18000	7.6	B	30	4	36	52	0	0	92	0	0	0	0	0	0	0	0	0	0								
					C	30	14	63	575	1	6	0	659	1	0	0	0	0	0	0	0	0	0	1	0					
					A	19	11	57	828	0	2	0	898	0	0	0	0	0	0	0	0	0	0	0	0	8	0			
					Total	29	156	1455	1	8	0	1649	1	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0		
					Releases	4	15	42	0	0	0	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
19	20030630	5630N	18000	7.3	B	30	1	18	23	0	1	43	0	0	0	0	0	0	0	0	0	0								
					C	30	10	46	362	1	3	0	422	4	0	0	0	0	0	0	0	0	0	0	3	0				
					A	19	15	86	465	0	1	0	567	0	0	0	0	0	0	0	0	0	1	0	0	28	0			
					Total	26	150	850	1	5	0	1032	4	0	0	0	0	0	0	0	0	0	1	0	0	0	31	0		
					Releases	1	8	15	0	1	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
20	20030701	5730N	18000	8.1	B	30	1	14	43	1	4	63	0	0	0	0	0	0	0	0	0	0								
					C	30	28	57	273	0	24	0	382	0	0	0	0	0	0	0	0	0	0	0	0	17	0			
					A	19	17	68	450	1	20	0	556	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0		
					Total	46	139	766	2	48	0	1001	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	0	
					Releases	1	1	29	0	4	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
21	20030702	5830N	18000	8.2	B	30	2	13	64	0	16	95	0	0	0	0	0	0	0	0	0	0								
					C	30	27	37	113	1	1	0	179	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0		
					A	19	15	72	245	0	2	0	334	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	
					Total	44	122	422	1	19	0	608	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0
					Releases	2	3	42	0	11	0	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	20030703	5730N	17900W	8.1	B	30	0	4	14	0	3	21	0	0	0	0	0	0	0	0	0	0								
					C	30	55	24	134	0	3	0	216	0	0	0	0	0	0	0	0	0	1	0	0	1	5	0		
					A	19	12	12	190	0	2	0	216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					Total	67	40	338	0	8	0	453	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	5	0	
					Releases	0	0	13	0	1	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	20030704	5730N	17800W	8	B	30	1	14	17	1	8	41	0	0	0	0	0	0	0	0	0	0								
					C	30	76	54	148	0	19	0	297	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
					A	19	22	77	186	0	16	0	301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					Total	99	145	351	1	43	0	639	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					Releases	1	1	13	1	8	0	24	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	Chino	Steel	Salmonid total	Squids	pomfret	Pacific saury	Pacific fish	Lancet	Sharks	Atka mackerel	Walleye	Other fishes	Sea birds	Dall's porpoi se						
																									Releases	Releases	Releases	Releases	Releases	Releases
24	20030705	5630N	17800W	8.1	B	30	2	48	26	0	0	0	76	0	0	0	0	0	0	0	0	0	0							
						C	30	25	116	174	0	2	0	0	317	1	0	0	0	0	0	0	0	0	2	0				
						A	19	16	137	329	1	0	0	483	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	
						Total	43	43	301	529	1	2	0	876	1	0	0	1	0	0	0	0	0	0	0	0	1	0	4	0
						Releases	1	1	20	19	0	0	0	40	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
25	20030706	5630N	17900W	7.9	B	30	0	31	27	0	0	0	58	0	0	0	0	0	0	0	0	0	0							
						C	30	11	43	162	0	2	0	218	14	0	0	0	0	0	0	0	0	0	0	4	0			
						A	19	3	30	244	1	1	0	279	0	0	0	0	0	0	0	0	0	0	0	0	1	0		
						Total	14	14	104	433	1	3	0	555	14	0	0	14	0	0	0	0	0	0	0	0	0	5	0	
						Releases	0	0	20	19	0	0	0	39	0	0	0	39	0	0	0	0	0	0	0	0	0	0	0	0
26	20030707	5630N	17900E	8.6	B	30	1	21	40	0	0	0	62	0	0	0	0	0	0	0	0	0	0							
						C	30	8	60	203	0	2	0	273	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	
						A	19	8	35	355	0	0	0	398	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	
						Total	17	17	116	598	0	2	0	733	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5	0
						Releases	0	0	2	33	0	0	0	35	0	0	0	35	0	0	0	0	0	0	0	0	0	0	0	0
27	20030708	5630N	17800E	7.6	B	30	2	30	29	1	0	0	62	0	0	0	0	0	0	0	0	0	0							
						C	30	14	85	266	0	0	0	365	0	0	0	0	0	0	0	0	0	0	0	0	2	0		
						A	19	12	51	358	0	1	0	422	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	
						Total	28	28	166	653	1	1	0	849	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
						Releases	2	2	8	23	1	0	0	34	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0
28	20030709	5630N	17700E	7.9	B	30	0	9	3	0	0	0	12	0	0	0	0	0	0	0	0	0	0							
						C	30	9	88	207	0	0	0	304	7	0	0	0	0	0	0	0	0	0	1	0	0	4	0	
						A	19	5	41	394	0	0	0	440	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	
						Total	14	14	138	604	0	0	0	756	7	0	0	0	0	0	0	0	0	0	0	1	0	1	8	0
						Releases	0	0	3	3	0	0	0	6	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
29	20030710	5730N	17700E	8.6	B	30	1	15	44	0	5	0	65	0	0	0	0	0	0	0	0	0	0							
						C	30	11	69	230	0	1	0	311	0	0	0	0	0	0	0	0	0	0	1	0	0	11	0	
						A	19	9	35	413	0	5	0	462	0	0	0	0	0	0	0	0	0	0	1	0	1	5	0	
						Total	21	21	119	687	0	11	0	838	0	0	0	0	0	0	0	0	0	0	0	2	0	1	16	0
						Releases	1	1	4	31	0	3	0	39	0	0	0	39	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. (continued)

St	Date	Lat	Long	SST	Gear	No. sock unit eye	Chum	Pink	Coho	Chino ok	Steel total	Salmonid	Squids	pomfret	Pacific saury	Pacific fish	Lancet fish	Sharks	Atka mackerel	Walleye polllock	Other fishes	Sea birds	Dall's porpoi se					
																								Releases	Releases	Releases	Releases	Releases
30	20030711	5730N	17600E	8.2	B	30	0	10	49	0	0	0	59	0	0	0	0	0	0	0	0	0	0					
					C	30	9	90	172	2	1	0	0	274	0	0	0	0	0	0	0	0	0	0	0			
					A	19	8	38	326	0	0	0	0	372	0	0	0	0	0	0	0	0	0	0	0	0		
					Total	17	17	138	547	2	1	0	0	705	0	0	0	0	0	0	0	0	0	1	1	1	1	
					Releases	0	0	2	40	0	0	0	0	42														
31	20030712	5630N	17600E	7.9	B	30	1	8	5	0	0	0	14	0	0	0	0	0	0	0	0	0						
					C	30	16	114	167	0	1	0	0	298	0	0	0	0	0	0	0	0	1	0	0	0		
					A	19	8	30	239	1	0	0	0	278	0	0	0	0	0	0	0	0	0	0	0	1	0	
					Total	25	25	152	411	1	1	0	0	590	0	0	0	0	0	0	0	0	0	1	0	0	1	0
					Releases	1	1	0	4	0	0	0	0	5														
Total						870	31	401	775	43	38	4	1292	5	62	0	1	1	1	117	0	1	2	0				
						C	660	347	1098	3434	76	66	6	5027	104	128	6	1	0	6	0	1	84	0				
						F	8	0	0	0	0	0	0	0	0	1197	0	0	0	0	0	0	0	0				
						A	408	165	855	5208	117	55	6	6406	2	87	1	0	2	3	3	2	2	108	1			
						Total	543	2354	9417	236	159	16	12725	111	277	1204	2	2	3	126	2	4	194	1				
						Releases	26	166	579	30	29	4	834															

Table 3. Archival tag releases in the central North Pacific Ocean and Bering Sea in June and July 2003. FAJ, Fisheries Agency of Japan; FRI, Fisheries Research Institute, University of Washington.

Archival tag no.	Disk tag number			Release site			Species	Fork length (mm)	Age	
	FAJ	FRI	Date	Station	Latitude	Longitude			F	O
iB#1	Z5587	LL6187	6/26/2003	15	5230N	18000	pink	594	0	1
iB#2	Z5588	LL6188	6/26/2003	15	5230N	18000	pink	474	0	1
iB#3	Z7349	LL6449	6/30/2003	19	5630N	18000	chum	660	0	4
iB#4	Z5586	LL6186	6/26/2003	15	5230N	18000	pink	456	0	1
iB#5	Z7352	LL6452	6/30/2003	19	5630N	18000	chum	574	0	3
iB#6	Z7358	LL6458	6/30/2003	19	5630N	18000	chum	633	0	4
iB#7	Z5576	LL6176	6/26/2003	15	5230N	18000	pink	521	0	1
iB#8	Z7198	LL6298	6/27/2003	16	5330N	18000	chum	460	0	2
iB#9	Z7337	LL6437	6/29/2003	18	5530N	18000	chum	510	0	3
iB#10	Z7379	LL6479	7/1/2003	20	5730N	18000	chinook	528	1	2
iB#11	Z7396	LL6496	7/1/2003	20	5730N	18000	chinook	509	X	X
iB#12	Z7199	LL6299	6/27/2003	16	5330N	18000	chum	505	0	3
iB#13	Z7276	LL6376	6/28/2003	17	5430N	18000	chum	538	0	3
iB#14	Z7397	LL6497	7/1/2003	20	5730N	18000	chinook	511	X	2
iB#15	Z7418	LL6518	7/2/2003	21	5830N	18000	chinook	353	1	1
iB#16	Z7420	LL6520	7/2/2003	21	5830N	18000	chinook	560	1	2
iB#17	Z7320	LL6420	6/29/2003	18	5530N	18000	sockeye	544	2	3
iB#19	Z7398	LL6498	7/1/2003	20	5730N	18000	chinook	561	1	2
iB#20	Z7169	LL6269	6/27/2003	16	5330N	18000	sockeye	486	1	2
iB#21	Z7436	LL6536	7/2/2003	21	5830N	18000	chinook	344	X	1
iB#22	Z7197	LL6297	6/27/2003	16	5330N	18000	chum	454	0	2
iB#23	Z7275	LL6375	6/28/2003	17	5430N	18000	chum	465	0	2
iB#24	Z7360	LL6460	6/30/2003	19	5630N	18000	chum	560	0	3
iB#25	Z7400	LL6500	7/1/2003	20	5730N	18000	chum	659	0	4
iB#26	Z7456	LL6556	7/2/2003	21	5830N	18000	chum	569	0	3
iB#28	Z7406	LL6506	7/2/2003	21	5830N	18000	chum	610	0	4
iB#29	Z7365	LL6465	6/30/2003	19	5630N	18000	chinook	740	1	3
iB#30	Z7573	LL6673	7/6/2003	25	5630N	17900W	chum	542	0	3
iB#31	Z7454	LL6554	7/2/2003	21	5830N	18000	sockeye	587	2	3
iB#32	Z7571	LL6671	7/6/2003	25	5630N	17900W	chum	590	0	3
iB#33	Z7437	LL6537	7/2/2003	21	5830N	18000	chinook	572	X	X
iB#34	Z7468	LL6568	7/3/2003	22	5730N	17900W	chinook	516	X	2
iB#35	Z7479	LL6579	7/4/2003	23	5730N	17800W	chinook	528	X	2
iB#36	Z7489	LL6589	7/4/2003	23	5730N	17800W	chum	411	0	2
iB#37	Z7490	LL6590	7/4/2003	23	5730N	17800W	chinook	526	1	2
iB#38	Z7491	LL6591	7/4/2003	23	5730N	17800W	chinook	563	X	2
iB#39	Z7492	LL6592	7/4/2003	23	5730N	17800W	chinook	509	X	X
iB#40	Z7493	LL6593	7/4/2003	23	5730N	17800W	chinook	528	1	2
iB#41	Z7498	LL6598	7/5/2003	24	5630N	17800W	chum	515	0	3
iB#42	Z7505	LL6605	7/5/2003	24	5630N	17800W	chum	573	0	3
iB#43	Z7507	LL6607	7/5/2003	24	5630N	17800W	chum	526	0	3
iB#44	Z7516	LL6616	7/5/2003	24	5630N	17800W	chum	576	0	4
iB#45	Z7535	LL6635	7/5/2003	24	5630N	17800W	chum	536	0	3
iB#46	Z7572	LL6672	7/6/2003	25	5630N	17900W	chum	480	0	2
iB#47	Z7574	LL6674	7/6/2003	25	5630N	17900W	chum	505	0	3
iB#48	Z7575	LL6675	7/6/2003	25	5630N	17900W	chum	498	0	3
iB#50	Z7611	LL6711	7/8/2003	27	5630N	17800E	chum	492	0	2
iB#52	Z7621	LL6721	7/8/2003	27	5630N	17800E	chum	475	0	2
iB#53	Z7642	LL6742	7/8/2003	27	5630N	17800E	chum	580	0	3
iB#54	Z7661	LL6761	7/10/2003	29	5730N	17700E	chinook	568	X	X
iB#55	Z7674	LL6774	7/10/2003	29	5730N	17700E	chum	537	0	3
iB#56	Z7670	LL6770	7/10/2003	29	5730N	17700E	chum	548	0	3
iB#57	Z7686	LL6786	7/10/2003	29	5730N	17700E	chum	598	0	3
iB#58	Z7688	LL6788	7/10/2003	29	5730N	17700E	chinook	588	1	2
iB#59	Z7689	LL6789	7/10/2003	29	5730N	17700E	chinook	561	1	2
iB#60	Z7180	LL6280	6/27/2003	16	5330N	18000	pink	462	0	1
iB#61	Z7181	LL6281	6/27/2003	16	5330N	18000	pink	460	0	1

Table 3. (continued)

Archival tag no.	Disk tag number		Date	Release site			Species	Fork length (mm)	Age	
	F AJ	F RI		Station	Latitude	Longitude			F	O
iB#62	Z7167	LL6267	6/27/2003	16	5330N	18000	pink	464	0	1
iB#63	Z7166	LL6266	6/27/2003	16	5330N	18000	pink	486	0	1
iB#64	Z7208	LL6308	6/28/2003	17	5430N	18000	pink	471	0	1
iB#65	Z7206	LL6306	6/28/2003	17	5430N	18000	pink	495	0	1
iB#66	Z7201	LL6301	6/28/2003	17	5430N	18000	pink	468	0	1
iB#67	Z7205	LL6305	6/28/2003	17	5430N	18000	pink	462	0	1
iB#68	Z7290	LL6390	6/29/2003	18	5530N	18000	pink	484	0	1
iB#69	Z7291	LL6391	6/29/2003	18	5530N	18000	pink	452	0	1
iB#70	Z7350	LL6450	6/30/2003	19	5630N	18000	pink	538	0	1
iB#71	Z7367	LL6467	7/1/2003	20	5730N	18000	pink	490	0	1
iB#72	Z7281	LL6381	6/29/2003	18	5530N	18000	pink	484	0	1
iB#73	Z7354	LL6454	6/30/2003	19	5630N	18000	pink	499	0	1
iB#74	Z7348	LL6448	6/30/2003	19	5630N	18000	pink	440	0	1
iB#75	Z7368	LL6468	7/1/2003	20	5730N	18000	pink	547	0	1
iB#76	Z7280	LL6380	6/29/2003	18	5530N	18000	pink	482	0	1
iB#77	Z7353	LL6453	6/30/2003	19	5630N	18000	pink	528	0	1
iB#78	Z7366	LL6466	7/1/2003	20	5730N	18000	pink	518	0	1
iB#79	Z7369	LL6469	7/1/2003	20	5730N	18000	pink	560	0	1
iB#80	Z7377	LL6477	7/1/2003	20	5730N	18000	pink	548	X	X
iB#82	Z7403	LL6503	7/2/2003	21	5830N	18000	pink	452	0	1
iB#83	Z7407	LL6507	7/2/2003	21	5830N	18000	pink	490	0	1
iB#84	Z7408	LL6508	7/2/2003	21	5830N	18000	pink	495	0	1
iB#85	Z7409	LL6509	7/2/2003	21	5830N	18000	pink	472	0	1
iB#86	Z7419	LL6519	7/2/2003	21	5830N	18000	pink	431	0	1
iB#87	Z7459	LL6559	7/3/2003	22	5730N	17900W	pink	495	0	1
iB#88	Z7460	LL6560	7/3/2003	22	5730N	17900W	pink	500	0	1
iB#89	Z7463	LL6563	7/3/2003	22	5730N	17900W	pink	467	0	1
iB#90	Z7464	LL6564	7/3/2003	22	5730N	17900W	pink	460	0	1
iB#91	Z7465	LL6565	7/3/2003	22	5730N	17900W	pink	501	0	1
iB#92	Z7473	LL6573	7/4/2003	23	5730N	17800W	pink	479	0	1
iB#93	Z7474	LL6574	7/4/2003	23	5730N	17800W	pink	505	0	1
iB#94	Z7483	LL6583	7/4/2003	23	5730N	17800W	pink	475	0	1
iB#95	Z7484	LL6584	7/4/2003	23	5730N	17800W	pink	477	0	1
iB#96	Z7487	LL6587	7/4/2003	23	5730N	17800W	pink	473	0	1
iB#97	Z7497	LL6597	7/5/2003	24	5630N	17800W	pink	493	0	1
iB#98	Z7499	LL6599	7/5/2003	24	5630N	17800W	pink	545	0	1
iB#99	Z7508	LL6608	7/5/2003	24	5630N	17800W	pink	493	0	1
iB#100	Z7510	LL6610	7/5/2003	24	5630N	17800W	pink	446	X	X
iB#101	Z7537	LL6637	7/6/2003	25	5630N	17900W	pink	500	0	1
iB#102	Z7538	LL6638	7/6/2003	25	5630N	17900W	pink	504	0	1
iB#103	Z7552	LL6652	7/6/2003	25	5630N	17900W	pink	490	0	1
iB#104	Z7554	LL6654	7/6/2003	25	5630N	17900W	pink	512	0	1
iB#106	Z7576	LL6676	7/7/2003	26	5630N	17900E	pink	455	0	1
iB#107	Z7577	LL6677	7/7/2003	26	5630N	17900E	pink	474	0	1
iB#108	Z7578	LL6678	7/7/2003	26	5630N	17900E	pink	507	0	1
iB#109	Z7586	LL6686	7/7/2003	26	5630N	17900E	pink	468	0	1
iB#110	Z7618	LL6718	7/8/2003	27	5630N	17800E	pink	493	0	1
iB#111	Z7619	LL6719	7/8/2003	27	5630N	17800E	pink	465	0	1
iB#112	Z7620	LL6720	7/8/2003	27	5630N	17800E	pink	514	0	1
iB#113	Z7622	LL6722	7/8/2003	27	5630N	17800E	pink	531	0	1
iB#114	Z7646	LL6746	7/9/2003	28	5630N	17700E	pink	520	0	1
iB#115	Z7649	LL6749	7/9/2003	28	5630N	17700E	pink	486	0	1
iB#116	Z7651	LL6751	7/10/2003	29	5730N	17700E	pink	478	0	1
iB#117	Z7652	LL6752	7/10/2003	29	5730N	17700E	pink	510	0	1
LTD#0034	Z7635	LL6735	7/8/2003	27	5630N	17800E	chum	710	0	5
LTD#0054	Z7638	LL6738	7/8/2003	27	5630N	17800E	chum	545	0	3
LTD#0132	Z7640	LL6740	7/8/2003	27	5630N	17800E	chum	652	0	4
LTD#0188	Z7645	LL6745	7/9/2003	28	5630N	17700E	chum	593	X	X
LTD#941	Z7648	LL6748	7/9/2003	28	5630N	17700E	chum	641	0	3
LTD#1348	Z7675	LL6775	7/10/2003	29	5730N	17700E	sockeye	600	2	3

Table 3. (continued)

Archival tag no.	Disk tag number		Date	Release site			Species	Fork length (mm)	Age	
	F AJ	F RI		Station	Latitude	Longitude			F	O
LTD#1396	Z7684	LL6784	7/10/2003	29	5730N	17700E	chum	631	0	5
LTD#1603	Z7647	LL6747	7/9/2003	28	5630N	17700E	chum	564	0	3
LTD#1607	Z5454	LL6054	6/20/2003	9	4700N	18000	chinook	801	1	3
LTD#1635	Z5473	LL6073	6/22/2003	11	4830N	18000	sockeye	612	1	3
LTD#1651	Z5489	LL6089	6/23/2003	12	4930N	18000	sockeye	574	2	3
LTD#1658	Z5494	LL6094	6/23/2003	12	4930N	18000	sockeye	672	1	3
LTD#1666	Z5495	LL6095	6/23/2003	12	4930N	18000	sockeye	626	X	3
LTD#1668	Z5535	LL6135	6/25/2003	14	5130N	18000	sockeye	588	1	3
LTD#1672	Z7105	LL6205	6/26/2003	15	5230N	18000	sockeye	690	2	3
LTD#1674	Z7131	LL6231	6/26/2003	15	5230N	18000	chum	534	0	3
LTD#1680	Z7168	LL6268	6/27/2003	16	5330N	18000	sockeye	557	2	2
LTD#1685	Z7260	LL6360	6/28/2003	17	5430N	18000	sockeye	519	1	2
LTD#1688	Z7309	LL6409	6/29/2003	18	5530N	18000	sockeye	619	2	3
LTD#1689	Z7310	LL6410	6/29/2003	18	5530N	18000	sockeye	648	2	3
LTD#1692	Z7341	LL6441	6/30/2003	19	5630N	18000	sockeye	592	2	3
LTD#1695	Z7380	LL6480	7/1/2003	20	5730N	18000	sockeye	612	2	3
LTD#1697	Z7417	LL6517	7/2/2003	21	5830N	18000	sockeye	602	2	3
LTD#1702	Z7480	LL6580	7/4/2003	23	5730N	17800W	sockeye	566	1	3
LTD#1707	Z7519	LL6619	7/5/2003	24	5630N	17800W	sockeye	574	2	2
LTD#1709	Z7606	LL6706	7/7/2003	26	5630N	17900E	chum	595	X	X
LTD#1714	Z7610	LL6710	7/7/2003	26	5630N	17900E	chum	648	0	4
LTD#1923	Z7623	LL6723	7/8/2003	27	5630N	17800E	sockeye	541	2	2
LTD#1958	Z7630	LL6730	7/8/2003	27	5630N	17800E	sockeye	496	2	2

Table 4. Number of tissue samples collected from chum salmon for endocrine studies during the summer research cruise of *Wakatake maru*, 2003.

Station no.	Olfactory nerve	Olfactory epithelium	Brain	Pituitary	Gonad	Liver	Blood
14	1	1	1	1			1
15	1	1	3	3	2	2	3
16	2	2	10	10	8	8	10
17	2	2	10	10	8	8	10
18	2	2	12	12	10	10	12
19	2	2	7	7	5	5	7
20	2	2	9	9	7	7	9
21	2	2	9	9	7	7	9
22	2	2	4	4	2	2	4
23	2	2	11	11	9	9	11
24	2	2	13	13	11	11	13
25	2	2	5	5	3	3	5
26	2	2	10	10	8	8	10
27					10	10	10
28					5	5	5
29					8	8	8
30					6	6	6
31					7	7	7
Total	24	24	104	104	116	116	140

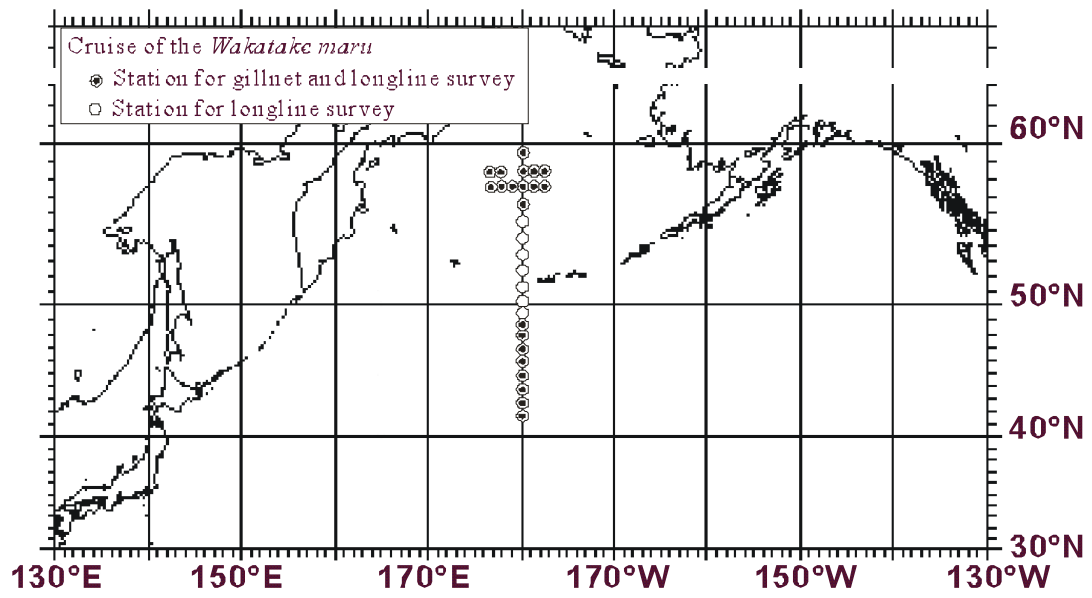


Fig. 1. Cruise of the summer 2003 research cruise of the R/V *Wakatake maru*.