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2008 Summer Japanese Salmon Research Cruise of the R/V *Hokko maru*

by

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Abstract: A summer high-seas research cruise to investigate biology of Pacific salmon was conducted in the Bering Sea from 1 July to 18 July (first leg) and from 20 August to 11 September (second leg) onboard the Japanese research vessel *Hokko maru*. Research cruise activities included the collection of data on oceanography, zooplankton, micronekton, salmonid fishes, and other organisms. A total of 7,530 salmonids were caught by trawl and angling: 3,737 fishes in the first leg and 3,793 fishes in the second leg. In the first leg, chum salmon was the most abundant species (85.3%), followed by chinook (8.6%), sockeye (5.6%), and pink salmon (0.5%). In the second leg, chum salmon was the most abundant species (79.3%), followed by sockeye (17.2%), chinook (3.3%), pink (0.1%), coho salmon and steelhead trout. Salmonids were measured for fork length, body and gonad weight, lipid content by fat meter, sexed, and removed scales for age determination. Isotope, genetic, otolith, stomach contents, lipid samples were obtained for future studies.

Introduction

Japanese research vessels have monitored the stock condition of Pacific salmon (*Oncorhynchus* spp.) since 1952 (Ishida and Ogura, 1992). Several interesting findings have found from analyses of data collected during these surveys (e.g., Ishida *et al*., 1993; Ogura and Ito, 1994; Shiomoto *et al*., 1997; Welch *et al*., 1998; Ishida *et al*., 2002). The new R/V *Hokko maru* was launched in 2004 and it was her second salmon research cruise in the North Pacific (Morita *et al.*, 2007). 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, and analysis of the genetic structure of salmon populations in the ocean. This document summarizes the research cruise conducted by the R/V *Hokko maru* in the Bering Sea during summer 2008.

Survey Area

The R/V *Hokko maru* departed from Kushiro, Japan, on 1 July 2008 and returned to Kushiro on 18 July 2008 (first leg); the *Hokko maru* departed Kushiro 20 August 2008 and returned to Kushiro on 11 September 2008 (second leg). A total of 37 trawling were conducted at 32 stations during the cruise (Fig. 1 and Table 1). Eighteen trawling were conducted during the first leg, and 19 trawling were conducted during the second leg. All fishing stations were located in the Bering Sea.

Temperature and Salinity Sampling

A salinity, temperature, and depth sensor (STD) was used at each fishing station before the trawling. The STD recorded data at 1-m intervals from the surface to a maximum of approximately 500 m.

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) at each fishing station of leg 2. The NORPAC net was towed vertically from 150 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 10% borax-buffered formalin.

Large macro-zooplankton were collected at 7 fishing stations using an BONGO net (2 rings, 0.7 m diameter, 4.1 m in overall length, 0.335 mm mesh size). An hour past sunset, the net was towed obliquely along the stern of the vessel from 100 m to the surface at a speed of approximately 1.5 knots. Samples were fixed in 10% borax-buffered formalin in seawater.

Fish Collection

A surface 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 30 m depth for one hour in daytime. In the first leg, the trawl was also towed at the speed of 4 knots for a distance of 5 miles at two fishing stations (W27, H24). The height and the width of the mouth of trawl were c.a. 23 and 45 m, respectively, for the speed of 5 knots and c.a. 36 and 43 m, respectively, for the speed of 4 knots (Fig. 2). The length of trawl was 152 m. The cod end of the net was lined with a net of mesh size 17.5 mm in the first leg, whereas the cod end of the net was not lined and was mesh size of 60.0 mm in the second leg except for final station (OP2). In addition, hooks and lines were used to collect live fish samples.

A total of 7,530 salmonids (7,568 kg) was caught by trawl and angling: 3,737 fishes in the first leg and 3,793 fishes in the second leg (Table 1). In the first leg, chum salmon (*Oncorhynchus keta*) was the most abundant species (85.3%), followed by chinook (*O. tshawytscha*; 8.6%), sockeye (*O. nerka*; 5.6%), and pink salmon (*O. gorbuscha*; 0.5%). In the second leg, chum salmon was the most abundant species (79.3%), followed by sockeye (17.2%), chinook (3.3%), and pink salmon (0.1%). A coho salmon (*O. kisutch*) and a steelhead trout (*O. mykiss*) were caught in the second leg. Two strange chum salmon characterized by mottled coloration were caught (Fig. 3). Hikita (1958) reported the occurrence of the same mottled chum salmon in the Teshio River. Furthermore, two strange salmon (chum and sockeye) with hyperplasia on lower jaw were also caught (Fig. 4). The hyperplasia samples were collected and sent to NASREC.

In addition, 73,493 non-salmonid fishes (1,758 kg), many squids (82 kg), jellyfish (128 kg) and a common murre (*Uria aalge*; 1.3 kg) were caught with the trawl (Table 1). Walleye pollock (*Theragra chalcogramma*; n = 2, 1.6 kg), Atka mackerel (*Pleurogrammus monopterygius*; n = 72426, 1565 kg), Pacific saury (*Cololabis saira*; n = 1063, 190 kg), Pacific pomfret (*Brama japonica*; n = 1, 1.3 kg) and smooth lumpsucker (*Aptocyclus ventricosus*; n = 1) were caught. Two walleye pollock were large adult. Most Atka mackerel were small juveniles.

Fish Measurement

Salmonids were processed soon after removal from the fishing gear. The catch was sorted by species and counted. Biological data were recorded on the deck in each trawl (Fig. 5). Biological data included fork length (mm), body weight (10 g), sex, gonad weight (0.1 g) and lipid content. The basic biological data were recorded from all individuals. The gonad weight was recorded from a maximum of 120 individuals per species caught in each trawl. Body and gonad weigh were measured using the Marine scale (POLS, Iceland). Lipid contents of chum and pink salmon were measured from a maximum of 50 individuals per species caught in each trawl by the Distell

fatmeter (Distell, Scotland). The presence of visceral adhesions was also recorded. 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. Samples of chum and pink salmon body were collected for analyses of lipid content. Samples of chum and sockeye salmon body were also collected for parasite study. The isotope and lipid samples were frozen and carried to Hokkaido National Fisheries Research Institute (HNFRI) and National Salmon Resources Center (NASREC), respectively, for a further examination in a laboratory. The parasite samples were also frozen and carried to NASREC. Adipose fin of chum and chinook salmon and otoliths of chum salmon 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 20 stomachs for each species at each trawl was fixed in 10% borax-buffered formalin for further examination in a laboratory and carried to HNFRI or Hokkaido University. In addition, frozen samples of chinook stomach with scales and Atka mackerel juveniles were sent to scientists at the University of Washington, Seattle, WA, USA.

Effects of Towed Speed on Chum Salmon Catches

The sampling efficiency of two different towed speeds of surface trawl was compared at two fishing stations. Average fork length of caught fish was larger for the trawl towed at speed of 5 knots than for the trawl towed at speed of 4 knots (H24; 4 knots: 400 ± 72 mm, n = 94, 5 knots: 480 ± 95 mm, n = 51, W27; 4 knots: 408 ± 63 mm, n = 403, 5 knots: 428 ± 81 mm, n = 130). However, the total number of catches was larger for the trawl towed at speed of 4 knots than for the trawl towed at speed of 5 knots (Table 1). There was a negative correlation between the total number of catches and the actual towed speed of 5 knots trawling for the 14 fishing stations in the first leg (r = –0.776, p = 0.001, actual speed through water: range 4.54–5.12 knots). The size of the trawl's mouth opening might decrease with increase in towed speed (Fig. 2).

Acknowledgements

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Table 1. Catches of sockeye salmon (SO), chum salmon (CH), pink salmon (PK), coho salmon (CO), chinook salmon (CN), steelhead trout (ST), Atka mackerel (AM), walleye pollock (WP), Pacific saury (PS), and other fishes (OF) along with the sea surface temperature (SST, °C) at each station during the R/V *Hokko maru* cruise in 2008 summer. J-gear, surface trawl; O-gear, hook and line. *The cod end of the net was not lined. †Failure. ‡The trawl was towed at the speed of 4 knots.

St.	Date	Location			SST	Gear	Pacific salmon						AM	WP	PS	OF
							SO	CH	PK	CO	CN	ST				
W31	7/6	56.6°N	176.0°	E	8.0	J	31	54	0	0	0	0	19	0	0	0
W30	7/6	57.5°N	176.2°	E	8.2	J	13	90	0	0	1	0	29	0	0	0
W29	7/7	57.4°N	177.0°	E	8.0	J	16	293	1	0	3	0	1	0	0	0
W28	7/7	56.5°N	177.1°	E	8.2	J	23	232	1	0	1	0	495	0	0	0
W27	7/8	56.5°N	178.1°	E	8.1	J	15	130	1	0	4	0	3	0	0	0
W27-2‡	7/8	56.5°N	178.1°	E		J	38	403	2	0	7	0	3	1	0	0
W26	7/8	56.6°N	179.1°	E	7.9	J	4	128	1	0	0	0	713	0	0	0
W25	7/9	56.5°N	178.9°	W	7.9	J	12	120	1	0	13	0	2	0	0	0
W24	7/9	56.5°N	177.9°	W	8.1	J	8	183	1	0	33	0	0	0	0	0
W23	7/10	57.5°N	177.9°	W	7.9	J	19	218	0	0	103	0	0	0	0	0
W22	7/10	57.6°N	179.1°	W	8.7	J	2	121	0	0	21	0	13	0	0	0
W21	7/11	58.4°N	179.9°	W	7.4	J	9	302	3	0	41	0	0	0	0	0
W20	7/11	57.5°N	180.0°		8.3	J	6	488	1	0	70	0	0	0	0	0
W19	7/12	56.5°N	180.0°		8.7	J	5	93	1	0	16	0	73	0	0	0
W18	7/12	55.5°N	180.0°	W	8.5	J	4	36	1	0	0	0	1458	0	0	0
H24	7/13	54.1°N	174.9°	E	9.6	J	1	51	0	0	0	0	23207	0	0	0
H24-2†	7/13	54.1°N	175.0°	E		J	0	23	1	0	0	0	0	0	0	0
H24-3‡	7/13	54.2°N	175.1°	E		J	0	94	2	0	1	0	36381	0	0	0
1st leg	7/6–7/13	Bering Sea				O	5	128	0	0	8	0	0	0	0	0
H22	8/25	55.9°N	175.1°	E	12.1	J*	6	161	0	0	15	0	6	0	0	0
H23	8/26	54.9°N	175.0°	E	12.0	J*	4	136	1	0	1	0	12	0	0	0
H24	8/26	54.0°N	175.1°	E	12.3	J*	3	144	0	0	5	1	62	0	0	0
H25	8/27	53.0°N	175.0°	E	11.1	J*	83	35	0	0	3	0	86	1	1063	0
H15	8/28	52.6°N	180.0°	W	6.3	J*	56	90	1	0	1	0	133	0	0	0
H16	8/28	53.5°N	179.9°	W	9.6	J*	33	286	0	0	4	0	100	0	0	0
H17	8/29	54.5°N	179.9°	W	10.8	J*	19	152	0	0	9	0	26	0	0	0
H18	8/29	55.5°N	179.9°	W	11.5	J*	9	210	0	0	7	0	41	0	0	0
H19	8/30	56.5°N	180.0°	W	11.2	J*	5	165	1	0	15	0	3	0	0	0
H20	8/30	57.4°N	180.0°	W	11.2	J*	66	352	0	0	11	0	0	0	0	0
H21	8/31	58.5°N	180.0°	E	10.4	J*	23	87	0	0	3	0	4	0	0	1

——*Table 1. continued* ——

St.	Date	Location			SST	Gear	Pacific salmon						AM	WP	PS	OF
							SO	CH	PK	CO	CN	ST				
H07	9/1	58.0°N	175.0°	W	10.4	J*	22	140	0	0	8	0	8	0	0	0
H08	9/1	57.0°N	175.0°	W	10.6	J*	41	181	0	1	9	0	0	0	0	0
H09	9/2	55.9°N	175.0°	W	10.5	J*	107	264	0	0	5	0	0	0	0	0
H10	9/2	57.4°N	180.0°	W	10.5	J*	10	70	0	0	15	0	32	0	0	0
H11	9/3	54.0°N	175.0°	W	10.3	J*	19	159	0	0	3	0	24	0	0	0
H12	9/3	53.0°N	175.1°	W	10.4	J*	23	72	0	0	8	0	130	0	0	0
OP1-1	9/4	52.8°N	178.8°	W	9.5	J*	65	163	0	0	3	0	79	0	0	0
OP1-2	9/4	52.8°N	178.8°	W		J	53	66	2	0	2	0	9283	0	0	1
2nd leg	8/26–9/4	Bering Sea				O	5	74	0	0	0	0	0	0	0	0
Total							863	6194	22	1	449	1	72426	2	1063	2

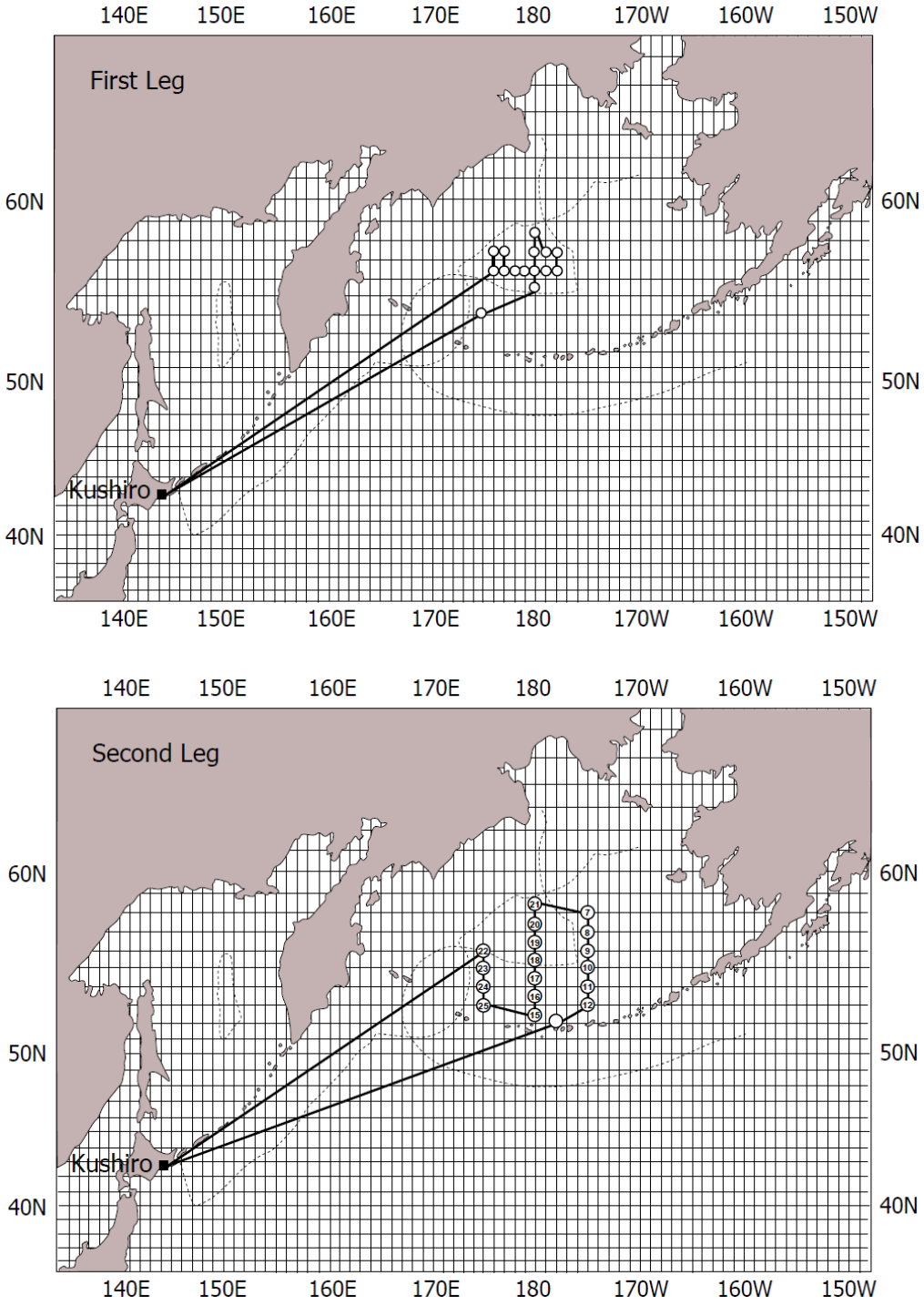

Fig. 1. The survey area of the R/V *Hokko maru* cruise during summer 2008. Upper panel: first leg, lower panel: second leg.

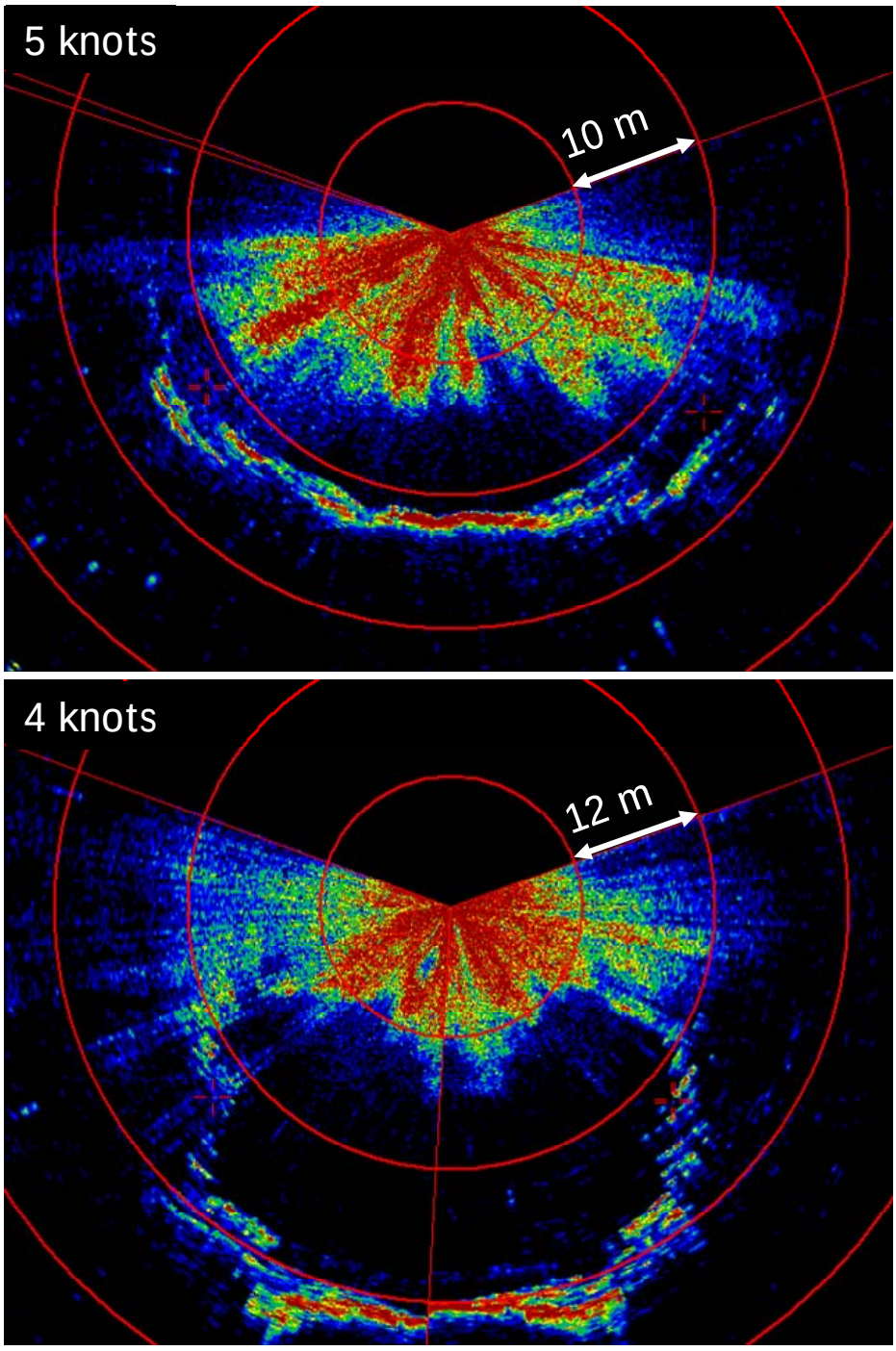

Fig. 2. The image of trawl sonar for the two different towed speeds. Upper panel: 5 knots, lower panel: 4 knots.

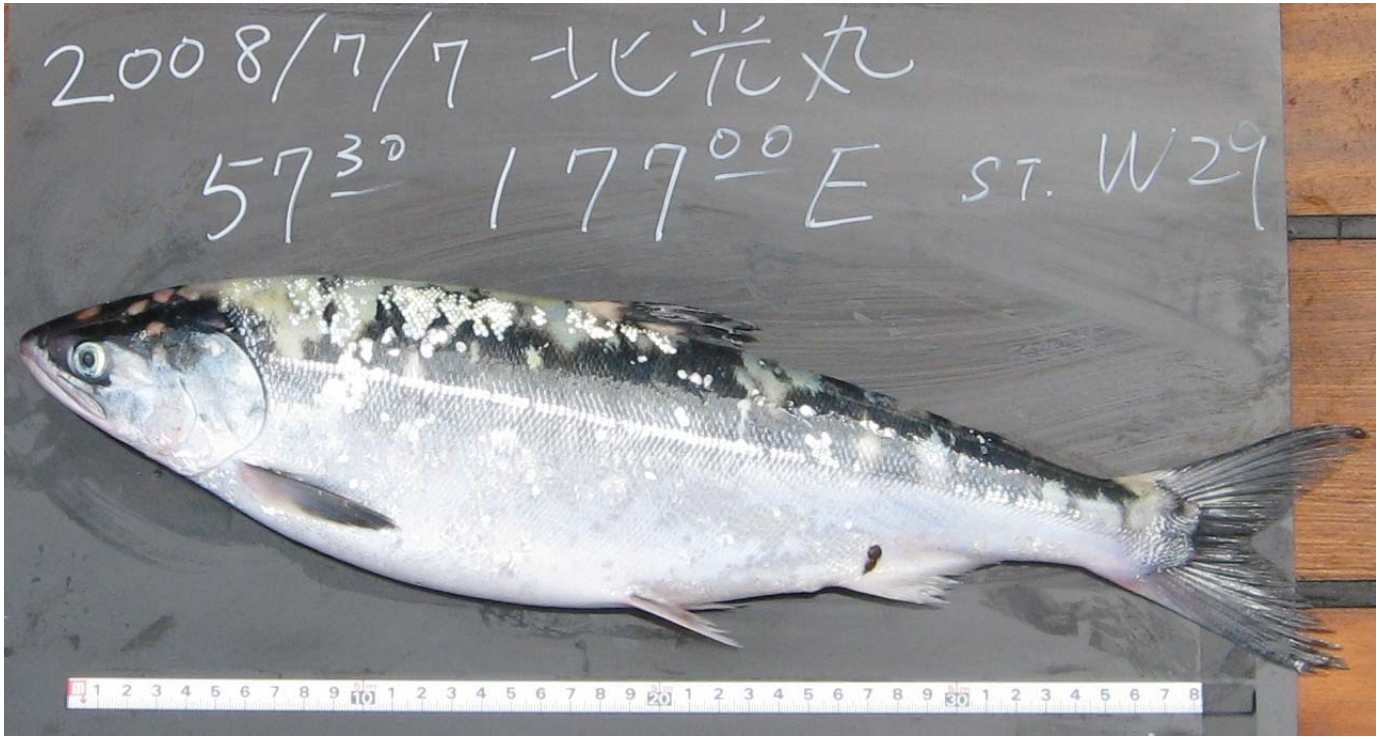

Fig. 3. A strange chum salmon characterized by mottled coloration caught in the Bering Sea (fork length = 421 mm).

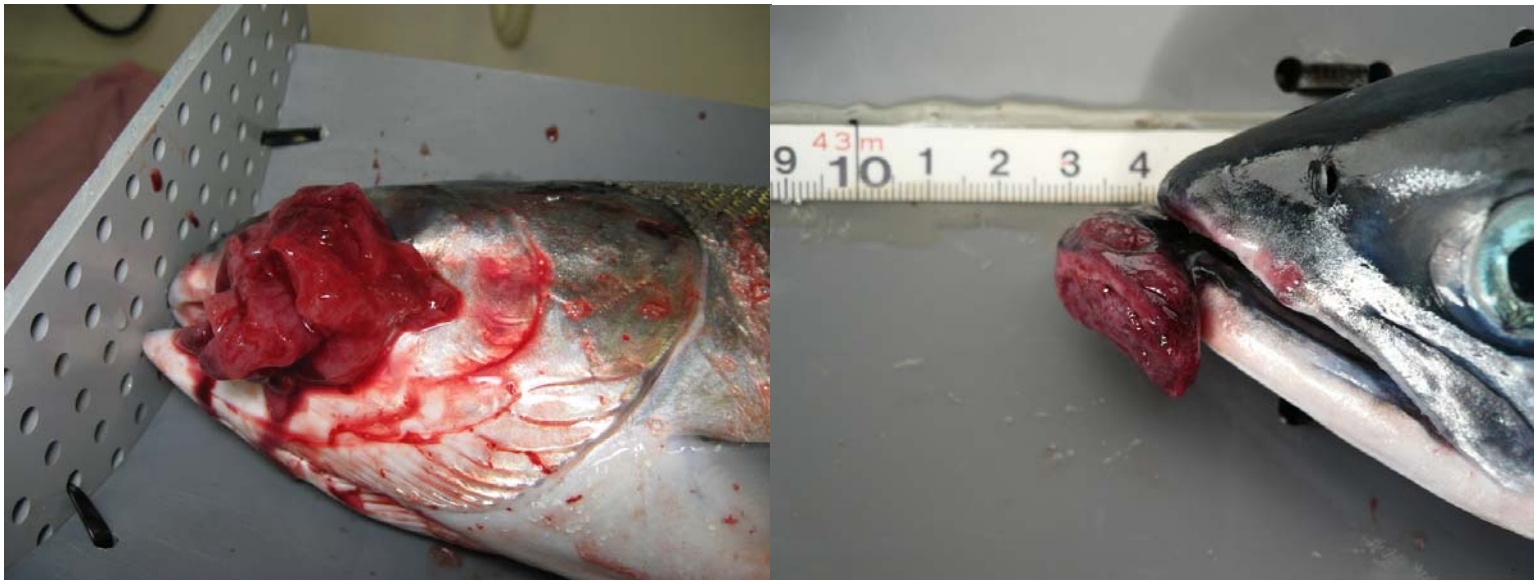

Fig. 4. Two salmon with hyperplasia on lower jaw caught in the Bering Sea (left panel: chum salmon, right panel: sockeye salmon).

Fig. 5. A scene of fish measurement on the deck of R/V *Hokko maru* on 10 July 2008.