

**International Salmon Research Aboard the R/V *Wakatake maru* in
the Central North Pacific Ocean and Bering Sea during the
Summer of 2010**

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Abstract

An annual high-seas salmonid research cruise was conducted in the central North Pacific Ocean and Bering Sea from June 10 to July 19, 2010, 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 2010 was 8.3°C, which was cooler by 1°C than the average temperature in 2009. The Subarctic Boundary was located between 41°N and 42°N, which was further north of its position in 17 of the previous 19 years. In the central Bering Sea, average sea surface temperature in 2010 was 6.5°C, which was 0.1°C warmer than in 2009. At 24 experimental fishing stations, a total of 5,816 salmonids was caught by longline and gillnet: 790 fish in the central North Pacific and 5,026 fish in the central Bering Sea. In the central North Pacific, coho salmon was the most abundant species (46.6% of the salmonid catch), followed by chum (31.9%), pink (10.1%), steelhead (6.6%), sockeye (3.3%), and chinook salmon (1.5%). In the Bering Sea, chum salmon was the most abundant species (81.3% of the salmonid catch), followed by sockeye (15.5%), pink (2.2%), chinook (1.0%), and coho salmon (0.02%). A total of 1,401 salmonids was disk tagged during the survey, which included 18 sockeye, 102 chum, 21 pink, 84 coho, and one chinook salmon, and nine steelhead released in the central North Pacific and 74 sockeye, 1,067 chum, 14 pink, and 11 chinook salmon released in the Bering Sea. Snouts from 14 adipose fin-clipped steelhead were collected for later potential recovery of coded-wire tags. Other salmonid research activities included sampling for total lipid content, otolith thermal marks, genetic stock identification, food habits, and stable isotopes.

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 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. A recent study of chum salmon in the 1990s and 2000s has shown ocean growth and body size at maturity has reversed direction (increased) and recovered to pre-1970s levels (Fukuwaka et al. 2007). 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, 2010.

Methods

Research Vessel and Survey Areas

The *Wakatake maru* (666 gross tons) began the cruise when she departed Kushiro on June 10, 2010, and completed it when she returned to Kushiro on July 19, 2010. There were 24 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, five 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, 2008, Kaga and Davis 2009). 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 = 38).

Primary Production

Surface seawater was collected with a bucket to sample chlorophyll at fishing station numbers 1 to 21 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 24 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 24 fishing stations using an Ocean Research Institute (ORI) net (1.60 m diameter, 7.5 m in overall length, 0.67 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. After the ORI net towing operations 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 9 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 24 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

At each station, the total catch of salmonids was counted and sorted by species and mesh size (for gillnet catches) and by species from longline mortalities. Routine salmonid examination consisted of determining fork length (FL, mm), body weight (BW, g), sex, and gonad weight (GW, g), and collecting scale samples from 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 and visceral adhesions was recorded (Nagasawa et al. 1997), and fish 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 and from longline mortalities. Body length was determined for non-salmonid fish, squid, and other organisms up to a maximum of 30 per species by mesh size. 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 Tagging

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

Other Sampling and Research

In the Bering Sea sockeye, chum, and pink salmon were frozen after removal of the gut for later analysis of total lipid content as a measure of their body condition. After routine fish examination heads of all chum salmon caught in the research mesh gillnet were frozen for later detection of otolith thermal marks and analysis of tissues for genetic stock identification.

Salmonid stomach samples were collected from all chinook salmon and steelhead trout. These samples were frozen for later laboratory analysis. In the Bering Sea chinook salmon round samples were frozen for later collection and analyses of stomach contents, gonad maturity, stable isotopes, and lipid content.

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 2 and 3 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 41°N (St. 3) and 42°N (St. 4). The position of the Subarctic Boundary in 2010 was one degree further north than observed during cruises in 1991 to 2005 and 2007 to 2008, and one degree further south than in 2009 (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, 2007, 2008, Kaga and Davis 2009). 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 ($< 4^{\circ}\text{C}$) shoaling to near of just below 100 m depth in the central North Pacific. The Transition Domain was located between 41°N and 47°N (between St. 3 and 9; 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 $49^{\circ}30'\text{N}$ (St. 12). Further to the north, the westward-flowing Alaska Current, identified by warm ($> 4^{\circ}\text{C}$) and dilute (< 33.6 psu) freshwater run-off at depths less than 100 m, was located between $48^{\circ}30'\text{N}$ (St. 11) and $51^{\circ}30'\text{N}$ (St. 14).

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 ($52^{\circ}30'\text{N}$, $180^{\circ}00'$) was located on the relatively shallow (~ 300 m depth) Bowers Bank and stations north of $52^{\circ}30'\text{N}$ (St. 16 through St. 27) 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 2010, average sea surface temperature in the central North Pacific was 8.3°C , which was 1°C cooler than the average temperature in 2009 (St. 3-13; 2010 mean = 8.3°C , 2009 mean = 9.3°C). In the central Bering Sea, average sea surface temperature in 2010 was 6.5°C , which was 0.1°C warmer than in 2009 (St. 14-29; 2010 mean = 6.5°C , 2009 mean = 6.4°C).

Salmonid Catches

A total of 5,816 salmonids was caught by longline and gillnet: 790 fish in the central North Pacific Ocean (St. 3-13) and 5,026 fish in the central Bering Sea (St. 14-27; Table 2). In the central North Pacific, coho salmon was the most abundant species (46.6% of the salmonid catch), followed by chum (31.9%), pink (10.1%), steelhead (6.6%), sockeye (3.3%), and chinook salmon (1.5%). In the Bering Sea, chum salmon was the most abundant species (81.3% of the salmonid catch), followed by sockeye (15.5%), pink (2.2%), chinook (1.0%), and coho salmon (0.02%).

A total of 14 adipose fin-clipped steelhead was caught by gillnet (Table 3). Snouts from these fish were collected for later potential retrieval of CWTs.

Non-Salmonid Catches

Pacific pomfret (*Brama japonica*: $n = 630$) was particularly abundant in the catch (Table 2). In addition, 210 smalleye squaretail (*Tetragonurus cuvieri*), 61 boreal clubhook squid (*Onychoteuthis borealijaponicus*), 39 eight-armed squid (*Gonatopsis borealis*), 23 albacore (*Thunnus alalunga*), 19 neon flying squid, 12 salmon shark (*Lamna ditropis*), 10 Pacific saury (*Cololabis saira*), 9 Atka mackerel (*Pleurogrammus monoptyerygius*), 6 spiny dogfish (*Squalus acanthias*), 2 lancet fish (*Alepisaurus ferox*), 8 other fishes from a mixture of species, and 41 seabirds were caught.

Tagging Operations

A total of 1,401 salmonids was disk tagged and released during the survey. In the central North Pacific (St. 3-13), 221 disk tags were placed on fish, including 18 sockeye, 102 chum, 21 pink, 84 coho, and one chinook salmon, and nine steelhead. In the Bering Sea (St. 14-27), 1,166 disk tags were placed on salmon including 74 sockeye, 1,067 chum, 14 pink, and 11 chinook salmon.

Other Sampling and Research

Samples for lipid content were obtained from 250 salmonids (100 sockeye, 100 chum, and 50 pink salmon). A total of 1,545 chum salmon heads was collected for examination of thermal marks on otoliths and for genetic stock identification.

A total of 94 samples was collected for food habits analysis of 52 chinook salmon and 42 steelhead trout. Round samples were collected from 31 chinook salmon in the Bering Sea.

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Table 1. Research activities conducted at each station during the *Wakatake maru* cruise in 2010.

NO	ST	Date			Latitude		Longitude			XBT	CTD	Primary	NORPAC	ORI	Gillnet	Longline	Remarks
1	T-1	2010	6	11	40	0	150	0	E								Flowmeter calibration
2	T-2	2010	6	11	40	0	151	0	E								
3	T-3	2010	6	11	40	0	152	0	E								
4	T-4	2010	6	12	40	0	153	0	E								
5	T-5	2010	6	12	40	0	154	0	E								
6	T-6	2010	6	12	40	0	155	0	E								
7	T-7	2010	6	12	40	0	156	0	E								
8	T-8	2010	6	13	40	0	157	0	E								
9	T-9	2010	6	13	40	0	158	0	E								
10	T-10	2010	6	13	40	0	159	0	E								
11	T-11	2010	6	13	40	0	160	0	E								
12	T-12	2010	6	13	40	0	161	0	E								
13	T-13	2010	6	13	40	0	162	0	E								
14	T-14	2010	6	14	40	0	163	0	E								
15	T-15	2010	6	14	40	0	164	0	E								
16	T-16	2010	6	14	40	0	165	0	E								
17	T-17	2010	6	14	40	0	166	0	E								
18	T-18	2010	6	14	40	0	167	0	E								
19	T-19	2010	6	14	40	0	168	0	E								
20	T-20	2010	6	15	40	0	169	0	E								
21	T-21	2010	6	15	40	0	170	0	E								
22	T-22	2010	6	15	40	0	171	0	E								
23	T-23	2010	6	15	40	0	172	0	E								
24	T-24	2010	6	15	40	0	173	0	E								
25	T-25	2010	6	15	40	0	174	0	E								
26	T-26	2010	6	16	40	0	175	0	E								
27	T-27	2010	6	16	40	0	176	0	E								
28	T-28	2010	6	16	39	45	177	0	E								
29	T-29	2010	6	16	39	30	178	0	E								
30	T-30	2010	6	16	39	15	179	0	E								
31	ST-1	2010	6	16	39	0	180	0									
32	ST-2	2010	6	17	40	0	180	0									
33	ST-3	2010	6	17	41	0	180	0									
34	ST-4	2010	6	18	42	0	180	0									
35	ST-5	2010	6	19	43	0	180	0									
36	ST-6	2010	6	20	44	0	180	0									
37	ST-7	2010	6	21	45	0	180	0									
38	ST-8	2010	6	23	46	0	180	0									CTD replaced by XBT cast
39	ST-9	2010	6	24	47	0	180	0									
40	ST-10	2010	6	25	47	30	180	0									
41	ST-11	2010	6	26	48	30	180	0									
42	ST-12	2010	6	27	49	30	180	0									
43	ST-13	2010	6	28	50	30	180	0									
44	ST-14	2010	6	29	51	30	180	0									
45	ST-15	2010	6	30	52	30	180	0									
46	ST-16	2010	7	1	53	30	180	0									
47	ST-17	2010	7	2	54	30	180	0									
48	ST-18	2010	7	3	55	30	180	0									
49	ST-19	2010	7	4	56	30	180	0									
50	ST-20	2010	7	5	57	30	180	0									
51	ST-21	2010	7	6	58	30	180	0									
52	ST-22	2010	7	7	57	30	179	0	W								
53	ST-23	2010	7	8	57	30	178	0	W								
54	ST-24	2010	7	9	56	30	178	0	W								Fishing operations cancelled
55	ST-25	2010	7	10	56	30	179	0	W								
56	ST-26	2010	7	11	56	30	179	0	E								
57	ST-27	2010	7	12	56	30	178	0	E								
60	T-50	2010	7	13	56	0	176	0	E								
61	T-51	2010	7	13	55	30	175	0	E								
62	T-52	2010	7	13	55	0	174	0	E								
63	T-53	2010	7	13	54	30	173	0	E								
64	T-54	2010	7	14	54	0	172	0	E								
65	T-55	2010	7	14	53	30	171	0	E								
66	T-56	2010	7	14	53	0	170	0	E								
67	T-57	2010	7	14	52	20	169	0	E								
68	T-58	2010	7	14	51	40	168	0	E								
69	T-59	2010	7	14	51	10	167	0	E								
70	T-60	2010	7	15	50	40	166	0	E								
71	T-61	2010	7	15	50	0	165	0	E								
72	T-62	2010	7	15	49	20	164	0	E								

Table 1. (continued)

NO	ST	Date			Latitude		Longitude			XBT	CTD	Primary	NORPAC	ORI	Gillnet	Longline	Remarks
73	T-63	2010	7	15	48	40	163	0	E								
74	T-64	2010	7	15	48	0	162	0	E								
75	T-65	2010	7	16	47	30	161	0	E								
76	T-66	2010	7	16	46	50	160	0	E								
77	T-67	2010	7	16	46	10	159	0	E								
78	T-68	2010	7	16	45	30	158	0	E								
79	T-69	2010	7	16	44	50	157	0	E								
80	T-70	2010	7	16	44	10	156	0	E								
81	T-71	2010	7	17	43	30	155	0	E								
82	T-72	2010	7	17	42	50	154	0	E								
83	T-73	2010	7	17	42	10	153	0	E								
84	T-74	2010	7	17	41	20	152	0	E								
85	T-75	2010	7	17	40	40	151	0	E								
86	T-76	2010	7	18	40	0	150	0	E								Flowmeter calibration

Table 2. Catch of salmonids, other fishes, and squid and sea surface temperature (SST, °C) obtained at each station during the summer research cruise of the *Wakatake maru*, 2010. 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). Number of salmonids tagged and released with disk tags is listed by station.

St	Date	Lat	Long	SST	Gear	No. unit	Sockeye	Chum	Pink	Coho	Chi-nook	Steel-head	Salmonid total	Neon flying squid	Eight-armed squid	Club-hook squid	Salmon shark	dog-fish	Lancet fish	Pacific saury	Pacific pomfret	Atka mackerel	Square tail	Alba-corefishes	Other fishes	Sea birds			
3	6/18/10	4100	18000	12.8	B	30	0	0	0	1	0	0	1	0	0	2	0	0	0	0	105	0	0	0	0	0			
					A	19	0	0	0	0	0	0	0	0	0	0	10	0	0	2	0	0	0	18	0	0	7	0	0
					C	30	0	0	0	0	0	0	0	0	0	0	7	0	16	3	0	1	1	31	0	0	16	0	0
					Total		0	0	0	1	0	0	1	0	0	1	17	0	18	5	0	1	1	154	0	0	23	0	0
					Rel.		0	0	0	1	0	0	1	0	0	1													
4	6/19/10	4200	18000	12.1	B	30	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0		
					A	19	0	1	0	2	0	0	3	2	0	0	0	0	5	0	0	0	62	0	0	0	0	0	0
					C	30	0	1	0	7	0	0	8	0	3	25	1	0	0	1	0	1	70	0	29	0	2	0	0
					Total		0	2	0	9	0	0	11	2	3	27	6	0	0	3	132	0	29	0	2	0	0	0	0
					Rel.		0	0	0	0	0	0	0	0	0	0													
5	6/20/10	4300	18000	10.3	B	30	0	10	2	10	0	0	22	0	0	0	0	0	0	0	25	0	0	0	0	0	0		
					A	19	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	51	0	0	0	0	0	1	
					C	30	0	7	0	9	1	0	17	0	0	2	0	0	0	0	0	4	61	0	10	0	1	1	
					Total		0	17	2	24	1	0	44	0	0	2	0	0	2	0	0	4	137	0	10	0	1	2	
					Rel.		0	8	1	9	0	0	18																
6	6/21/10	4400	18000	9.8	B	30	0	29	0	22	0	3	54	0	0	0	0	0	0	0	38	0	0	0	0	0	0		
					A	19	0	0	0	4	0	2	6	0	0	0	0	0	0	0	0	58	0	0	0	0	0	0	
					C	30	0	8	2	21	2	0	33	0	1	9	0	4	0	4	97	0	170	0	0	0	0	1	
					Total		0	37	2	47	2	5	93	0	1	9	0	4	0	4	193	0	170	0	0	0	0	1	
					Rel.		0	25	0	14	0	3	42																
7	6/22/10	4500	18000	8.4	B	30	0	4	3	4	0	0	11	0	0	0	0	0	0	0	5	0	0	0	0	0			
					A	19	0	0	1	7	0	1	9	0	0	0	0	1	0	0	3	0	0	0	0	0	0	2	
					C	30	0	6	1	23	0	0	30	0	1	5	0	1	0	0	6	0	1	0	0	0	0	1	
					Total		0	10	5	34	0	1	50	0	1	5	0	2	0	0	14	0	1	0	0	0	0	3	
					Rel.		0	2	3	1	0	0	6																
8	6/24/10	4600	18000	6.3	B	30	0	13	2	7	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0			
					A	19	0	0	5	26	0	2	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
					C	30	2	51	6	24	0	3	86	0	13	0	0	0	0	0	0	0	0	0	0	0	0	3	
					Total		2	64	13	57	0	5	141	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	4
					Rel.		0	12	2	4	0	0	18																

Table 2. (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sockeye	Chum	Pink	Coho	Chi-nook	Steel-head	Salmonid total	Neon flying squid	Eight-armed squid	Club-hook squid	Salmon shark	Spiny dog-fish	Lancet fishh	Pacific saury	Pacific pomfret	Atka mackerel	Square tail	Alba-corefishes	Other fishes	Sea birds				
9	6/25/10	4700	18000	5.8	B	30	0	11	1	2	1	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	0	0	3	13	1	7	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					C	30	3	12	8	10	3	2	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
					Total		3	23	12	25	5	9	77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
					Rel.		0	10	1	0	1	0	12																	
10	6/26/10	4730	18000	6.1	B	30	2	10	6	45	0	1	64	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	2	1	10	60	3	13	89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
					C	30	5	49	19	46	0	14	133	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	
					Total		9	60	35	151	3	28	286	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2	
					Rel.		2	10	6	37	0	1	56																	
11	6/26/10	4830	18000	6.4	B	30	4	12	6	17	1	4	44	0	0	0	0	0	0	0	0	0	0	0	0	0				
					Rel.		4	11	4	14	0	4	37																	
12	6/27/10	4930	18000	6.4	B	30	11	24	5	4	0	1	45	0	0	0	0	0	0	0	0	0	0	0	0	0				
					Rel.		10	16	3	4	0	1	34																	
13	6/28/10	5030	18000	6.7	B	30	2	9	1	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0				
					Rel.		2	8	1	0	0	0	11																	
14	6/29/10	5130	18000	5.1	B	30	1	24	2	0	0	0	27	0	0	0	0	0	0	0	0	0	2	0	0	0	1			
					Rel.		0	20	2	0	0	0	22																	
15	6/30/10	5230	18000	5.0	B	30	11	45	0	0	0	0	56	0	0	0	0	0	0	0	0	0	4	0	0	0	0			
					Rel.		11	39	0	0	0	0	50																	
16	7/01/10	5330	18000	6.0	B	30	10	66	1	0	0	0	77	0	0	0	0	0	0	0	0	0	0	0	0	0				
					Rel.		9	63	1	0	0	0	73																	
17	7/02/10	5430	18000	6.1	B	30	5	91	3	0	0	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0				
					Rel.		5	75	2	0	0	0	82																	
18	7/04/10	5530	18000	6.5	B	30	8	97	2	0	0	0	107	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	26	124	2	0	0	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
					C	30	47	130	6	0	0	0	183	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					Total		81	351	10	0	0	0	442	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
					Rel.		7	79	2	0	0	0	88																	

Table 2. (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sockeye	Chum	Pink	Coho	Chi-nook	Steel-head	Salmonid total	Neon flying squid	Eight-armed squid	Club-hook squid	Salmon shark	Spiny dog-fish	Lancet fish	Pacific saury	Pacific pomfret	Atka mackerel	Square-tail	Alba-corefishes	Other corefishes	Sea-birds					
19	7/05/10	5630	18000	6.7	B	30	4	48	2	0	0	0	54	0	0	0	0	0	0	0	0	0	1	0	0	2	0				
					A	19	40	131	0	0	1	0	172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
					C	30	38	122	8	0	12	0	180	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
					Total						82	301	10	0	13	0	406	0	3	0	0	0	0	0	0	0	1	0	0	2	2
					Rel.						4	44	2	0	0	0	50														
20	7/06/10	5730	18000	7.3	B	30	4	114	1	0	3	0	122	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	14	183	6	0	1	0	204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
					C	30	11	119	14	0	3	0	147	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
					Total						29	416	21	0	7	0	473	0	0	0	0	0	0	0	0	0	1	0	0	0	0
					Rel.						4	97	1	0	3	0	105														
21	7/07/10	5830	18000	7.1	B	30	3	145	1	0	2	0	151	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	15	149	3	0	1	0	168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
					C	30	25	87	10	0	3	0	125	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
					Total						43	381	14	0	6	0	444	0	1	0	0	0	0	0	0	0	0	0	0	0	
					Rel.						3	125	0	0	0	0	128														
22	7/08/10	5730	17900W	7.1	B	30	0	65	0	0	0	0	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	9	85	2	0	0	0	96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
					C	30	27	144	6	0	7	0	184	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
					Total						36	294	8	0	7	0	345	0	1	0	0	0	0	0	0	0	0	0	0	1	
					Rel.						0	54	0	0	0	0	54														
23	7/09/10	5730	17800W	6.9	B	30	0	115	3	0	6	0	124	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	11	150	5	0	0	0	166	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	2		
					C	30	24	137	11	0	4	0	176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2		
					Total						35	402	19	0	10	0	466	0	0	0	0	0	0	0	0	1	0	0	3	4	
					Rel.						0	92	3	0	4	0	99														
25	7/11/10	5630	17900W	6.8	B	30	2	131	1	0	0	0	134	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	25	96	3	0	2	0	126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
					C	30	51	200	4	0	1	0	256	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2		
					Total						78	427	8	0	3	0	516	0	0	0	0	0	0	0	0	0	0	0	0	3	
					Rel.						1	101	1	0	0	0	103														

Table 2. (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sockeye	Chum	Pink	Coho	Chi-nook	Steel-head	Salmonid total	Neon flying squid	Eight-armed squid	Club-hook squid	Salmon shark	Spiny dog-fish	Lancet fish	Pacific saury	Pacific pomfret	Atka mackerel	Square-tail	Alba-corefishes	Other fishes	Sea-birds				
26	7/12/10	5630	17900E	7.8	B	30	19	201	3	0	4	0	227	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	45	201	7	1	0	0	254	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	
					C	30	144	301	0	0	0	0	445	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
					Total		208	703	10	1	4	0	926	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
					Rel.		12	143	0	0	4	0	159																	
27	7/13/10	5630	17800E	6.8	B	30	24	199	0	0	2	0	225	0	0	0	0	0	0	0	0	0	0	0	0	0				
					A	19	31	115	3	0	0	0	149	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	
					C	30	103	272	0	0	0	0	375	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
					Total		158	586	3	0	2	0	749	0	12	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
					Rel.		18	135	0	0	0	0	153																	
Total	B					720	110	1463	45	112	19	9	1758	0	0	4	0	0	0	0	173	7	0	0	2	1				
	A					323	218	1236	50	118	9	25	1656	12	0	0	8	1	0	0	192	1	0	7	3	20				
	C					510	480	1646	95	140	36	19	2416	7	39	57	4	5	2	10	265	1	210	16	3	20				
	Total						803	4339	189	369	64	52	5816	19	39	61	12	6	2	10	630	9	210	23	8	41				
	Rel.						92	1169	35	84	12	9	1401																	

Table 3. Steelhead observed with clipped fins during the summer cruise of the R/V *Wakatake maru* in 2010. Attributes of fin-clipped fish included, fork length, body weight, sex, gonad weight, clipped fin, and sample number. Gear: A = commercial-mesh gillnet; C = research-mesh gillnet followed by mesh size (mm). Clipped fin: Ad = adipose fin. Dash – = no data.

Date	Location		Gear	Species	Fork length (mm)	Body weight (g)	Sex	Gonad weight (g)	Clipped fin	Sample #
	Lat.	Long.								
6/24/10	46°00'N	180°00'	C138	steelhead	770	4200	F	2	Ad	35-1
6/24/10	46°00'N	180°00'	C106	steelhead	540	1470	F	5	Ad	38-6
6/25/10	47°00'N	180°00'	A115	steelhead	762	4920	F	20	Ad	49-23
6/26/10	47°30'N	180°00'	C082	steelhead	550	1740	M	2	Ad	51-11
6/26/10	47°30'N	180°00'	C082	steelhead	661	3050	F	21	Ad	51-12
6/26/10	47°30'N	180°00'	C093	steelhead	685	5180	M	5	Ad	56-25
6/26/10	47°30'N	180°00'	A115	steelhead	727	4230	F	25	Ad	59-25
6/26/10	47°30'N	180°00'	A115	steelhead	683	3570	F	35	Ad	59-26
6/26/10	47°30'N	180°00'	A115	steelhead	640	2340	F	3	Ad	59-27
6/26/10	47°30'N	180°00'	A115	steelhead	697	3990	F	25	Ad	59-28
6/26/10	47°30'N	180°00'	A115	steelhead	531	1540	M	5	Ad	59-29
6/26/10	47°30'N	180°00'	C138	steelhead	703	3840	F	28	Ad	60-3
6/26/10	47°30'N	180°00'	C106	steelhead	700	3350	F	37	Ad	61-21
6/26/10	47°30'N	180°00'	C106	steelhead	800	5820	F	36	Ad	61-22

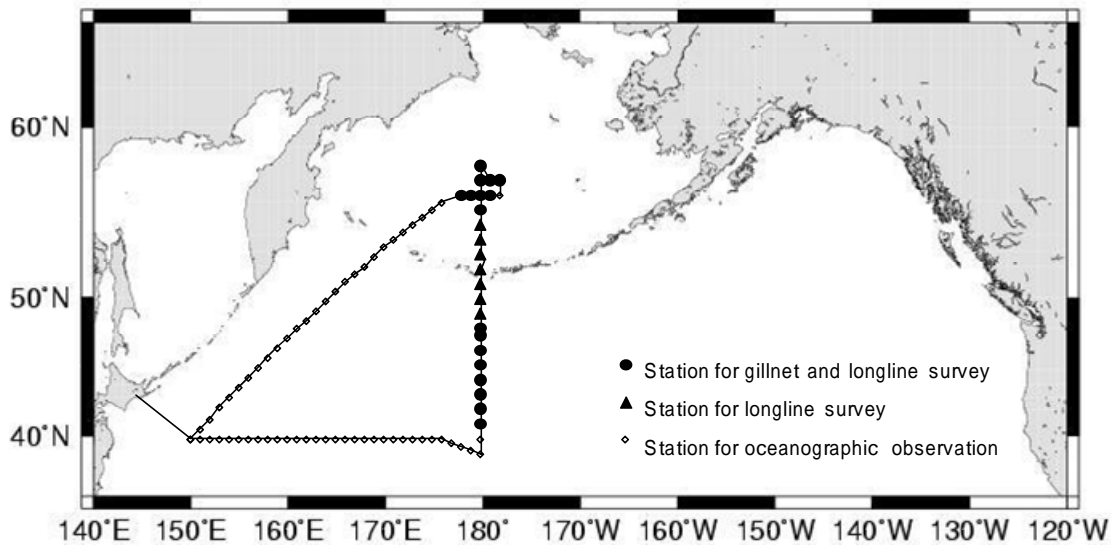


Fig. 1. Survey area of the R/V *Wakatake maru* salmon research cruise, summer 2010.

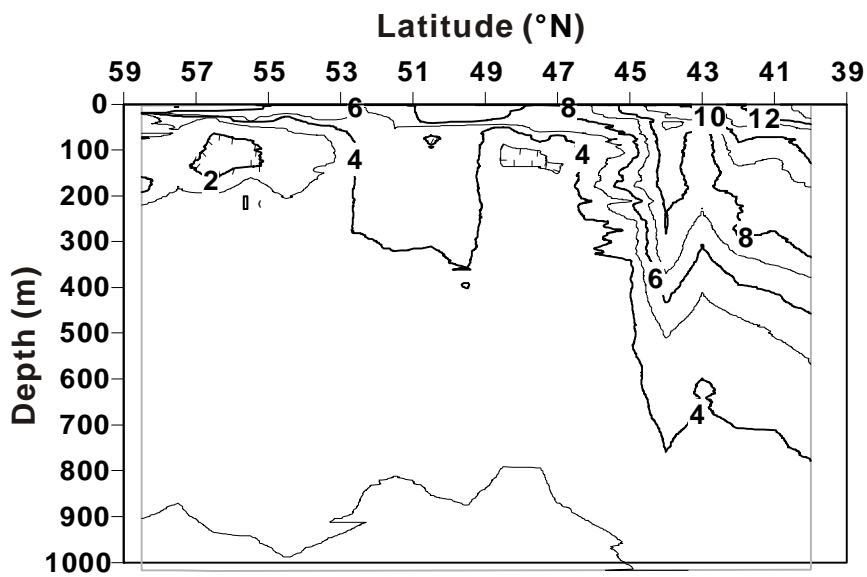


Fig. 2. Vertical section of water temperature (°C) along the 180° transect of the *Wakatake maru* cruise, 2010.

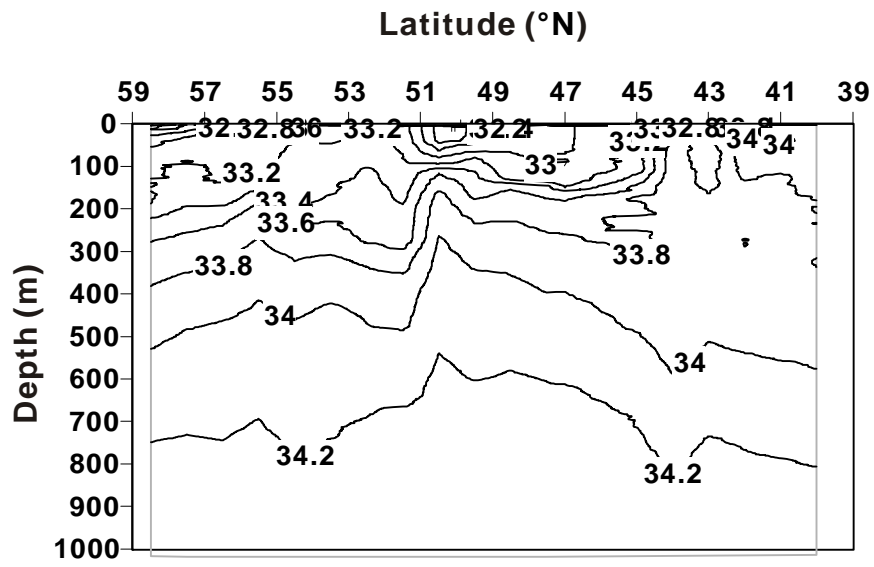


Fig. 3. Vertical section of salinity (psu) along the 180° transect of the *Wakatake maru* cruise, 2010.