

# The 2006 Spring International Cooperative Salmon Research Cruise of the R/V *Kaiyo maru*

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Submitted to the

NORTH PACIFIC ANADROMOUS FISH COMMISSION

by

Japan

October 2006

This paper may be cited in the following manner:

Morita, K., S. Sato, T. Kaga, D. Takasaki, T. Chiba, A. F. Volkov, K. Cieciel, S. K. Kang, N. Tanimata, Y. Kamezawa, M. Katsumata, and T. Azumaya. 2006. The 2006 spring international cooperative salmon research cruise of the R/V *Kaiyo maru*. (NPAFC Doc. 958). 10 p. Hokkaido National Fisheries Research Institute, FRA, Kushiro 085-0802.

# The 2006 Spring International Cooperative Salmon Research Cruise of the R/V *Kaiyo maru*

**Abstract:** A spring high-seas research cruise to investigate the stock condition of Pacific salmon was conducted in the North Pacific Ocean and the Bering Sea from 22 April to 20 May (first leg) and from 24 May to 22 June (second leg) onboard the Japanese research vessel *Kaiyo maru*. Research cruise activities included the collection of data on oceanography, primary production, zooplankton, micronekton, salmonid fishes, and other organisms. A total of 7,197 salmonids were caught by midwater trawl and angling: 4,487 fishes in the first leg and 2,627 fishes in the second leg. In the first leg, chum salmon was the most abundant species (42.3%), followed by pink (34.4%), sockeye (22.5%), chinook (0.45%), and coho salmon (0.33%). In the second leg, chum salmon was the most abundant species (50.3%), followed by sockeye (21.1%), pink (21.0%), chinook (7.45%), and coho salmon (0.11%). A total of 5,109 salmonids were measured for fork length, body and gonad weight, lipid content by fat meter, sexed, and removed scales for age determination. Isotope ( $n = 210$ ), genetic ( $n = 2,278$ ), otolith ( $n = 2,798$ ), stomach contents ( $n = 4,319$ ), lipid ( $n = 1,160$ ), muscle ( $n = 113$ ), parasite ( $n = 60$ ) samples were obtained for future studies. There were 122 salmon (47 sockeye, 46 chum, 24 pink, 1 coho, and 4 chinook salmon) tagged and released in the North Pacific Ocean and the Bering Sea. From among fish released, 15 sockeye, 5 chum, and 4 chinook salmon were released carrying archival tags.

## Introduction

Since 1992, the Japanese research vessel *Kaiyo maru* has been collecting data on the biology of Pacific salmon (*Oncorhynchus* spp.) and the oceanography of the North Pacific Ocean and the Bering Sea in winter and summer (Nagasawa *et al.* 1994; Ueno *et al.* 1996; Ishida *et al.* 1998; Azumaya *et al.* 2003; Fukuwaka *et al.* 2006). Several interesting findings have found from analyses of data collected during these surveys (Sakai *et al.* 1996; Nagasawa 2000; Azumaya *et al.* 2005). In particular, the results of winter surveys have received considerable attention. The main objective of this research program is to explore the biology of salmonids in the offshore areas. Routine observations have included the collection of data on physical oceanography, primary production, and the trophic interactions among zooplankton, salmonids, and organisms at higher trophic levels. Other studies have included using archival data tags to study salmon habitat and movement patterns, monitoring the endocrinological changes that occur in salmon during migration, and analysis of the genetic structure of salmon populations in the ocean. This document summarizes the research cruise conducted by the R/V *Kaiyo maru* in the North Pacific Ocean and the Bering Sea during spring 2006.

## Survey Area

The R/V *Kaiyo maru* departed from Kushiro, Japan, on 22 April 2006 and visited Kodiak, Alaska, on 20 May 2006 (first leg); the *Kaiyo maru* departed Kodiak 24 May 2006 and returned to Kushiro on 22 June 2006 (second leg). A total of 67 fishing stations were visited during the

cruise (Fig. 1 and Table 1). Thirty-four fishing stations were visited during the first leg, and 37 fishing stations were visited during the second leg. Eleven fishing stations were located in the Bering Sea, and 56 fishing stations were located in the North Pacific Ocean.

### Temperature and Salinity Sampling

The collection method of seawater temperature and salinity data has remained the same since 1992 (Nagasawa *et al.* 1994; Ueno *et al.* 1996; Ishida *et al.* 1998; Azumaya *et al.* 2003; Fukuwaka *et al.* 2006). A conductivity, temperature, and depth sensor (CTD) was used at each fishing station. An expendable CTD (XCTD) and memory CTD (MCTD) were supplementary used. The CTD, XCTD and MCTD recorded data at 1-m intervals from the surface to a maximum of approximately 1500 m. In additions, the Electric Plankton Counting and Sizing (EPCS) system was used to collect data of water temperature, salinity, and fluorescent strength due to chlorophyll in surface water during the whole leg of the cruise.

### Zooplankton and Micronekton Sampling

Macro-zooplankton were sampled with a remodeled NORPAC net (0.45 m ring diameter, 1.93 m net length, 0.33 mm mesh size) and a Juday net (0.37 m mouth diameter, 1.2 m net length, 0.168 mm mesh size) at each fishing station. The NORPAC net was towed vertically from 150 m to the surface and the Juday net was towed from 200 m to the surface. A calibrated flow meter was attached to the opening of these nets in a position slightly off-center. The NORPAC net samples were fixed in 5% borax-buffered formalin in seawater and the Juday net samples were examined by a scientist from TINRO-Center on board the ship.

Large macro-zooplankton were collected at 31 fishing stations using an BONGO net (2 rings, 0.7 m diameter, 4.1 m in overall length, 0.335 mm mesh size). The net was towed obliquely along the side of the vessel from 100 m to the surface at a speed of approximately 2 knots around 20:00 hrs. Samples were fixed in 10% borax-buffered formalin in seawater.

Micronekton was collected at 30 fishing stations using a Matuda-Oozeki-Hu trawl (MOHT; 2.242×2.242 m rectangular mouth, 12 m net length, 1.59 mm mesh size). The trawl was towed obliquely at the stern of the vessel from 300 m to the surface at a speed of 4 knots an hour after sunset. Lantern fishes was sorted from a part of samples on board the ship and frozen for further examinations in a laboratory and another part of samples was fixed in 10% borax-buffered formalin in seawater. These samples were sent to the Graduate School of Fisheries Science, Hokkaido University.

In additions, the EPCS system was used to collect data of particle density due to zooplankton in surface water during the whole leg of the cruise.

### Fish Collection

A midwater trawl was used for experimental fishing operations to collect salmonids and other pelagic fish at each fishing station (Fig. 1, Table 1). The trawl was towed at the speed of 5 knots at the surface layer from the surface to approximately 50 m depth for one hour in daytime. The height and the width of the mouth of trawl was c.a. 50 m, the length was 222.02 m, and the cod end of the net was lined with a net of mesh size 12 mm (Murphy *et al.* 2003). In addition, hooks and lines were used to collect live fish for tagging.

A total of 7,197 salmonids was caught by midwater trawl and angling: 4,487 fishes in the first leg and 2,627 fishes in the second leg (Table 1). In the first leg, chum salmon (*Oncorhynchus keta*) was the most abundant species (42.3%), followed by pink (*O. gorbuscha*; 34.4%), sockeye (*O. nerka*; 22.5%), chinook (*O. tshawytscha*; 0.45%), and coho salmon (*O. kisutch* 0.33%). In the second leg, chum salmon was the most abundant species (50.3%), followed by sockeye (21.1%), pink (21.0%), chinook (7.45%), and coho salmon (0.11%).

In addition, 3,454 non-salmonid fishes and 112,205 squids were caught with the trawl (Table 1). Atka mackerel (*Pleurogrammus monopterygius*;  $n = 3,026$ ), walleye pollock (*Theragra chalcogramma*;  $n = 148$ ), and three-spined sticklebacks (*Gasterosteus aculeatus*;  $n = 243$ ) were particularly abundant in the catch.

## Fish Measurement

Salmonids were processed soon after removal from the fishing gear. The catch was sorted by species and counted. Biological data were recorded from a maximum of 60-100 individuals per species caught in each fishing station. Biological data included fork length (mm), body weight (10 g), sex, gonad weight (0.1 g) and lipid content. The presence of visceral adhesions was also recorded. Fork lengths were measured using the Sokutei-kun, an effective fish measuring board (Takami Fisheries Development Co. Inc., Mashike, Japan). Body and gonad weight were measured using the Marine scale (POLIS, Iceland). Lipid contents were measured by the Distell fatmeter (Distell, Scotland). Samples of one scale (pink salmon), two scales (sockeye, chum, coho, and chinook salmon) were collected for age determination and back calculation of growth. When possible, scales were collected from the preferred body area identified by the International North Pacific Fisheries Commission for scale sampling (INPFC; Davis *et al.* 1990).

Samples of salmon body from each species were collected for analyses of stable isotope analysis and lipid content, and frozen and carried to Hokkaido National Fisheries Research Institute (HNFRI) and National Salmon Resources Center (NASREC) for a further examination in a laboratory. A part of pectoral fin and otoliths were collected for genetic stock identification and for detection of thermal marks on the otolith. Fixed fin samples in ethanol and dried otoliths were sent to NASREC. Stomach samples were collected from all species of salmon. A maximum 30 stomachs for each species was fixed in 10% borax-buffered formalin for further examination in a laboratory and carried to HNFRI. A maximum 30 stomachs from each salmon species were examined by a scientist from TINRO-Center while onboard the vessel.

Some additional samples were collected in the second leg. Scales were collected from a maximum 10 fish of each salmon species for stable isotope analysis and from all sockeye and chinook salmon for genetic stock identification. Dried scale samples were carried to Auke Bay Laboratory, Alaska Fisheries Science Center, NOAA, USA. Brain and gut were collected from 30 chum salmon and fixed 10% formalin for parasitological analysis. These samples were carried to Korean laboratories for further examination.

A total of 5,109 salmonids were obtained for biological data. Isotope ( $n = 210$ ), genetic ( $n = 2,278$ ), otolith ( $n = 2,798$ ), stomach contents ( $n = 4,319$ ), lipid ( $n = 1,160$ ), muscle ( $n = 113$ ), parasite ( $n = 60$ ) samples were obtained.

The non-salmonid catch was identified and counted at each station. Body length of non-salmonid fishes, squid, and other organisms was measured, and some individuals were frozen or fixed in 10% borax-buffered formalin in seawater for taxonomic and ecological studies.

## Release of Tagged Salmon

*Disk tagging:* Live salmon caught in healthy condition were quickly put into a recovery tank. Each fish was tagged with two disk tags, one issued by the Fisheries Agency of Japan and one by the Fisheries Research Institute, University of Washington. Both disk tags were placed on one plastic cinch strap and attached to the fish in an area anterior to the dorsal fin. The fork length was measured and one or two scales were collected before the fish was released to the sea. A total of 98 disk-tagged salmonids were released (Table 1), consisting of 32 sockeye, 41 chum, 24 pink, and 1 coho salmon.

*Archival tagging:* Two types of archival tags were used. First, CTD tag manufactured by Star-Oddi, Reykjavik, Iceland, recorded seawater temperature and salinity, and the depth of fish movement (model DST CTD; size, 15 × 46 mm; weight in air, 19 g; number of records, 43,582 per sensor). Second, LTD tag manufactured by Lotek Marine Technologies, Newfoundland, Canada, was used to record seawater temperature and depth of the fish (model LTD 1100-300; size, 8 × 16 × 27 mm; weight in air, 5 g; number of records, 32,768). Archival tags were attached externally with nickel pins to the dorsal musculature of the fish anterior to the dorsal fin. A total of 24 salmon was released with archival tags in the North Pacific Ocean and the Bering Sea (Table 1). Releases included 1 chinook with CTD tag and 15 sockeye, 5 chum, and 3 chinook salmon with LTD tags.

## Acknowledgements

We thank Captain Jishu Doi, officers, and crew of the R/V *Kaiyo maru* for their cooperation in the research and collection of samples during the cruise. We thank Tatsuya Takami for providing handy measurement boards. This work was supported by the Promotion Program for International Resources Surveys of the Fisheries Agency of Japan.

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**Table 1.** Catches of sockeye salmon (SO), chum salmon (CH), pink salmon (PK), coho salmon (CO), chinook salmon (CN), Atka mackerel (AM), walleye pollock (WP), squids (SQ), three-spined sticklebacks (TS), prowfish (PF), daggertooth (DT), lancetfish (LF), and other fishes (OF) along with the sea surface temperature (SST, °C) at each station during the R/V *Kaiyo maru* cruise in 2006 spring. J-gear, midwater trawl (depth ca. 0–50 m); J\*-gear, midwater trawl (depth ca. 50–120m); O-gear, hook and line. The numbers of fish tagged and released are in parentheses.

St.	Date	Location		SST	Gear	Pacific salmon						AM	WP	SQ	TS	PF	DT	LF	OF
						SO	CH	PK	CO	CN	Total								
ST01	2006/4/24	41.0°N	155.0°E	8.4	J	0	3	87	0	0	90	0	0	0	0	0	0	0	0
ST02	2006/4/24	42.0°N	155.0°E	5.7	J	0	15	844	0	0	859	0	0	0	0	0	0	0	0
ST03	2006/4/25	43.0°N	155.0°E	5.9	J	0	5	102	0	0	107	0	0	0	0	0	0	0	0
ST04	2006/4/25	44.0°N	155.0°E	3.3	J	0	0	10	0	0	10	0	0	650	0	0	0	0	0
ST05A	2006/4/28	49.0°N	165.0°E	2.5	J	7	6	0	0	0	13	0	0	0	0	0	0	0	0
ST06A	2006/4/28	48.0°N	165.0°E	2.2	J	0	3	0	0	0	3	0	0	0	0	0	0	0	0
ST07A	2006/4/29	47.0°N	165.0°E	3.3	J	51	16	0	0	0	67	0	0	0	0	0	0	0	0
ST08A	2006/4/30	46.0°N	165.0°E	3.0	J	20	2	0	0	0	22	0	0	0	0	0	0	0	0
ST09	2006/4/30	45.0°N	165.0°E	4.4	J	5	24	0	0	0	29	0	0	4	0	0	0	0	0
ST10	2006/4/30	44.0°N	165.0°E	4.6	J	238	99	0	0	0	337	0	0	2	0	0	0	0	0
ST11	2006/5/1	43.0°N	165.0°E	5.0	J	117	44	3	0	0	164	0	0	5	0	0	0	0	0
ST12	2006/5/2	43.0°N	170.0°E	7.0	J	0	52	38	4	2	96	0	0	0	0	0	0	0	0
ST13	2006/5/2	44.0°N	170.0°E	4.8	J	1	8	9	0	0	18	0	0	0	0	0	0	1	0
ST14	2006/5/3	45.0°N	170.0°E	4.8	J	15	15	3	0	0	33	0	0	1	0	0	0	0	0
ST15	2006/5/3	46.0°N	170.0°E	3.4	J	1	1	1	0	0	3	0	0	344	0	0	0	0	0
ST16	2006/5/4	47.0°N	170.0°E	3.4	J	0	4	1	0	0	5	0	0	1	0	0	0	0	0
ST17	2006/5/4	48.0°N	170.0°E	3.2	J	17	6	0	0	0	23	0	0	0	0	0	0	2	0
ST18	2006/5/5	49.0°N	170.0°E	3.7	J	41	13	0	0	0	54	1	0	0	0	0	0	0	0
ST19	2006/5/6	49.0°N	175.0°E	3.4	J	1	4	0	0	0	5	0	0	2	0	0	0	0	15
ST20	2006/5/6	48.0°N	175.0°E	3.6	J	34	102	32	0	0	168	0	0	3	0	0	0	0	0
ST21	2006/5/7	47.0°N	175.0°E	4.2	J	113	391	59	0	0	563	0	0	1	0	0	1	0	0
ST22	2006/5/7	46.0°N	175.0°E	5.2	J	86	14	9	0	1	110	0	0	10000	0	0	0	0	0
ST23	2006/5/8	45.0°N	175.0°E	5.4	J	82	52	15	0	2	151	0	0	0	0	0	0	0	0
ST24	2006/5/8	44.0°N	175.0°E	5.7	J	16	106	46	2	1	171	0	0	0	0	0	0	0	0
ST25	2006/5/9	43.0°N	175.0°E	6.1	J	0	89	42	4	3	138	0	0	1	0	0	0	0	0
ST26	2006/5/10	43.0°N	180.0°E	8.1	J	0	170	5	1	5	181	0	0	2	0	0	0	0	1
ST27	2006/5/10	44.0°N	180.0°E	6.8	J	1	97	35	2	3	138	0	0	0	0	0	0	0	0
ST28	2006/5/11	45.0°N	180.0°E	6.1	J	121	142	128	1	2	394	0	0	0	0	0	0	0	0
ST29	2006/5/11	46.0°N	180.0°E	4.5	J	34	264	23	0	1	322	0	0	0	0	0	0	0	0
ST30	2006/5/12	47.0°N	180.0°E	4.4	J	2	65	3	0	0	70	0	0	0	0	0	0	0	0

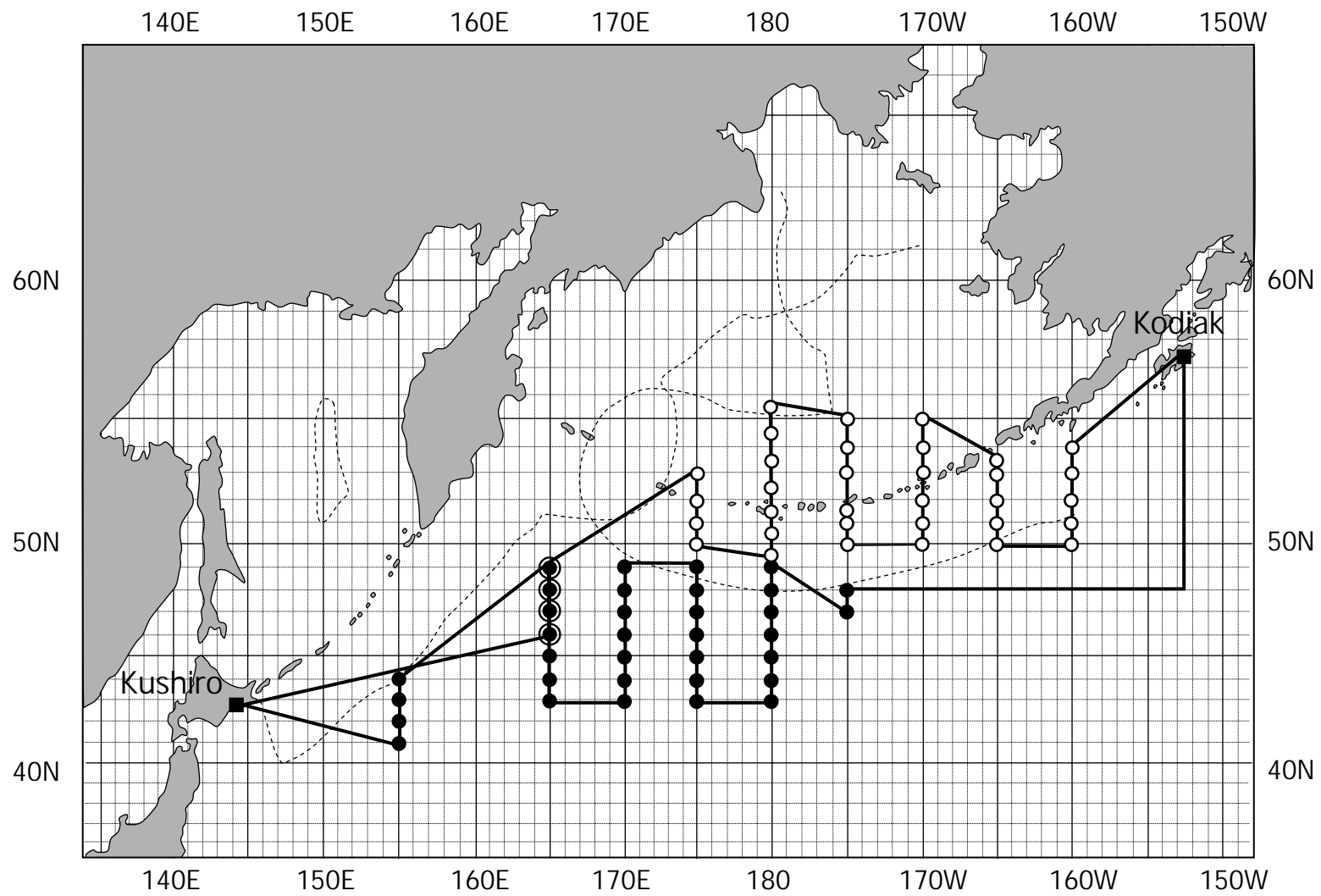
—Table 1. continued—

St.	Date	Location		SST	Gear	Pacific salmon						AM	WP	SQ	TS	PF	DT	LF	OF
						SO	CH	PK	CO	CN	Total								
ST31	2006/5/12	48.0°N	180.0°	4.6	J	1	20	12	0	0	33	0	0	0	0	0	0	0	0
ST32A	2006/5/13	49.0°N	180.0°	3.7	J	3	0	6	0	0	9	0	0	0	0	0	0	0	0
ST32B	2006/5/13	49.0°N	180.0°	3.8	J*	0	0	0	0	0	0	0	0	0	1	0	0	0	0
ST66F	2006/5/13	47.0°N	175.0°	W	O	0	15	8	1	0	24	0	0	0	0	0	0	0	0
ST66A	2006/5/14	47.0°N	175.0°	W	5.1	J*	0	21	0	0	21	0	0	0	0	0	0	0	0
ST66B	2006/5/14	47.0°N	175.0°	W	5.1	J	0	2	10	0	0	12	0	0	0	0	0	0	1
ST67A	2006/5/15	48.0°N	175.0°	W	4.6	J	3	28	13	0	0	44	0	0	0	0	0	0	0
ST67B	2006/5/15	48.0°N	175.0°	W	4.6	J*	0	0	0	0	0	0	0	6	0	0	0	1	0
ST33	2006/5/26	54.0°N	160.0°	W	6.2	J	84	44	43	0	0	171	0	0	0	0	0	0	0
ST34	2006/5/26	53.0°N	160.0°	W	6.1	J	22	28	29	0	0	79	1	0	0	0	0	0	1
ST34F	2006/5/26	53.0°N	160.0°	W		O	1(1)	0	0	0	0	1(1)	0	0	0	0	0	0	0
ST35	2006/5/27	52.0°N	160.0°	W	6.1	J	5	3	18	0	0	26	0	0	0	0	0	0	0
ST36	2006/5/27	51.0°N	160.0°	W	5.3	J	10	39	36	0	0	85	0	0	0	0	0	0	0
ST36F	2006/5/27	51.0°N	160.0°	W		O	1(1)	1(1)	3(3)	0	0	5(5)	0	0	0	0	0	0	0
ST37	2006/5/28	50.0°N	160.0°	W	5.1	J	13	33	34	0	0	80	0	0	0	0	0	0	0
ST37F	2006/5/28	50.0°N	160.0°	W		O	2(2)	1(1)	13(13)	0	0	16(16)	0	0	0	0	0	0	0
ST38	2006/5/29	50.0°N	165.0°	W	5.8	J	31	72	57	0	0	160	0	0	0	0	0	0	0
ST39	2006/5/29	51.0°N	165.0°	W	6.4	J	6	114(9)	21(1)	1(1)	0	142(11)	0	0	301	0	0	0	0
ST39F	2006/5/29	51.0°N	165.0°	W		O	0	4(4)	1(1)	0	0	5(5)	0	0	0	0	0	0	0
ST40	2006/5/30	52.0°N	165.0°	W	8.0	J	35	56	14	0	0	105	0	17	0	0	0	1	0
ST41	2006/5/30	53.0°N	165.0°	W	7.6	J	7(2)	83(3)	1	0	0	91(5)	0	8	0	0	1	0	0
ST41F	2006/5/30	53.0°N	165.0°	W		O	3(3)	1(1)	0	0	0	4(4)	0	0	0	0	0	0	0
ST42	2006/5/31	53.5°N	165.0°	W	7.9	J	33(2)	98(3)	2	0	0	133(5)	0	17	0	0	0	0	0
ST42F	2006/5/31	53.5°N	165.0°	W		O	0	1(1)	0	0	0	1(1)	0	0	0	0	0	0	0
ST43	2006/6/2	55.0°N	170.0°	W	5.8	J	27	35	8	0	66	136	0	28	1	0	1	0	0
ST44	2006/6/2	54.0°N	170.0°	W	5.9	J	23	32	25	0	1	81	0	15	1	0	0	0	0
ST44F	2006/6/2	54.0°N	170.0°	W		O	3(3)	4(4)	3(3)	0	1(1)	11(11)	0	0	0	0	0	0	0
ST45	2006/6/3	53.0°N	170.0°	W	4.9	J	24	90	46	0	2	162	2	50	0	236	0	0	0
ST46	2006/6/3	52.0°N	170.0°	W	6.3	J	11	27	3	0	0	41	0	1	0	7	0	0	1
ST47	2006/6/4	51.0°N	170.0°	W	6.4	J	11	26	4	0	0	41	0	0	1	0	0	0	0



—Table 1. continued—

St.	Date	Location	SST	Gear	Pacific salmon						AM	WP	SQ	TS	PF	DT	LF	OF	
					SO	CH	PK	CO	CN	Total									
ST48	2006/6/4	50.0°N 170.0°	W 6.5	J	20	68(6)	17	0	0	105(6)	0	0	0	0	1	0	0	0	
ST49	2006/6/5	50.0°N 175.0°	W 6.4	J	5(1)	68	13	0	0	86(1)	0	0	10	0	0	0	1	0	
ST50	2006/6/6	51.0°N 175.0°	W 6.5	J	16	31	7	0	0	54	0	1	0	0	0	0	0	0	
ST51	2006/6/6	52.5°N 175.0°	W 5.8	J	1	8	0	0	3	12	0	10	2	0	0	0	0	0	
ST51F	2006/6/6	52.5°N 175.0°	W	O	1(1)	0	0	0	0	1(1)	0	0	0	0	0	0	0	0	
ST52	2006/6/7	53.0°N 175.0°	W 5.6	J	6	13	11	0	96	126	0	1	152	0	0	0	0	0	
ST53	2006/6/7	54.0°N 175.0°	W 6.1	J	13(2)	47(1)	37	0	14	111(3)	2	0	2	0	0	0	0	0	
ST53F	2006/6/7	54.0°N 175.0°	W	O	8(8)	4(4)	2(2)	0	1(1)	15(15)	0	0	0	0	0	0	0	0	
ST54	2006/6/8	55.0°N 175.0°	W 5.7	J	9(3)	43(3)	1	0	7(1)	60(7)	0	0	350	0	0	0	0	0	
ST54F	2006/6/8	55.0°N 175.0°	W	O	17(17)	4(4)	1(1)	0	1(1)	23(23)	0	0	0	0	0	0	0	0	
ST55	2006/6/9	55.5°N 180.0°	4.4	J	1	5	0	0	2	8	0	0	0	0	0	0	0	0	
ST56	2006/6/9	54.5°N 180.0°	5.4	J	2	3(1)	5	0	0	10(1)	0	0	0	0	0	0	0	0	
ST56F	2006/6/9	54.5°N 180.0°		O	1(1)	0	0	0	0	1(1)	0	0	0	0	0	0	0	0	
ST57	2006/6/10	53.5°N 180.0°	5.4	J	9	27	20	0	5	61	0	0	0	0	0	0	0	0	
ST58	2006/6/10	52.5°N 180.0°	4.4	J	6	26	24	0	0	56	53	0	0	0	0	0	0	0	
ST59	2006/6/11	51.5°N 180.0°	5.3	J	4	27	7	0	2	40	106	0	0	0	0	0	0	0	
ST60	2006/6/11	50.5°N 180.0°	6.4	J	5	18	3	1	0	27	2	0	13	0	1	0	0	0	
ST61	2006/6/12	49.5°N 180.0°	5.8	J	47	29	18	0	0	94	0	0	0	0	2	1	0	0	
ST62	2006/6/13	50.0°N 175.0°	E 5.8	J	3	52	7	0	0	62	0	0	0	0	0	0	0	0	
ST63	2006/6/13	51.0°N 175.0°	E 5.9	J	10	2	1	0	0	13	0	0	0	0	0	1	0	0	
ST64	2006/6/14	52.0°N 175.0°	E 5.8	J	2	24	5	0	1	32	2603	0	0	0	0	0	0	0	
ST65	2006/6/14	53.0°N 175.0°	E 5.7	J	2	9	3	0	0	14	254	0	0	0	0	0	0	0	
ST05B	2006/6/16	49.0°N 165.0°	E 5.3	J	9	22	4	0	0	35	2	0	181	0	0	0	0	0	
ST06B	2006/6/16	48.0°N 165.0°	E 5.9	J	3	9	0	1	0	13	0	0	161	0	0	0	0	0	
ST07B	2006/6/17	47.0°N 165.0°	E 5.8	J	16	18	18	0	0	52	0	0	8	0	0	0	0	0	
ST08B	2006/6/17	46.0°N 165.0°	E 5.6	J	3	15	5	0	0	23	0	0	0	0	1	0	0	0	
Total						1581 (47)	3262 (46)	2114 (24)	18 (1)	222 (4)	7197 (122)	3026	148	12205	243	8	4	6	19



**Fig. 1.** The survey area of the R/V *Kaiyo maru* cruise during spring 2006. Filled circles indicate first leg stations, open circles indicate second leg stations, and double circles indicate stations where fishing operations were conducted in both first and second legs.