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The Summer 2011 Japanese Salmon Research Cruise of the R/V *Hokko maru*

by

Kentaro Morita, Shunpei Sato, Tomoki Sato, & Tsutomu Ohnuki

Hokkaido National Fisheries Research Institute, Fisheries Research Agency
2-2 Nakanoshima, Toyohira-ku, Sapporo 062-0922, Japan
(E-mail: moritak@affrc.go.jp, shuns@affrc.go.jp)

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Abstract: A summer high-seas research cruise to investigate the biology of Pacific salmon was conducted from July 20 to August 9 in the Bering Sea aboard 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 3,662 salmonids were caught by trawls and angling. Chum salmon was the most abundant species (92.1%), followed by sockeye salmon (5.5%), chinook salmon (1.8%), pink salmon (0.6%), coho salmon (*O. kisutch*; 0.1%), and Dolly Varden charr (*Salvelinus malma*; 0.03%). Salmonids were measured with respect to fork length and body and gonad weights, they were sexed, and the scales were removed for age determination. Isotope, genetic, otolith, and lipid samples were obtained for future study. There were 49 chum salmon tagged with disk tags and released in the Bering Sea. From among fish released with disk-tags, 30 small chum salmon were released carrying archival tags. Age-specific catch per surface trawl (CPUE) from 17 fixed fishing stations from 2007 to 2011 are documented here.

Introduction

Japanese research vessels have monitored the condition of Pacific salmon (*Oncorhynchus* spp.) stock since 1952 (Ishida and Ogura, 1992). Several interesting findings have arisen from analyses of data collected during these surveys (e.g., Ishida *et al*., 1993, 2002; Ogura and Ito, 1994; Welch *et al*., 1995; 1998; Tadokoro *et al.*, 1996; Shiomoto *et al*., 1997; Moriya *et al*. 2007, 2009; Fukuwaka *et al.*, 2010; Morita *et al.*, 2009, 2010a,b; Beacham *et al*., 2011; Morita 2011). The new R/V *Hokko maru* (902 gross tons) was launched in 2004 and the 2011 expedition was her fourth salmon research cruise in the North Pacific (Morita *et al.*, 2007, 2008, 2009a). The main objective for this cruise was to conduct the annual survey of Japanese stocks of chum salmon in the Bering Sea. Routine observations on the *Hokko maru* have included the collection of data on physical oceanography, trophic interactions among zooplankton, salmonids, and organisms at higher trophic levels, and analysis of the genetic structure of salmon populations. This document summarizes the research cruise conducted by the R/V *Hokko maru* during summer 2011.

Survey Area

The R/V *Hokko maru* departed from Kushiro, Japan, on July 20, 2011, and returned to Kushiro on August 9, 2010. A total of 17 trawls were conducted at 17 stations during the cruise (Fig. 1 and Table 1). All fishing stations were located in the Bering Sea.

Temperature and Salinity Sampling

A salinity, temperature, and depth sensor (STD, model AST1016, no. 1077 manufactured by Alec Electronics Co., Ltd., Kobe, Japan) was used at each fishing station before the trawl. The STD recorded data at 1-m intervals from the surface to a maximum of approximately 500 m. Surface water was sampled using a bucket to measure sea surface temperature (SST) and sea surface salinity (SSS) at each fishing station.

Zooplankton and Micronekton Sampling

NORPAC net. 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. The NORPAC net was towed vertically from a maximum of 150 m to the surface. A calibrated flow meter was attached to the opening of net in a position slightly off-center. The NORPAC net samples were fixed in 10% borax-buffered formalin.

BONGO net. Large macro-zooplankton were collected at seven trawl locations (H22, H24, H16, H18, H20, H08, H10) using a BONGO net (2 rings, 0.7-m diameter, 4.1-m overall length, 0.335-mm mesh size). An hour after 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. Calibrated flow meter was attached to the interior of each ring. 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. The length of trawl net was 152 m. The cod end of the trawl net was lined with a non-tied net of mesh size 60.0 mm. To monitor depth and temperature of the trawl net, small depth–temperature recorders (SBT-500 manufactured by Murayama Denki Ltd., Tokyo, Japan) were attached to five different points of the trawl net (head rope, ground rope, cod end, right and left otter boards). In addition, hooks and lines were used to collect live fish samples for tagging study.

A total of 3,662 salmonids (2,518 kg) was caught by trawl and angling: 3,500 fishes by trawl and 162 fishes by angling (Table 1). Six species of salmonids were caught during the R/V *Hokko maru* cruise in 2011 summer (Fig. 2). Chum salmon (*Oncorhynchus keta*) was the most abundant species (92.05%), followed by sockeye salmon (*O. nerka*; 5.46%), chinook salmon (*O. tshawytscha*; 1.75%), pink salmon (*O. gorbuscha*; 0.57%), coho salmon (*O. kisutch*; 0.14%), and Dolly Varden charr (*Salvelinus malma*; 0.03%). This is the first time that Dolly Varden was caught during the R/V *Hokko maru* salmon research cruise, although Dolly Varden charr was often caught in the past gillnet observations (Morita *et al*., 2009b). In addition, two chum salmon characterized by mottled coloration and a chum salmon characterized by meandering vertebra were caught (Fig. 3). Hikita (1958) and Morita *et al.* (2008) reported the occurrence of the same mottled chum salmon in the Teshio River and the

Bering Sea, respectively.

In addition to salmonids, 2,396 teleost fishes (345 kg), 28 squids (0.18 kg), a shark and many jellyfish (44 kg) were caught in trawls (Table 1). Atka mackerel (*Pleurogrammus monopterygius*; *n* = 2,394), walleye pollock (*Theragra chalcogramma*; *n* = 2), salmon shark (*Lamna ditropis*; n = 1), and unknown small squids were caught. All walleye pollock and 22.7% of Atka mackerel were small (<100 mm) 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 for each trawl: fork length (mm), body weight (10 g), sex, and gonad weight (0.1 g). Basic biological data were recorded for all individuals. Gonad weight was recorded from a maximum of 240 individuals per species caught in each trawl. Body and gonad weights were measured using the Marine scale (manufactured by POLS, Reykjavik, Iceland). The presence of visceral adhesions was also recorded. One scale (for pink salmon) or two scales (for sockeye, chum, coho, and chinook salmon) were collected for age determination and back-calculations of growth. When possible, scales were collected from the preferred body area identified by the International North Pacific Fisheries Commission (INPFC) for scale sampling (Davis *et al*., 1990).

Samples of body tissues from each salmon species were collected for stable isotope analyses. The isotope samples were frozen and transported to the Hokkaido National Fisheries Research Institute (HNFRI) for further laboratory examination. Round samples of small chinook salmon (<450 mm) were collected for lipid content and stomach content analyses. The round sample of small chinook salmon were frozen and is ready to transport to the Dr. Trey Walker of the University of Washington, USA. Adipose fins of chum, sockeye, chinook, coho and pink salmon and Dolly Varden were collected for genetic analyses. Otoliths of chum salmon were collected for detection of thermal marks on the otoliths. Chum salmon fin and otolith samples, fixed in ethanol, were transported to HNFRI. Sockeye and chinook salmon fin samples, fixed in ethanol, were sent to Dr. Terry Beacham of the Pacific Biological Station, Canada, and Dr. James Seeb of the University of Washington, USA, respectively. Five species of salmonids fin samples, fixed in ethanol, were also sent to Dr. Shoichiro Yamamoto of the National Research Institute of Aquaculture.

Release of Tagged Chum Salmon

Live chum salmon caught in healthy condition were put into a recovery tank. Each fish was tagged with two disk tags, one issued by the Fisheries Agency of Japan (FAJ) and one by the North Pacific Anadromous Fish Commision (NPAFC). Both disk tags were placed on one plastic cinch strap and attached to the fish in an area anterior to the dorsal fin. In additions to two disk tags, small archival tags (model DST micro manufactured by Star-Oddi, Reykjavik, Iceland, size, 8.3 × 25.4 mm; weight in air, 3.3 g; number of records, 21,739 per sensor) were also used to record seawater temperature and depth of the immature chum salmon. Archival tags were attached

externally with nickel pins to the dorsal musculature of the fish anterior to the dorsal fin. The fork length was measured before the fish was released to the sea. A total of 19 disk-tagged chum salmon was released into the Bering Sea (Table 2). A total of 30 chum salmon was released with both disk and archival tags into the Bering Sea (Table 2).

Preliminary Results

The main objective of this research program is to monitor the stock condition of Japanese chum salmon. Fixed point observations (17 fixed fishing stations) have been conducted since 2007 by the R/V *Hokko maru*. In every years, fork length was distributed bimodally, with chum salmon in the small size group (<400 mm) being mostly 1+ year old, and those in the large size group (>400 mm) being mostly older than 2 years (Fig. 4). Average body size of chum salmon in this year was smaller compared with previous years (2007, 2008, 2009). In addition, body weight of chum salmon in this year was significantly smaller compared with previous years after controlling for fork length (Fig. 5).

Age-specific catch per surface trawl (CPUE) from 17 fixed fishing stations for each year are documented here (Fig. 6). To calculate age-specific CPUE for 2011, age-length key of 2009 was used as provisional estimation. In addition to CPUE, age-specific stock origin will be routinely estimated using DNA techniques (cf. Sato *et al.*, 2009). We are hoping that the *Hokko-maru* data will be useful for the stock assessment of Japanese chum salmon.

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Table 1. Catches of sockeye salmon (SO), chum salmon (CH), pink salmon (PK), coho salmon (CO), chinook salmon (CN), Dolly Varden charr (DV), Atka mackerel (AM), walleye pollock (WP), salmon shark (SS), and jellyfish (JF) along with the sea surface temperature (SST, °C) at each station during the R/V *Hokko maru* cruise in summer 2011. Above line was expressed in number whereas below gray line was expressed in kg for each station. J-gear, surface trawl; O-gear, hook and line; n.a., not available. *Point at which the net was hauled.

St.	Date	Location*			SST	Gear	Salmonid fishes						AM	WP	SS	JF
							SO	CH	PK	CO	CN	DV				
H22	2011/7/25	56°01´N	175°05´	E	9.4	J	0	269	1	0	0	0	0	0	1	n.a.
							0	129.1	0.8	0	0	0	0	0	n.a.	3.8
H23	2011/7/26	55°00´N	175°05´	E	8.8	J	0	46	3	0	0	0	20	0	0	n.a.
							0	41.9	3.4	0	0	0	0.1	0	0	13.3
H24	2011/7/26	54°00´N	175°01´	E	8.4	J	1	217	3	0	1	0	0	0	0	n.a.
							1.4	126.4	3.2	0	3.9	0	0	0	0	9.2
H25	2011/7/27	52°59´N	175°07´	E	8.8	J	1	115	0	0	0	0	0	0	0	n.a.
							0.7	74.8	0	0	0	0	0	0	0	4.4
H15	2011/7/28	52°34´N	179°59´	E	6.3	J	1	70	0	0	1	0	1,847	0	0	0
							3.3	114	0	0	3.2	0	337.2	0	0	0
H16	2011/7/28	53°32´N	179°55´	E	8.5	J	3	111	0	0	0	0	1	0	0	n.a.
							3.8	93.9	0	0	0	0	0.9	0	0	4.5
H17	2011/7/29	54°33´N	179°56´	E	8.4	J	3	102	0	0	5	0	23	0	0	n.a.
							3.1	61.4	0	0	12.5	0.0	0.1	0	0	2.4
H18	2011/7/29	55°33´N	170°55´	E	8.6	J	3	119	1	0	5	0	61	0	0	n.a.
							3.9	62.3	1.3	0	9.1	0.0	0.3	0	0	2.1
H19	2011/7/30	56°32´N	179°58´	E	8.8	J	1	142	0	0	4	0	0	0	0	n.a.
							2.1	94.6	0.0	0	14.8	0.0	0	0	0	0.02
H20	2011/7/30	57°33´N	179°59´	E	9.5	J	22	650	2	1	8	0	423	2	0	n.a.
							18.9	323.0	1.7	3.8	16.6	0.0	4.1	9×10^{-4}	0	1.0
H21	2011/7/31	58°31´N	179°52´	W	9.1	J	30	410	3	1	13	1	2	0	0	0
							34.5	234.5	3.3	3.5	20.5	0.1	0	0	0	0
H07	2011/8/1	57°56´N	174°55´	W	9.5	J	8	145	2	0	0	0	0	0	0	n.a.
							4.5	105.4	2.6	0	0	0	0	0	0	0.4

——Table 1. continued ——

St.	Date	Location			SST	Gear	Salmonid fishes						AM	WP	SS	JF
							SO	CH	PK	CO	CN	DV				
H08	2011/8/1	57°00´N	174°55´	W	9.4	J	33	315	1	0	0	0	7	0	0	n.a.
							17.9	183.6	1.2	0	0.0	0	0.1	0	0	0.5
H09	2011/8/2	55°56´N	175°00´	W	9.1	J	60	315	1	0	6	0	1	0	0	n.a.
							51.9	170.0	1.3	0	19.3	0	0.9	0	0	1.0
H10	2011/8/2	54°57´N	175°04´	W	9.4	J	10	112	2	0	13	0	0	0	0	n.a.
							11.1	64.8	3.4	0	21.0	0	0.0	0	0	0.4
H11	2011/8/3	53°57´N	175°00´	W	8.2	J	5	54	1	0	1	0	9	0	0	n.a.
							5.9	52.0	0.5	0	2.4	0	1.0	0	0	1.0
H12	2011/8/3	52°59´N	174°57´	W	8.8	J	0	42	0	0	5	0	0	0	0	n.a.
							0	35.3	0	0	14.3	0	0	0	0	0.2
H24-H10	7/16–8/3	Bering Sea				O	19	137	1	3	2	0	0	0	0	0
							27.9	178.7	1.4	8.9	3.2		0	0	0	0
Total							200	3,371	21	5	64	1	2,394	2	1	n.a.
							190.9	2145.8	38.2	16.2	126.6	0.1	344.6	9×10^{-4}	n.a.	44.0

Table 2. Tag releases during the R/V *Hokko maru* cruise in the Bering Sea in 2011 summer. FAJ, Fisheries Agency of Japan; NPAFC, North Pacific Anadromous Fish Commission.

#	St.	Date	Type of archival tag	Archival tag number	Disk tag number		Species	Fork length (mm)	Gear
					NPAFC	FAJ			
1	H24	2011/7/26			NA5451	CC6301	chum	520	O
2	H24	2011/7/26			NA5452	CC6302	chum	550	O
3	H16	2011/7/28	DST-micro	5594	NA5402	H1901	chum	530	O
4	H16	2011/7/28			NA5453	CC6303	chum	490	O
5	H17	2011/7/29	DST-micro	5596	NA5403	H1902	chum	410	O
6	H17	2011/7/29			NA5454	CC6304	chum	528	O
7	H17	2011/7/29			NA5455	CC6305	chum	570	O
8	H17	2011/7/29			NA5456	CC6306	chum	534	O
9	H18	2011/7/29	DST-micro	5597	NA5404	H1903	chum	336	J
10	H18	2011/7/29			NA5957	CC6307	chum	538	O
11	H18	2011/7/29	DST-micro	5598	NA5405	H1904	chum	348	O
12	H19	2011/7/30	DST-micro	5599	NA5406	H1905	chum	442	O
13	H19	2011/7/30			NA5458	CC6308	chum	535	O
14	H19	2011/7/30			NA5459	CC6309	chum	511	O
15	H19	2011/7/30	DST-micro	5600	NA5407	H1906	chum	442	O
16	H19	2011/7/30	DST-micro	5601	NA5408	H1907	chum	416	O
17	H19	2011/7/30			NA5460	CC6310	chum	595	O
18	H19	2011/7/30			NA5461	CC6311	chum	478	O
19	H19	2011/7/30			NA5462	CC6312	chum	489	O
20	H19	2011/7/30	DST-micro	5602	NA5409	H1908	chum	405	J
21	H19	2011/7/30	DST-micro	5603	NA5410	H1909	chum	390	J
22	H19	2011/7/30	DST-micro	5604	NA5414	H1910	chum	390	J
23	H19	2011/7/30	DST-micro	5605	NA5601	H1911	chum	380	J
24	H20	2011/7/30	DST-micro	5606	NA5602	H1912	chum	340	J
25	H20	2011/7/30	DST-micro	5607	NA5603	H1913	chum	340	J
26	H20	2011/7/30	DST-micro	5608	NA5604	H1914	chum	340	J
27	H20	2011/7/30	DST-micro	5609	NA5605	H1915	chum	410	J
28	H20	2011/7/30			NA5463	CC6313	chum	470	O
29	H20	2011/7/30			NA5464	CC6314	chum	560	O
30	H20	2011/7/30	DST-micro	5610	NA5606	H1916	chum	380	O
31	H20	2011/7/30			NA5465	CC6315	chum	510	O
32	H20	2011/7/30			NA5466	CC6316	chum	550	O
33	H20	2011/7/30	DST-micro	5611	NA5607	H1917	chum	460	O
34	H20	2011/7/30	DST-micro	5612	NA5608	H1918	chum	435	O
35	H20	2011/7/30	DST-micro	5613	NA5609	H1919	chum	392	O
36	H21	2011/7/31			NA5467	CC6317	chum	532	O
37	H21	2011/7/31	DST-micro	5614	NA5610	H1920	chum	432	O
38	H21	2011/7/31	DST-micro	5616	NA5612	H1922	chum	452	O
39	H21	2011/7/31			NA5468	CC6318	chum	610	O
40	H21	2011/7/31	DST-micro	5615	NA5611	H1921	chum	440	O
41	H21	2011/7/31	DST-micro	5617	NA5613	H1923	chum	358	O
42	H21	2011/7/31	DST-micro	5618	NA5614	H1924	chum	382	O
43	H21	2011/7/31	DST-micro	5620	NA5615	H1925	chum	396	O
44	H21	2011/7/31	DST-micro	5622	NA5616	H1926	chum	454	O
45	H21	2011/7/31	DST-micro	5624	NA5617	H1927	chum	450	O
46	H21	2011/7/31	DST-micro	5626	NA5618	H1928	chum	448	O
47	H21	2011/7/31			NA5469	CC6319	chum	522	O
48	H21	2011/7/31	DST-micro	5627	NA5619	H1929	chum	368	J
49	H21	2011/7/31	DST-micro	5628	NA5620	H1930	chum	356	J

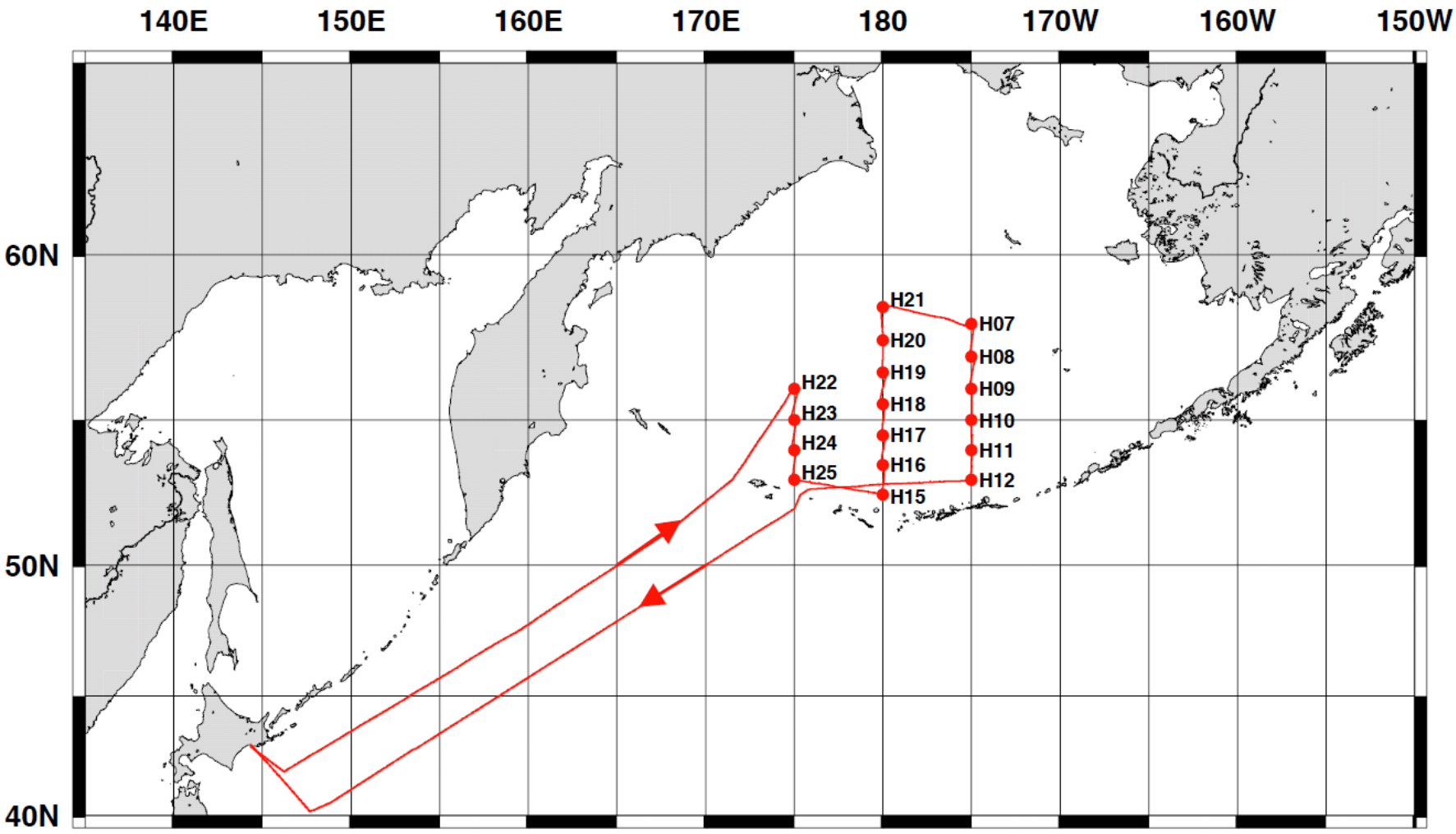

Fig. 1. The path of the R/V *Hokko maru* during the summer 2011 cruise and the location of 17 fishing stations (red circles).

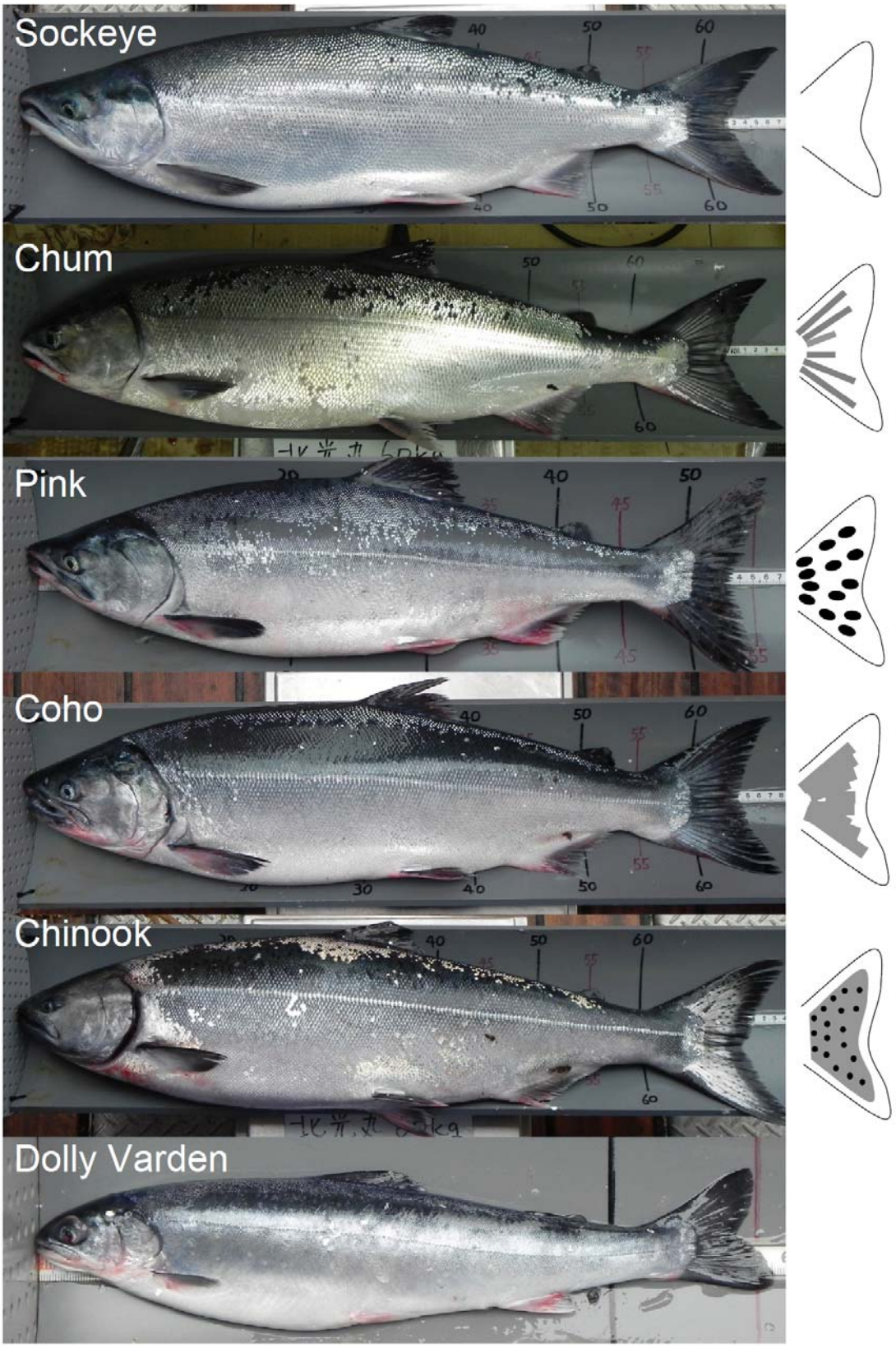

Fig. 2. Six species of salmonids caught during the R/V *Hokko maru* cruise in 2011 summer in the Bering Sea. Sockeye salmon (*Oncorhynchus nerka*), chum salmon (*O. keta*) pink salmon (*O. gorbuscha*), coho salmon (*O. kisutch*), chinook salmon (*O. tshawytscha*) and Dolly Varden charr (*Salvelinus malma*).

Fig. 3. A deformed chum salmon characterized by meandering vertebra (*above*) and two chum salmon characterized by mottled coloration (*below*) caught during the R/V *Hokko maru* cruise in 2011 summer in the Bering Sea.

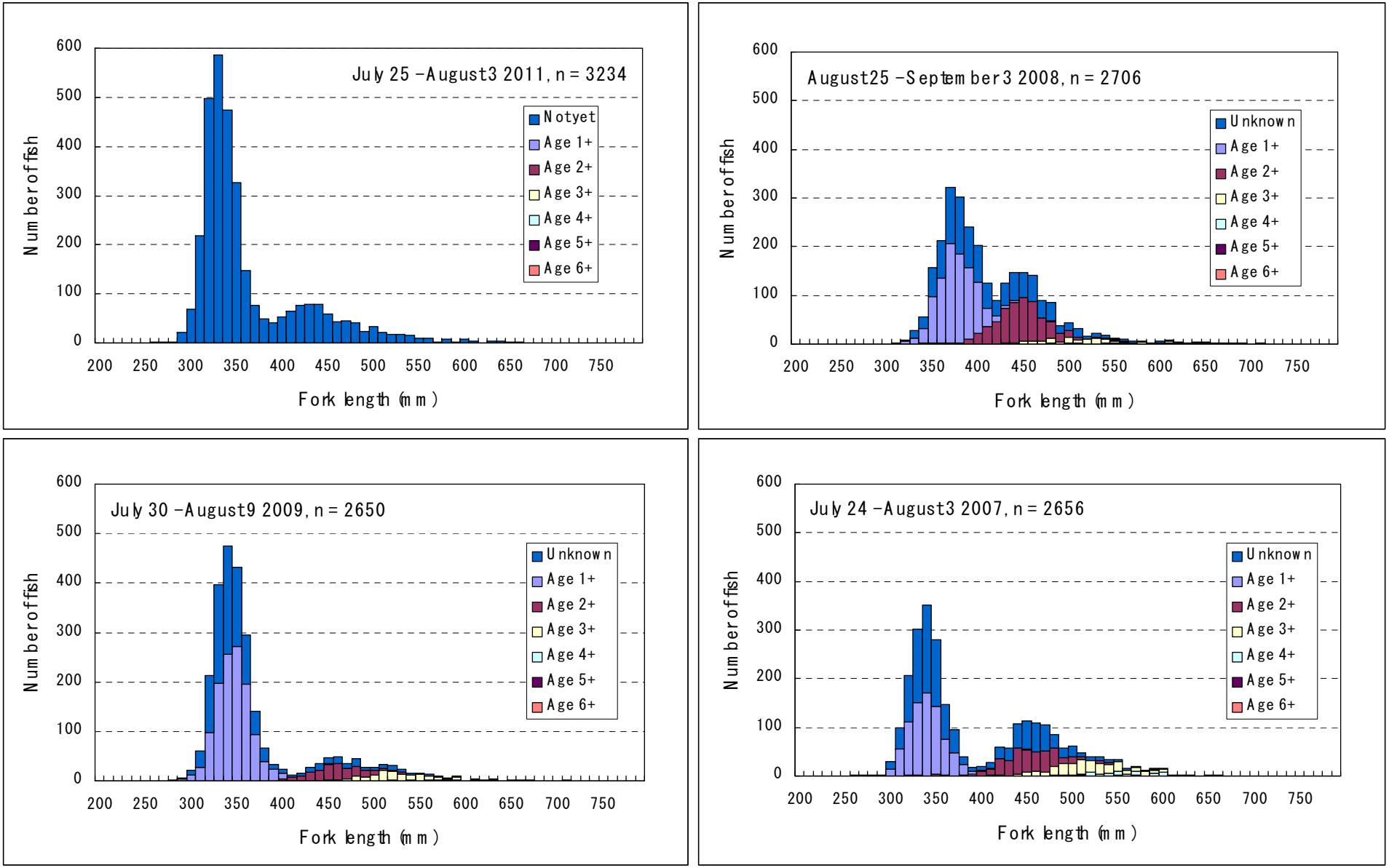

Fig. 4. Yearly fork length distributions of chum salmon in the 17 fixed fishing stations in Bering Sea from 2007 to 2011.

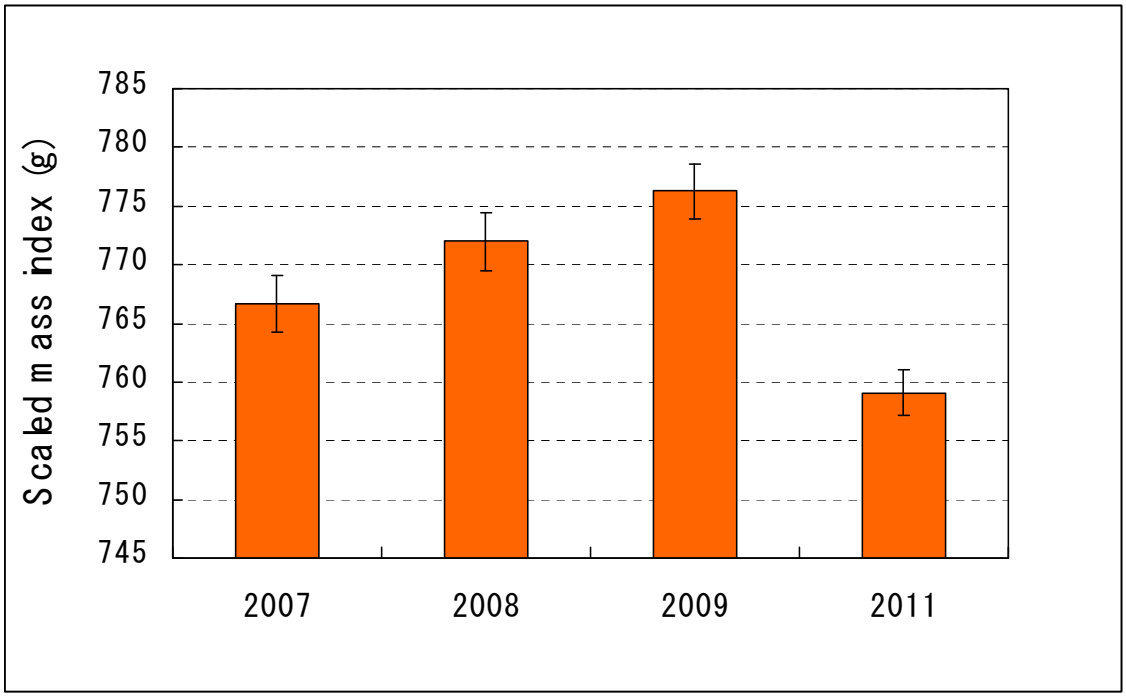

Fig. 5. Scaled mass index (Peig and Green 2009) of chum salmon for each year, obtained from 17 fixed fishing stations, i.e., body weight standardized to 400 mm fork length. Error bars indicate 95% confidence intervals.

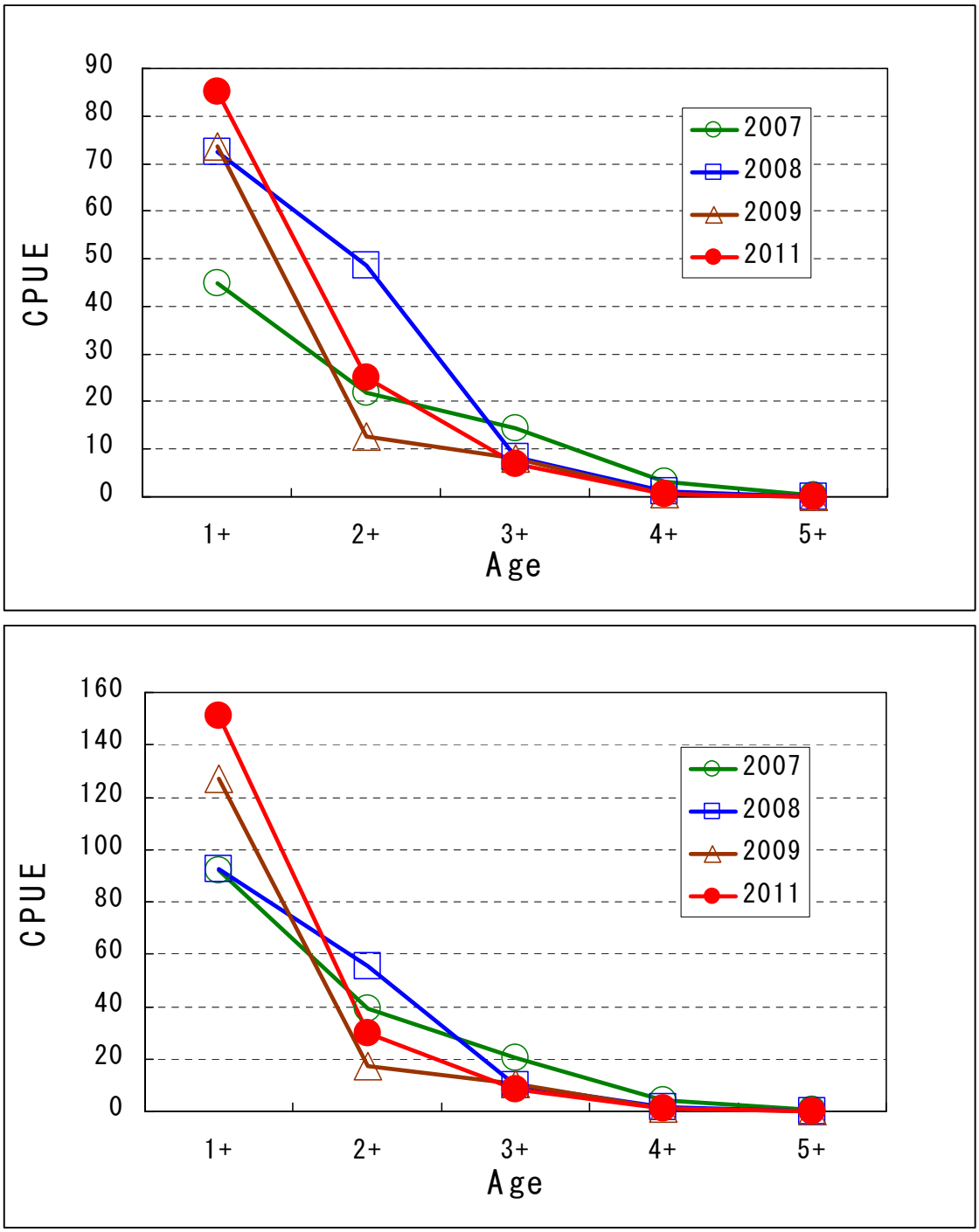

Fig. 6. Age-specific CPUE (number of individuals caught per surface trawl) of chum salmon for each year, obtained from 17 fixed fishing stations. Upper panel: a lognormal distribution of errors was assumed, lower panel: a normal distribution of errors was assumed.