

NPAFC

Doc. 78

Rev. _____

**Reports on the Research of Salmon Resources
in the North Pacific Ocean in 1994**

by

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Submitted to the

NORTH PACIFIC ANADROMOUS FISH COMMISSION

by

Japan

October 1994

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:

National Research Institute of Far Seas Fisheries. 1994. Report on the Research of Salmon Resources in the North Pacific Ocean in 1994. (NPAFC Doc. 78.). National Research Institute of Far Seas Fisheries. 5-7-1 Orido, Shimizu, Shizuoka 424, Japan. 70 p.

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Outline of Japanese Salmon Research in the North Pacific Ocean in 1994

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This report outlines Japanese salmon research conducted in 1994. Data are being analyzed at present, so tentative figures are reported here. The results of the *Hokuho maru* cruise, which will be conducted from September to October, will be reported in the next year.

1. Survey by the Salmon Research Vessels

Five research vessels conducted 103 gillnet and 42 longline operations in the western North Pacific Ocean, Bering Sea, Okhotsk Sea, and Gulf of Alaska from June to August in 1994 (Table 1 and Fig. 1). A total of 25,605 salmon including 2,419 sockeye, 10,106 chum, 10,990 pink, 1,681 coho, 166 chinook salmon, and 243 steelhead trout were caught by these operations. Seventy-four steelhead trout with missing adipose fin were found and snout samples were collected for CWT detection.

2. Number of Release and Recovery

A total of 71 salmon including 8 sockeye, 31 chum, 9 pink, 21 coho salmon, and 2 steelhead trout were tagged and released by the *Oshoro maru* in June and July in 1994. There is no recovery after September in 1993.

3. Oceanographic Observation

The eastward extension of the Western Subarctic Water was stronger than in normal years. Anomalies of sea surface temperature were positive except along 40° N

4. Cooperative Research

A U.S. scientist, N.D. Davis, was on board the *Wakatake maru*, two U.S. scientists, K.W. Myers and R.V. Walker were on board the *Oshoro maru*, as cooperative salmon research between Japan and U.S. One Russian scientist, A. A. Kovtun, was on board the *Wakashio maru*, as cooperative salmon research between Japan and Russia.

5. Catch-per-unit-effort (CPUE) of Salmon in 1994

In the western North Pacific, CPUE of salmon in 1994 was higher than the average CPUE (1982-1993), due to the high CPUE of pink salmon (Table 2). CPUE of salmon in the Bering Sea was also higher than the average CPUE (1983-1993), due to the high CPUE of chum salmon (Table 3). On the other hand, CPUE of salmon in the Gulf of Alaska was lower than the average CPUE (1987-1993), due to the changes in sampling location (Table 4).

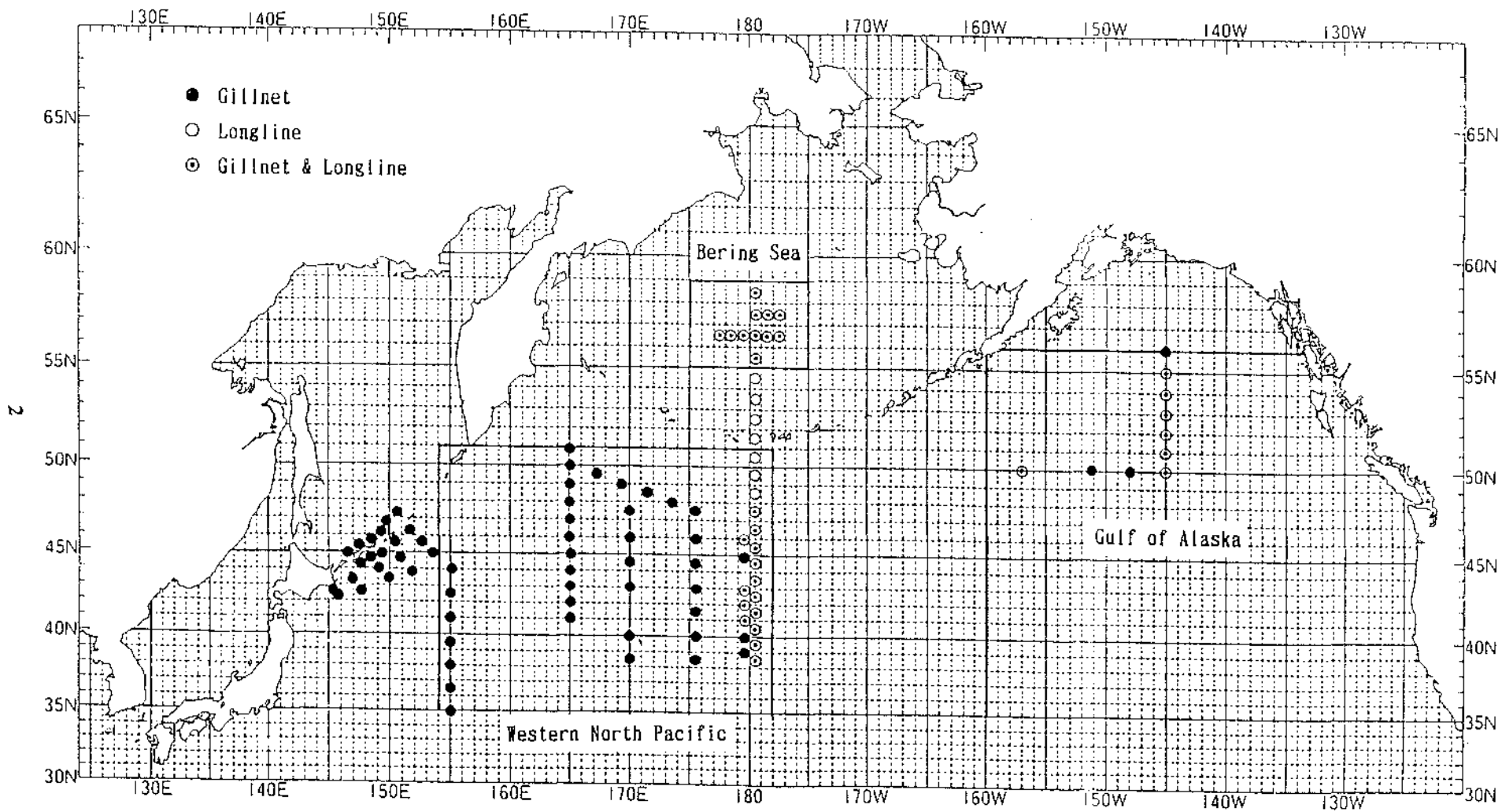


Fig. 1. Sampling locations for Japanese salmon research vessels in 1994.

Table 1. Japanese salmon research in the North Pacific Ocean in 1994.

Vessel	Gear		Number of fish	
	Gillnet	Longline	Caught	Released
Hokko maru	12	0	7,829	0
Wakatake maru	21	31	10,624	0
Oshoro maru	17	11	2,727	71
Hokusei maru 1st	7	0	1,689	0
2nd	7	0	872	0
3rd	18	0	1,497	0
Wakashio maru	21	0	367	0
Total	103	42	25,605	71

Table 2. Number of fishing operation (No.), number of non-selective (research) gillnet used (Tan), average sea surface temperature (SST in °C), and catch per unit effort (CPUE) of salmon in the western North Pacific (south of 51°N, 154°E-178°W).

=====										
CPUE										
Year	No.	Tan	SST	Sockeye	Chum	Pink	Coho	Chinook	Steelhead	Total

1982	42	1409	12.0	0.01	0.18	0.24	0.18	0.01	0.01	0.64
1983	43	1340	9.9	0.04	0.37	2.81	0.25	0.00	0.01	3.47
1984	41	1230	12.2	0.01	0.27	2.31	0.15	0.00	0.00	2.74
1985	30	900	12.1	0.03	0.46	1.52	0.57	0.02	0.01	2.62
1986	59	2120	9.8	0.73	0.66	0.53	0.14	0.03	0.01	2.11
1987	54	1670	11.1	0.59	0.37	0.76	0.13	0.02	0.00	1.88
1988	48	1443	10.0	1.78	0.89	0.98	0.10	0.01	0.01	3.77
1989	61	1723	9.8	0.45	0.49	1.02	0.12	0.00	0.01	2.10
1990	54	1560	11.4	0.74	0.43	0.73	0.11	0.01	0.00	2.02
1991	46	1330	12.8	0.17	0.30	1.07	0.31	0.01	0.02	1.88
1992	54	1620	10.9	0.14	0.44	0.84	0.37	0.02	0.01	1.83
1993	59	1820	11.6	0.06	0.66	0.54	0.22	0.01	0.02	1.52
1994	59	1766	12.6	0.11	0.53	2.78	0.30	0.01	0.04	3.77

Average										
1982-1993			11.3	0.40	0.46	1.11	0.22	0.01	0.01	2.22
Even year			11.1	0.59	0.48	0.94	0.18	0.01	0.01	2.19
Odd year			11.2	0.22	0.44	1.29	0.27	0.01	0.01	2.25

CPUE = total catch in number / total effort in tans

Data were collected by Hokusei maru, Hokko maru, Wakatake maru and Oshoro maru.

Table 3. Number of fishing operation (No.), number of non-selective (research) gillnet used (Tan), average sea surface temperature (SST in °C), and catch per unit effort (CPUE) of salmon in the Bering Sea (55°N-59°N, 175°E-175°W).

=====										
CPUE										
Year	No.	Tan	SST	Sockeye	Chum	Pink	Coho	Chinook	Steelhead	Total

1983	21	618	8.2	1.62	3.40	1.15	0.01	0.14	0.00	6.32
1984	31	1011	7.8	1.60	4.07	0.12	0.11	0.06	0.00	5.96
1985	21	638	6.3	0.21	1.05	0.57	0.02	0.03	0.00	1.88
1986	24	725	8.1	0.21	2.33	0.19	0.00	0.09	0.00	2.94
1987	23	1140	6.8	0.46	1.19	1.53	0.00	0.08	0.00	3.38
1988	18	810	6.4	0.88	2.09	0.35	0.00	0.36	0.00	3.69
1989	20	500	7.8	0.44	1.22	8.49	0.00	0.07	0.00	10.22
1990	14	420	7.4	0.33	3.38	0.50	0.00	0.07	0.00	4.28
1991	8	240	7.5	0.76	1.80	12.21	0.00	0.33	0.00	15.10
1992	13	390	7.7	0.63	7.27	0.26	0.01	0.15	0.00	8.33
1993	11	330	7.5	1.93	3.71	4.73	0.03	0.05	0.00	10.44
1994	11	330	6.7	1.67	7.46	0.43	0.00	0.17	0.00	9.75

Average										
1983-1993			7.4	0.82	2.86	2.74	0.02	0.13	0.00	6.59
Even year			7.5	0.73	3.83	0.28	0.02	0.15	0.00	5.04
Odd year			7.4	0.90	2.06	4.78	0.01	0.12	0.00	7.89

CPUE = total catch in number / total effort in tans

Data were collected by Wakatake maru.

Table 4. Number of fishing operation (No.), number of non-selective (research) gillnet used (Tan), average sea surface temperature (SST in °C), and catch per unit effort (CPUE) of salmon in the Gulf of Alaska (south of 56°N, east of 160°W).

Year	No.	Tan	SST	CPUE							Total
				Sockeye	Chum	Pink	Coho	Chinook	Steelhead		
1987	11	425	10.6	0.78	1.48	0.09	0.12	0.00	0.14	2.62	
1988	15	600	11.8	1.64	2.46	1.75	0.36	0.01	0.10	6.30	
1989	17	502	10.7	2.39	1.00	1.17	0.32	0.03	0.11	5.03	
1990	12	360	9.9	2.05	1.03	1.01	0.29	0.02	0.23	4.63	
1991	11	330	10.1	2.82	1.28	1.85	0.40	0.02	0.07	6.45	
1992	9	270	9.6	2.32	0.70	0.59	0.33	0.01	0.10	4.04	
1993	8	240	9.4	2.15	2.40	1.88	0.40	0.07	0.08	6.98	
1994	10	300	10.4	1.22	1.05	0.99	0.44	0.01	0.09	3.82	
Average											
1987-1993			10.3	2.02	1.48	1.19	0.32	0.02	0.12	5.15	
Even year			10.4	2.00	1.40	1.12	0.33	0.01	0.14	4.99	
Odd year			10.2	2.04	1.54	1.25	0.31	0.03	0.10	5.27	

CPUE = total catch in number / total effort in tans

Data were collected by Oshoro maru.

**Release Data and Recovery Data
for Japanese Salmon Tagging Experiments
from September 1993 to August 1994**

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Abstract

Japan conducted a total of 11 longline operations in the North Pacific Ocean and the Gulf of Alaska, and caught and released 71 salmon in 1994 using the *Oshoro maru* (Table 1). No salmon has been recovered since the autumn of 1993.

Table 1. Tagging experiments conducted by the Oshoro-maru in the summer of 1994

No.	Release		Number of Longline		Number of fish caught								Number of fish released								Type of tag & tag No. (Missing Tag No.)
	Date	Location	(Hatch)	Sockeye	Chum	Pink	Coho	Chinook	S.head	Masu	Total	Sockeye	Chum	Pink	Coho	Chinook	S. head	Masu	Total		
940501	8.14	4059N 17956E	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	8.15	4200N 17958E	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	8.18	4300N 17957E	10	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	Disc. CC2001~CC2008
4	8.19	4600N 17958E	10	0	1	0	4	0	0	0	0	0	1	0	4	0	0	0	0	0	Disc. CC2009~CC2013
5	8.29	5002N 15655W	10	4	13	3	1	0	2	0	23	4	13	3	1	0	2	0	0	23	Disc. CC2014~CC2038
6	7.03	4957N 14457W	12	0	1	1	0	0	0	0	2	0	1	1	0	0	0	0	0	2	Disc. CC2037~CC2038
7	7.04	5100N 14455W	12	0	7	1	5	0	0	0	13	0	7	1	5	0	0	0	0	13	Disc. CC2039~CC2053 (-44, -50)
8	7.05	5200N 14500W	12	0	1	2	1	0	0	0	4	0	1	2	1	0	0	0	0	4	Disc. CC2054~CC2058 (-57)
9	7.06	5259N 14449W	12	0	2	0	1	0	0	0	3	0	2	0	1	0	0	0	0	3	Disc. CC2060~CC2082
10	7.07	5400N 14502W	12	2	0	1	0	0	0	0	3	2	0	1	0	0	0	0	0	3	Disc. CC2083~CC2085
11	7.08	5459N 14505W	10	2	4	1	3	0	0	0	10	2	4	1	3	0	0	0	0	10	Disc. CC2088~CC2075
Total			120	8	31	9	21	0	2	0	71	8	31	9	21	0	2	0	0	71	

Outline of Oceanographic Conditions in the Western North Pacific Ocean during the Summer in 1994

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Abstract

Oceanographic conditions in the North Pacific Ocean during the summer of 1994 were examined using data obtained from salmon research vessels. Judging from cross sections of temperature and salinity, Western Subarctic Water which is colder water appearing in mid depth spread eastward stronger than normal, and it spread southward weaker than normal. Anomalies of SST were positive along 40° N.

Introduction

Oceanographic conditions in the western North Pacific during the summer of 1994 were examined using data on water temperature and salinity obtained from 7 salmon research cruises, as in previous years. Extension of the Western Subarctic Water and sea surface temperature, which characterizes the oceanographic conditions in the western North Pacific, were examined.

Materials

The total number of oceanographic stations was 224 (June:91, July:112). Figure 1 shows the locations of oceanographic stations in the western North Pacific in the summer of 1994. For additional data on sea surface temperature "Monthly Ocean Report" of the Japan Meteorological Agency was used.

Results

1. Western Subarctic Water

Figure 2 shows several sections of temperature and salinity. Figures 2-2a and 2b show the cross sections along 179° 30'W (Line 2). There was the least saline water near 50° N surface, affected by the Alaska Current. Since cold water less than 3° C and around 33.1 psu existed in 125m-150m deep from 47° N to 48° N, the eastward extension of the Western Subarctic Water was stronger than normal. This water also existed around 100m deep north of 45° N in Line 3 (56° 30'N-177° 30'E) to 40° N-150° E). The southward extension of this water was considerably weaker than normal, because this water reached 47° N along 165° E (Line 4).

2. Sea Surface Temperature (SST)

Figure 3 shows the anomalies of SST in June and July. Anomalies are calculated with respect to the monthly mean values from 1961 to 1990. In June, the anomalies were negative except in Kuroshio

Extension Area. In July, the positive anomalies prevailed between 35° N to 45° N.

References

Japan Meteorological Agency 1994. Monthly Ocean Report. No. 6, 7.

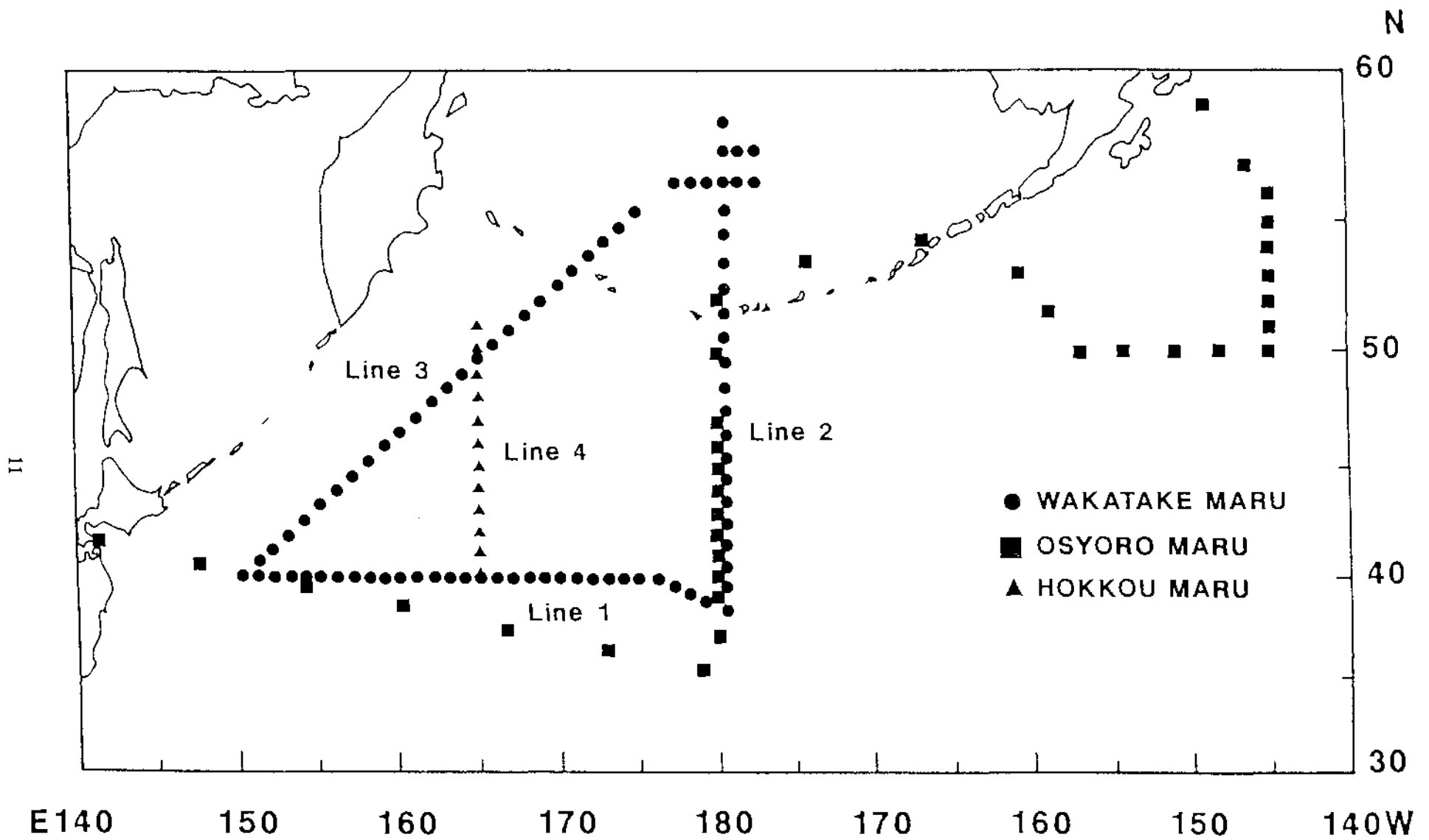


Fig.1 Locations of Oceanographic Stations.

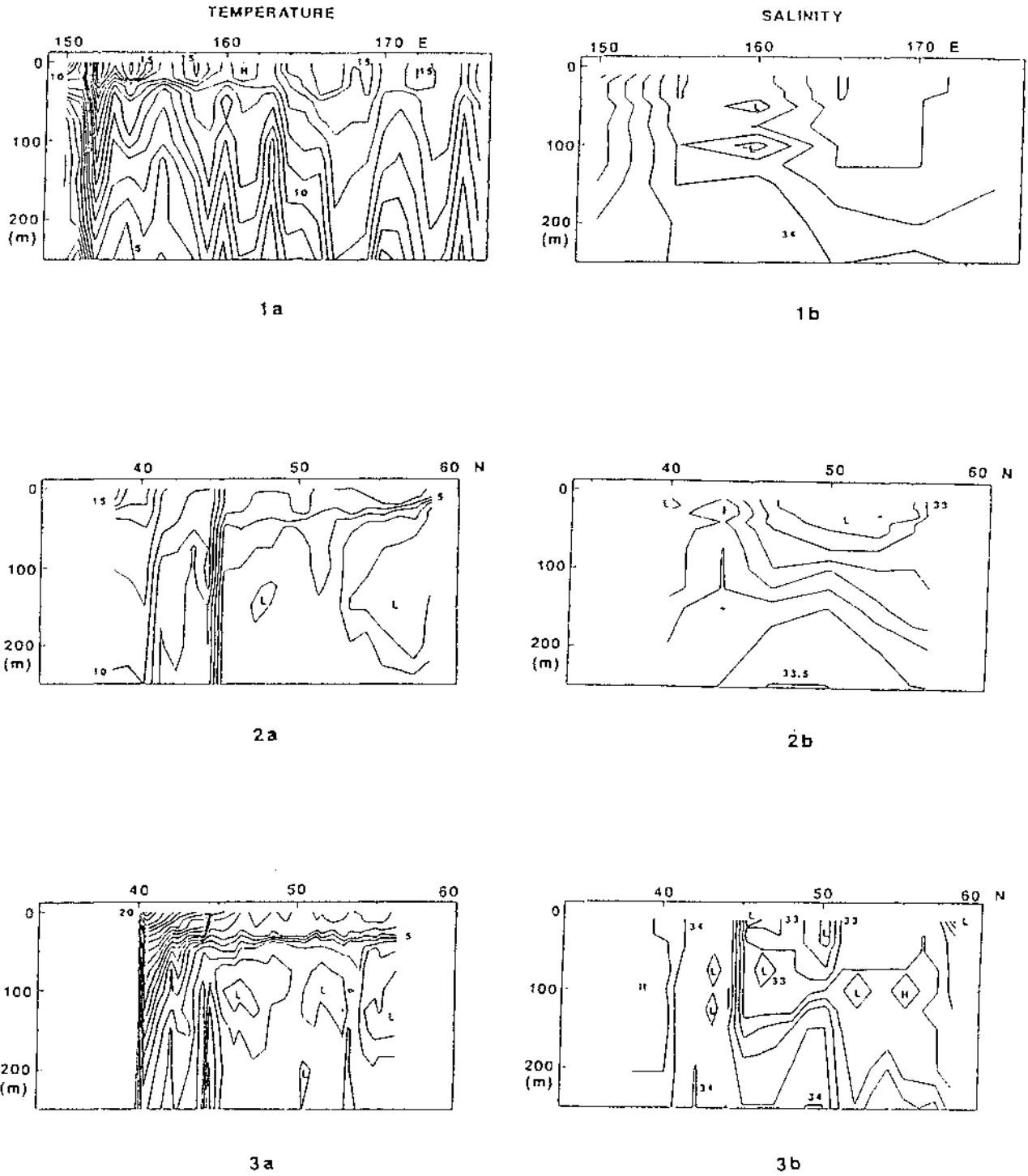


Fig.2 Isotherms, isohalines on the vertical section along Line1(1-a,b),Line2(2-a,b),and Line3(3-a,b). The contour interval of temperature is 1 degree and that of salinity is 0.2 .

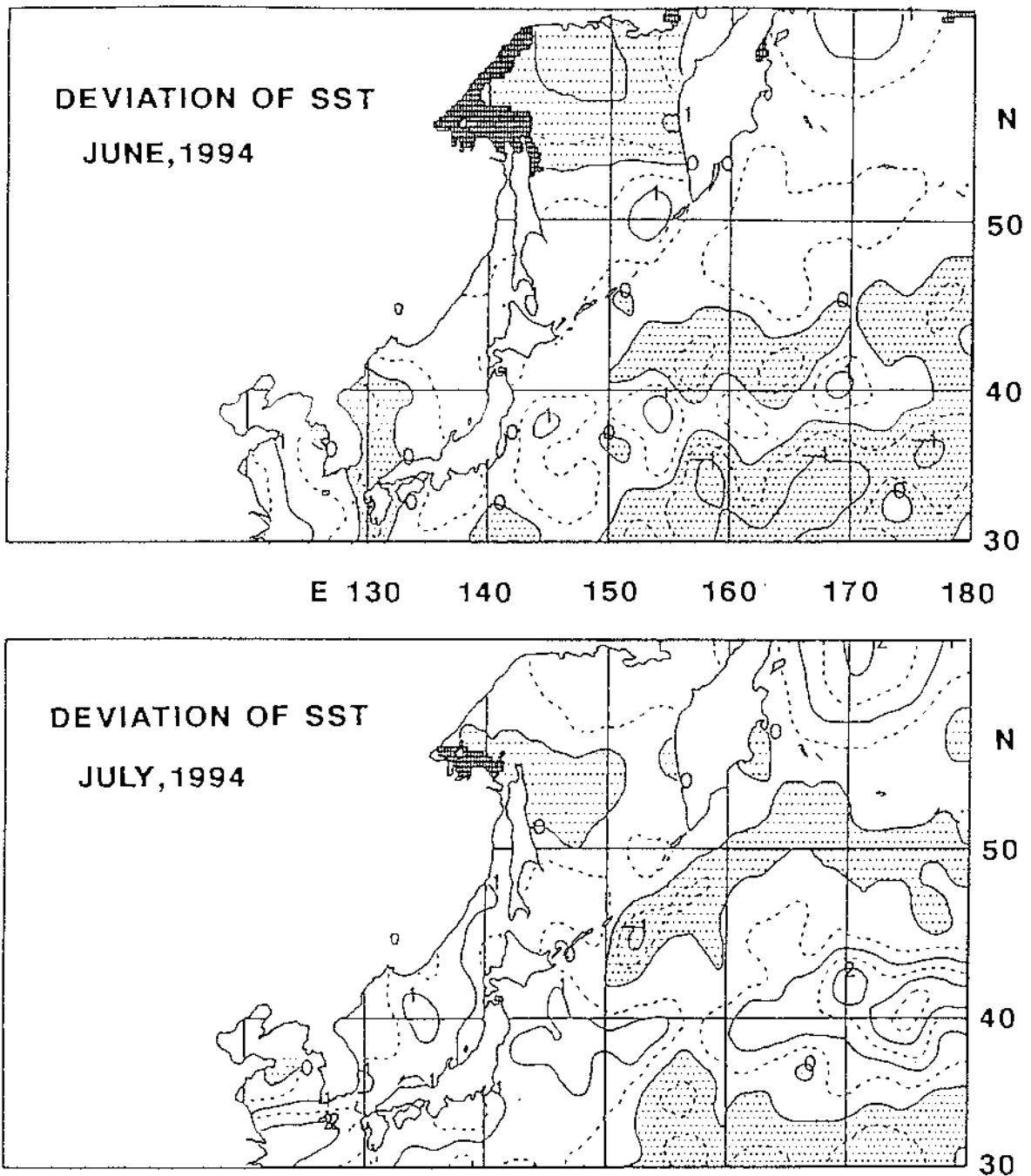


Fig.3 Anomalies of the sea-surface temperature in June and July, 1994. Anomaries are calculated from the monthly mean of 1961-1990. (From Monthly Ocean Report, No.6,7)

**Japan-U.S. Cooperative High Seas Salmon Research in 1994:
Summary of Research aboard the Japanese Research Vessel
Wakatake maru, 10 June to 24 July**

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Abstract

An annual cooperative Japan-U.S. survey, initiated four years ago in 1991, to investigate the ocean carrying capacity of salmonids in the North Pacific Ocean was continued. Japanese and U.S. scientists aboard the R/V *Wakatake maru* conducted fishing operations and collected data on oceanographic conditions, phytoplankton, and zooplankton in the North Pacific Ocean and Bering Sea. Fishing operations were conducted along a south-to-north transect at 179° 30'W longitude between 38° 30'N and 58° 30'N latitude with additional stations in the central Bering Sea. Sea surface temperatures were cooler in 1994 than in 1993, often by as much as 1° C. The catch included 10,626 salmonids (*Oncorhynchus* spp. and *Salvelinus malma*). Chum salmon (*O. keta*) were the most abundant species (76% of the salmonid catch) followed by sockeye (*O. nerka*, 12%), pink (*O. gorbuscha*, 6%), and coho (*O. kisutch*, 4%) salmon. Chinook salmon (*O. tshawytscha*) and steelhead trout (*O. mykiss*) were in low abundance (1%), and two Dolly Varden (*S. malma*) were caught. Fifty-five percent of the 120 steelhead trout caught were lacking the adipose or a ventral fin, which indicates that these fish were North American hatchery fish. A total of 331 neon flying squid (*Onmmastrephes bartramii*) were caught by gillnet. Ninety-seven percent of the neon flying squid were caught south of salmonid distributions, but salmonid and squid distributions overlapped at 42°-43°N latitude, where 11 squid and 14 salmonids were caught (4 chum, 1 pink, and 9 coho salmon). In the Bering Sea, an unusually large number of walleye pollock (*Theragra chalcogramma*, N=255) was caught by longline (N=124) and gillnet (N=131). Examination of salmonid stomach contents indicated that sockeye had a varied diet including copepods (27% mean volume), small squid (25%), amphipods (20%), and euphausiids (17%). Small squid (47%), euphausiids (17%), and copepods (14%) were also important prey of pink salmon. Chum salmon preyed upon euphausiids (14%) and amphipods (12%), but coelenterates (28%) were found in large volume. Squid was commonly found in the stomachs of coho salmon (92%), chinook salmon (66%), and steelhead trout (80%). The mean percent volume of crustaceous zooplankton found in the stomachs of chum salmon increased from 11% in 1993, a year of high pink salmon abundance, to 32% in 1994, a year of low pink salmon abundance.

Introduction

Each summer since 1991, the Fisheries Agency of Japan (FAJ) has chartered the R/V *Wakatake maru* to conduct studies on salmonids (*Oncorhynchus* spp; abundance and distribution, food habits, and age and growth), primary productivity, and zooplankton abundance in the central North Pacific Ocean and Bering Sea. The objectives of these cruises are to investigate the carrying capacity of salmonids in the ocean, and to develop a time series of oceanographic and biological data by sampling the same locations year after year. These studies are also of interest to U. S. salmon researchers, and each year the FAJ graciously invites a U. S. scientist to join its research staff aboard the *Wakatake maru*. In this report, we briefly describe the sampling methods used to collect fish and plankton; summarize the oceanographic conditions, catch, and results of salmonid stomach examinations that we found in 1994; and compare these results with those of earlier years.

The salmon research cruise of the *Wakatake maru* provided an opportunity to make collections of study materials for other salmonid studies including diurnal variation in salmonid food habits; caloric value of salmonid prey organisms, chum salmon (*O. keta*) tissue samples to determine stock origins by means of gel electrophoresis; fat and protein content and RNA/DNA ratios found in the muscle of chum, pink (*O. gorbuscha*), and sockeye salmon (*O. nerka*) to determine growth rates; abundance and distribution of the salmon louse, *Lepeophtheirus salmonis*; appearance of slash-marks on salmonids; round specimens of salmonid predators (e.g., salmon shark, *Lamna ditropis*, and daggertooth, *Anotopterus pharao*); and collection of Dolly Varden char (*Salvelinus malma*) for genetic and morphometric studies. In addition, round samples of Pacific pomfret (*Brama japonica*) and Pacific saury (*Cololabis saira*) were collected for studies of their biology and ecology. The details of these studies will be reported elsewhere.

Methods

The cruise track and sampling plan have changed little since this research program began in 1991 (Ishida et al. 1991, 1992; Nagasawa et al. 1994a). The cruise track included 28 fishing stations along a transect at 179° 30'W longitude from 38° 30'N to 58° 30'N latitude with additional stations in the central Bering Sea (see Table 1 for positions of fishing stations) and 56 transit stations, where oceanographic data and abbreviated water and zooplankton samples were collected (Fig. 1). At each fishing station a surface longline (30 hachi, 3.33 km) was set 30 minutes before sunset and retrieved 30 minutes after sunset. A gillnet was set in the afternoon and retrieved the following morning (49 tans, 2.45 km; Table 2). Noon-hour observations included salinity and temperature measurements (1-meter intervals) and water sampling for chlorophyll-a and nutrient analysis (seven depths; Table 2). Zooplankton samples were collected at midnight using Norpac, Bongo, ORI (Ocean Research Institute), and a fish larval net (Table 2). A detailed description of the towing method for each of these nets is given in Table 3.

Since 1992 zooplankton sampling has gradually intensified on the *Wakatake maru* salmonid cruises. In 1991 and 1992 only the Norpac and fish larval net were used (Ishida et al. 1991, 1992). In 1993 use of the ORI net began because the large net opening, fast towing speed, and large mesh enabled this net

to collect mobile mega-zooplankton that the Norpac net does not sample adequately (Nagasawa et al. 1994a; Table 3). In 1994 use of the bongo net was introduced because it is capable of catching large zooplankton, but it is a more commonly used net for zooplankton collections than the ORI net.

Transit stations were located along a direct route going to and returning from the fishing area (Fig. 1). Temperature, salinity, and depth data were collected using CTD and XBT, and water samples for chlorophyll-a and nutrient analysis were collected at the surface. A vertical tow of the Norpac net (0-150 meters) was used to collect zooplankton (Table 2). These activities were not conducted at any particular time of day, but whenever the ship arrived on station.

Method of fish examination, collection of scales and otoliths, and salmonid stomach content analysis are as described by Davis (1990), Ishida et al. (1991, 1992), and Nagasawa et al. (1994a). Salmonid stomach contents and index of stomach content weight (SCI; stomach contents x 100/body weight) were grouped according to oceanographic region as suggested by Nagasawa et al. (1994a) and Tadokoro et al. (1994).

Ishida et al. (1992) and Tadokoro et al. (in prep.) suggested that when pink salmon abundance was low more euphausiids, copepods, and squids were found in chum salmon diets than when pink salmon abundance was high. To determine if there was a change in the diet of salmonids between 1993 and 1994, the prey types found in the stomachs of salmonids were summarized in three categories: micro-nekton (fish and squid), crustaceous, and non-crustaceous zooplankton, and the percentage of each prey category was compared between years.

Results and Discussion

Oceanography

Temperature and salinity profiles were plotted for the south-to north transect at 179° 30'W longitude from 38° 30'N to 58° 30'N latitude (Fig. 2). Location of oceanographic regions are approximate because the sampling locations are widely separated (1° of latitude or longitude) and the salinity values used to produce the vertical profiles have not been calibrated with water samples analyzed in the laboratory. The Transition Zone, south of the Subarctic Boundary, was located between 38° 30'N and 40° 30'N (Stations 1-3; Roden 1991). The location of the Subarctic Boundary, denoted as a vertical 34.0 psu (practical salinity units) isohaline, was found in the vicinity between 40° 30'N and 41° 30'N (between Stations 3 and 4; Dodimead et al. 1963, Favorite et al. 1976). The Transition Domain defined by the presence of cold water less than 4° C below 100 m extended from approximately 41° 30'N to 45° 30'N (Stations 4-8). Between 46° 30'N and 50° 30'N, temperature and salinity had a homogeneous component indicating the eastward flowing Subarctic Current (Stations 9-13). The Alaska Current, indicated by slightly warmer surface waters where the 4° C isotherm dips below 100 m, was found at 51° 30'N (Station 14). The Bering Current was found in the vicinity between 52° 30'N and 53° 30'N (Stations 15 and 16), south of the Bering Sea Gyre that is characterized by a cold core of water less than 2° C at 75-200 m depth (54° 30'N to 58° 30'N, Stations 17-21).

We have included the temperature and salinity profiles for the east-to-west series of fishing stations at 56° 13'0" N latitude on Figure 3. Conditions across the central Bering Sea appear quite homogeneous, and from 178° 30' W to 177° 30' E (Stations 25-28) the cold core of water less than 2° C is found at less than 200 m, indicating these stations are within the Bering Sea Gyre. This cold core was not found at the most easterly station, 177° 30' W, indicating that this location was within the Bering Current (Station 24).

In 1994, sea surface temperatures north of 39° 30' N in the North Pacific Ocean and Bering Sea were generally cooler than in 1993, often by as much as 1° C (Fig. 4). The sea surface temperatures in the vicinity of the Subarctic Current (45° 30' N-49° 30' N latitude) were cooler in 1994 than in the previous three years. The approximate June location of the Subarctic Boundary at its intersection with the 179° 30' W longitude transect has moved progressively northwards from 1991 (40° 30' N) to reach a maximum in 1993 (between 42° 30' N and 43° 30' N), but shifted to a more southerly position in 1994 (between 40° 30' N and 41° 30' N latitude; Fig. 4).

Distribution and Abundance of Salmonids

A total of 10,626 salmonids was caught by longline and gillnet (Table 1). Chum salmon were the most abundant species caught (76% of the salmonid catch), followed by sockeye (12%), pink (6%), coho (*O. kisutch*, 4%), and chinook (*O. tshawytscha*, 1%) salmon, and steelhead trout (*O. mykiss*, 1%). Two Dolly Varden char (*Salvelinus malma*) were caught. The Subarctic Boundary is believed to be the southern limit of salmonid distribution. The most southerly station where salmonids were caught was 42° 30' N latitude, which was north of the Subarctic Boundary (four chum, one pink, nine coho; Table 1). This is unlike 1993, when 93 chum and 2 coho were found in the transition zone south of the Subarctic Boundary (Nagasawa et al. 1994b).

Sockeye salmon were caught northward from 47° 30' N (SST=6.1° C), and were abundant in the Bering Sea (Table 1). Longline catches and gillnet catch per unit of effort (CPUE; number of fish caught per tan) have been quite variable from 1991 to 1994 (Figs. 5, 6, and 7). In 1991, sockeye were abundant in the southern area of the donut hole sampled by the *Wakatake maru*. In 1992 and 1993, sockeye appear to have been abundant in the eastern area of the central Bering Sea. In 1994, we observed more sockeye salmon that appeared to be maturing fish than we encountered in 1993. Males and females with gonad weights greater than 50 g were caught from June 29 through July 16, northward from 49° 30' N to 58° 30' N, and in the Donut Hole area.

Chum salmon were caught at all stations northwards of 42° 30' N (SST=10.5° C), and were abundant northwards of 49° 30' N (SST=6.2° C; Table 1). Longline catch and gillnet CPUEs were greater in 1994 than in the previous three years, and the gillnet CPUEs indicate that abundance in even-numbered years (1992 and 1994) is greater than abundance in odd-numbered years in the Bering Sea (1991 and 1993; Figs. 5, 6, and 7).

Pink salmon were caught in small numbers northwards of 42° 30' N (SST=10.5° C), but this species was not abundant in the catch in 1994 (Table 1, Figs. 5, 6, and 7). Longline catches and gillnet CPUEs

indicate that in the survey area pink salmon are more abundant in odd-numbered years than in even-numbered years. Recoveries of high seas tags indicate that odd-year Asian pink salmon are abundant in this area of the central North Pacific Ocean and Bering Sea (Myers et al. 1990). The abundance of pink salmon was greater in 1991 than in the last three years. In 1991, the *Wakatake maru* began sampling approximately 6 days earlier (June 12) than in 1992-1994 (June 17 or 18). By the middle of June, many of the maturing pink salmon have begun their spawning migration, thereby reducing their number in our catches (Nagasawa et al. 1994a).

Ninety-eight percent of the coho salmon catch was between 42° 30'N and 47° 30' N (SST=6.1° - 10.5° C), but a few coho were caught in the Bering Sea (N=4; Table 1). Longline catch and gillnet CPUEs indicate that coho salmon were more abundant in 1991 than in 1992-1994 (Figs. 5, 6, and 7).

Chinook salmon were caught between 46° 30'N (SST=6.6° C) and 49° 30'N (SST=6.2° C) in the North Pacific Ocean and in the central Bering Sea northward of 54° 30'N (SST=6.3-7.7° C; Table 1). Longline catches indicate chinook salmon abundance is low in the area straddling the Aleutians Islands between approximately 48° 30'N and 53° 30'N latitude (Figs. 5, 6, and 7). The *Wakatake maru* does not conduct any gillnet fishing in this area because it is within the U. S. 200-mile zone, so it is not possible to corroborate this observation with gillnet CPUEs.

Steelhead trout were caught between 44° 30' N (SST=10.0° C) and 50° 30'N (SST=6.9° C), but they were not caught in the Bering Sea (Table 1). As indicated by longline catches and gillnet CPUEs, steelhead trout were more abundant in 1991 and 1994 than in 1992 and 1993 (Figs. 5, 6, and 7). Fifty-five percent of the steelhead trout caught in 1994 were lacking either the adipose or a ventral fin indicating these fish are likely to be North American hatchery fish (Table 4). We observed one steelhead trout that was lacking one of its ventral fins, but the fish still had an adipose fin, so we did not collect the snout. However, the Columbia Basin steelhead policy states that a left ventral fin clip (with or without other fin clips) is reserved for coded-wire tags placed in Columbia River steelhead and may not be used without a coded-wire tag (Johnson and Longwill 1993; see footnote on Table 4). In future salmonid research, we will examine all steelhead for ventral fin clips in addition to adipose fin clips and collect snouts from all steelhead that are lacking the adipose fin or lacking the left ventral fin. From the steelhead snouts that we collected three coded-wire tags were recovered: one steelhead originated from the North Fork of the Salmon River, ID, and the other two were from the Hoh River, WA (Dahlberg et al. 1994).

Two Dolly Varden char were caught in the research-mesh gillnet on July 9 at the northernmost station (58° 30'N latitude). The sea surface temperature at this station was the minimum temperature encountered during the survey (SST=5.5° C; Tables 1 and 5).

Catches of Non-Salmonids

A total of 331 neon flying squid (*Ommastrephes bartramii*) were caught by gillnet. Ninety-seven percent of the flying squid caught were found south of salmonid distributions (south of 42° 30'N latitude). At 42° 30' N (SST=10.5° C), where salmonid and squid distributions overlapped, 11 neon

flying squid were caught coincidentally with 14 salmonids (four chum, one pink, and nine coho salmon; Table 1). The abundance of neon flying squid was greater in 1994 than in the previous three years (Figs. 5, 6, and 7).

Common non-salmonid fishes caught in operations included Pacific pomfret (*Brama japonica*), Atka mackerel (*Pleurogrammus monopterygius*), and walleye pollock (*Theragra chalcogramma*). A total of 237 pomfret was caught at the southern end of the transect southwards from 44° 30'N (SST=10.0-15.9° C) and mainly on longline gear (67% of the total catch; Table 1). In the Bering Sea, Atka mackerel and walleye pollock were commonly caught on salmon gear. A total of 117 Atka mackerel was caught almost exclusively in research-mesh gillnet (N=116). Two hundred and fifty-five walleye pollock were caught. This total is dramatically larger than catches in any of the previous three years (six fish in 1991, two fish in 1992 and 1993). Forty-nine percent of the pollock were caught on surface longline gear (mean fork length=466 mm), 34% in research-mesh gillnet (mean fork length 488 mm), and the remaining 17% in commercial-mesh gillnet (mean fork length=557 mm). Perhaps the moratorium on pollock fishing in the international waters of the central Bering Sea has led to a recent increase in the abundance of pollock in the Donut Hole area.

Salmonid Food Habits

A total of 724 salmonid stomachs [141 sockeye (19%), 402 chum (56%), 89 pink (12%), 45 coho (6%), 29 chinook (4%) and 18 steelhead (2%)] were examined from the longline catch at 28 fishing stations (Table 6). In the Subarctic Current, sockeye salmon fed primarily on squid, but in the Alaska Current their diet included amphipods, mysids, and pteropods. In the Bering Current, sockeye salmon consumed many amphipods and euphausiids, but they switched to feeding chiefly on copepods and squid in the Bering Sea Gyre. The index of stomach content weight (SCI; prey weight X 100/body weight) was greater in the Bering Sea Gyre (0.99) than in the Bering Current (0.45). The SCI for sockeye salmon was approximately equal for the two regions of the North Pacific Ocean (0.83-0.87; Table 6).

The major prey components found in the stomachs of chum salmon were ctenophores and chaetognaths in the Transition Domain, and many pteropods, coelenterates, and material that could not be identified were found in the stomachs of chum salmon caught in the Subarctic Current (Table 6). Squid, euphausiids, and amphipods were abundant in the stomachs of chum salmon caught in the Alaska Current. Amphipods and coelenterates were important in the diets of chum salmon caught in the Bering Current, and coelenterates and euphausiids were important in the Bering Sea Gyre. The SCI for chum salmon ranged from a low of 0.83 in the Bering Current to a high of 1.23 in the Alaska Current.

Pink salmon fed chiefly on copepods and chaetognaths in the Transition Domain and fed on large numbers of squid in the Subarctic Current (Table 6). Mysids, amphipods, and pteropods were commonly found in the stomachs of pink salmon caught in the Alaska Current. The stomachs of pink salmon contained large quantities of squids and amphipods in the Bering Current and contained fish

and euphausiids in the Bering Sea Gyre. When pink salmon fed on squid in the Subarctic Current, the SCI value was larger than the value found in other regions (2.34; Table 6).

In the Subarctic Current, coho salmon fed exclusively on squid, but their diets included some fish in the Transition Domain (Table 6). Stomach content weight relative to body weight was heavier for coho and pink salmon than the other salmonids. Heavy feeding activity of coho and pink salmon may be related to the large growth these two species commonly show on their scales in the summer before they return to their natal streams to spawn.

Chinook salmon fed on squid in the Subarctic Current, squid and fish in the Bering Current, and squid and euphausiids in the Bering Sea Gyre (Table 6). Chinook salmon had a consistently low SCI because their stomachs often had little or no food in them. The SCI ranged from a low of 0.28 in the Subarctic Current to 1.13 in the Bering Sea Gyre (Table 6).

Steelhead trout preyed on squid and fish in the Transition Domain and in the Subarctic Current (Table 6). The SCI was higher in the Subarctic Current than in the Transition Domain (0.78-1.28).

The percentage of crustaceous zooplankton (euphausiids, copepods, amphipods, ostracods, and decapods) found in the stomach of chum salmon increased from 11% in 1993, year of high pink salmon abundance, to 32% in 1994, a year of low pink salmon abundance in the study area (Fig. 8). The proportion of non-crustaceous zooplankton (pteropods, gelatinous zooplankton, appendicularians, polychaetes, chaetognaths, and salps) decreased from 75% in 1993 to 61% in 1994. The percentage of crustaceous zooplankton found in other salmonid stomachs has also increased in 1994. Pink, sockeye, and chinook salmon all exhibited a reduction from previous years in the percentage of micro-nekton in the diet and an increase in the percentage of crustaceous zooplankton (Fig. 8).

Acknowledgments

We recognize the special contributions of Drs. Yukimasa Ishida and Kazuya Nagasawa (FAJ, National Research Institute of Far Seas Fisheries, Shimizu) who initiated and maintain this long-term study of ocean carrying capacity. We appreciate their insight and guidance. We thank Captain Yoshiyuki Hayasaka and all the officers, crew, teachers, and students aboard the R/V *Wakatake maru* for their hard work, careful collection of data and samples, and helpfulness in all aspects of this work. We recognize the logistical support graciously given by the staff of the Hokkaido Management Bureau of Training Ships. Funding for U. S. participation was provided by the U. S. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory (NOAA Contract No. 50ABNF400001).

References

- Dahlberg, M., S. Fowler, N. Maloney, and R. Heintz. 1994. Incidence of coded-wire tagged salmonids in commercial and research catches in the North Pacific Ocean and Bering Sea, 1993-1994. (NPAFC Doc.) Auke Bay Laboratory, Alaska Fisheries Science Center, NMFS, Juneau. 17 pp.

- Davis, N. D. 1990. U.S.-Japan cooperative high seas salmonid research in 1990: Summary of research aboard the Japanese research vessel, *Hokuho maru*, 4 June to 19 July. (INPFC Doc.) FRI-UW-9010. Fisheries Research Institute, Univ. Wash., Seattle. 24 pp.
- 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. INPFC Bull. 13: 195 pp.
- Favorite, F., A. J. Dodimead, and K. Nasu. 1976. Oceanography of the subarctic Pacific region, 1960-1971. INPFC Bull. 31:187 pp.
- Ishida, Y., N. D. Davis, and K. Tadokoro. 1991. Cooperative Japan-U.S. high seas salmonid research in 1991: summary of research aboard the Japanese research vessel *Wakatake maru*, 4 June to 23 July. (INPFC Doc.) National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, Shimizu, Shizuoka 424, Japan. FRI-UW-9113. Fisheries Research Institute, Univ. Wash., Seattle. 35 pp.
- Ishida, Y., N. D. Davis, and K. Monaka. 1992. Japan-U.S. cooperative high seas salmonid research by the *Wakatake maru* in 1992. Salmon Report Series No.36:31-44. National Research Institute of Far Seas Fisheries, Shimizu. (In Japanese and English).
- Johnson, J. K., and J. R. Longwill. 1993. Pacific salmonid coded wire tag releases, 1987-1993. Regional Mark Processing Center, Pacific States Marine Fisheries Commission, Gladstone, Oregon. 165 pp.
- Myers, K. W., R. V. Walker, S. Fowler, and M. L. Dahlberg. 1990. Known ocean ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1989. (INPFC Doc.) FRI-UW-9009. Fish. Res. Inst. Univ. Washington, Seattle. 57 pp.
- Nagasawa, K., N. D. Davis, and K. Tadokoro. 1994a. Japan-U.S. cooperative high seas salmonid research in 1993: summary of research aboard the Japanese research vessel *Wakatake maru*, 10 June to 25 July. Salmon Report Series No. 37:57-84. National Research Institute of Far Seas Fisheries, Shimizu. (In Japanese and English).
- Nagasawa, K., N. D. Davis, and K. Tadokoro. 1994b. Catch of chum (*Oncorhynchus keta*) and coho (*O. kisutch*) salmon in the central North Pacific Ocean south of the subarctic boundary. Salmon Report Series No. 37:184-195. National Research Institute of Far Seas Fisheries, Shimizu. (In Japanese and English).
- Roden, G. I. 1991. Subarctic-subtropical transition zone of the North Pacific: large-scale aspects and mesoscale structure. pp. 1-38. In J. A. Wetherall (ed.) Biology, oceanography, and fisheries of the North Pacific transition zone and subarctic frontal zone. NOAA Tech Rep. NMFS 105. U. S. Department of Commerce.
- Tadokoro, K., K. Nagasawa, N.D. Davis, and T. Sugimoto. 1994. Distribution of zooplankton biomass along 179° 30'W from the viewpoint of salmonid feeding. Salmon Report Series No. 37: 142-152. National Research Institute of Far Seas Fisheries, Shimizu. (In Japanese and English.)
- Tadokoro, K., Y. Ishida, N. D. Davis, and S. Ueyanagi. (in preparation). Shift in chum salmon

Oncorhynchus keta food habits due to changes in pink salmon (*O. gorbuscha*) abundance in the central North Pacific Ocean and Bering Sea. Ocean Research Inst., Univ. Tokyo, Tokyo.

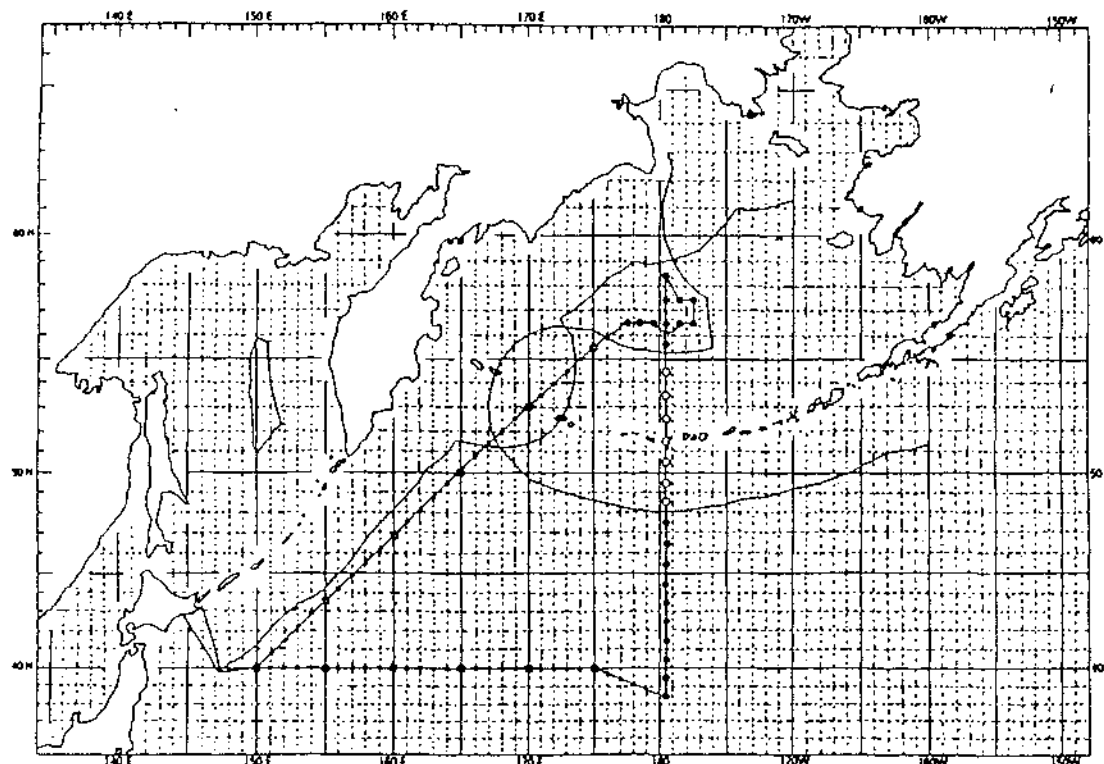


Figure 1. Station locations for the summer 1994 salmon research cruise of the *Wakatake maru*. The cruise track included 28 F (fishing) stations along a north-south transect at $179^{\circ}30'W$ longitude and an east-west transect at $56^{\circ}30'N$ latitude in the central Bering sea, and 56 T (transit) stations enroute and returning from the fishing research area. ● =longline and gillnet fishing operations, ○ =longline fishing operations, ■ =STD operations, • =XBT operations.

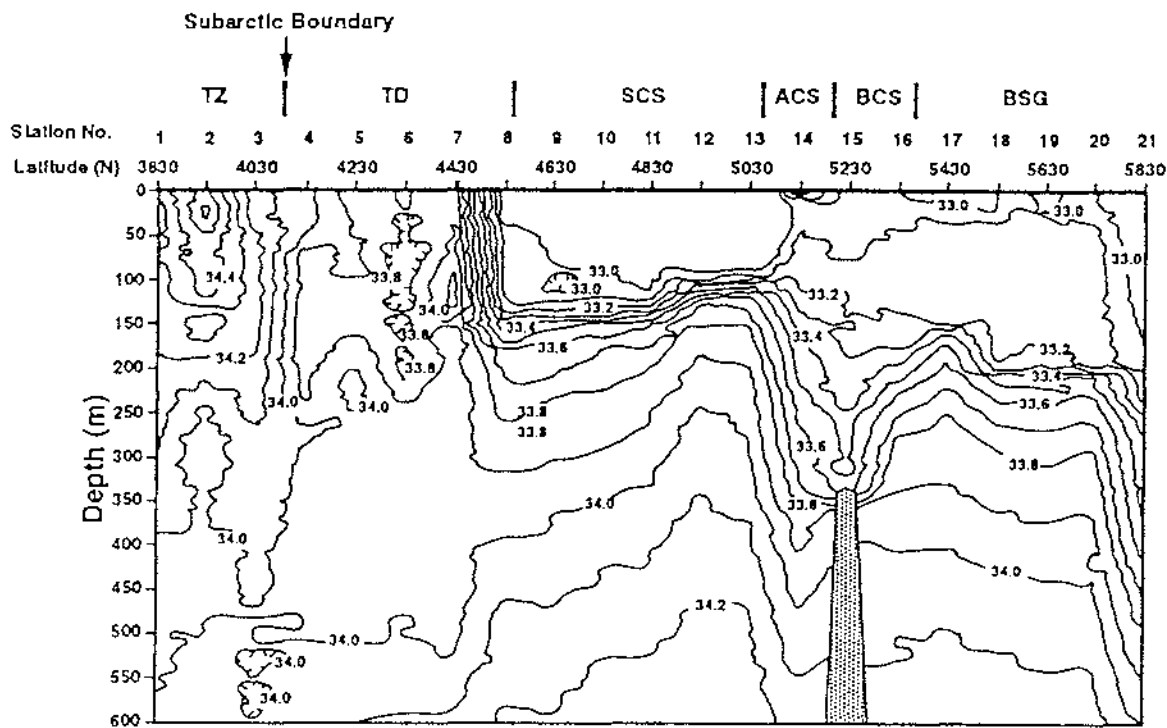
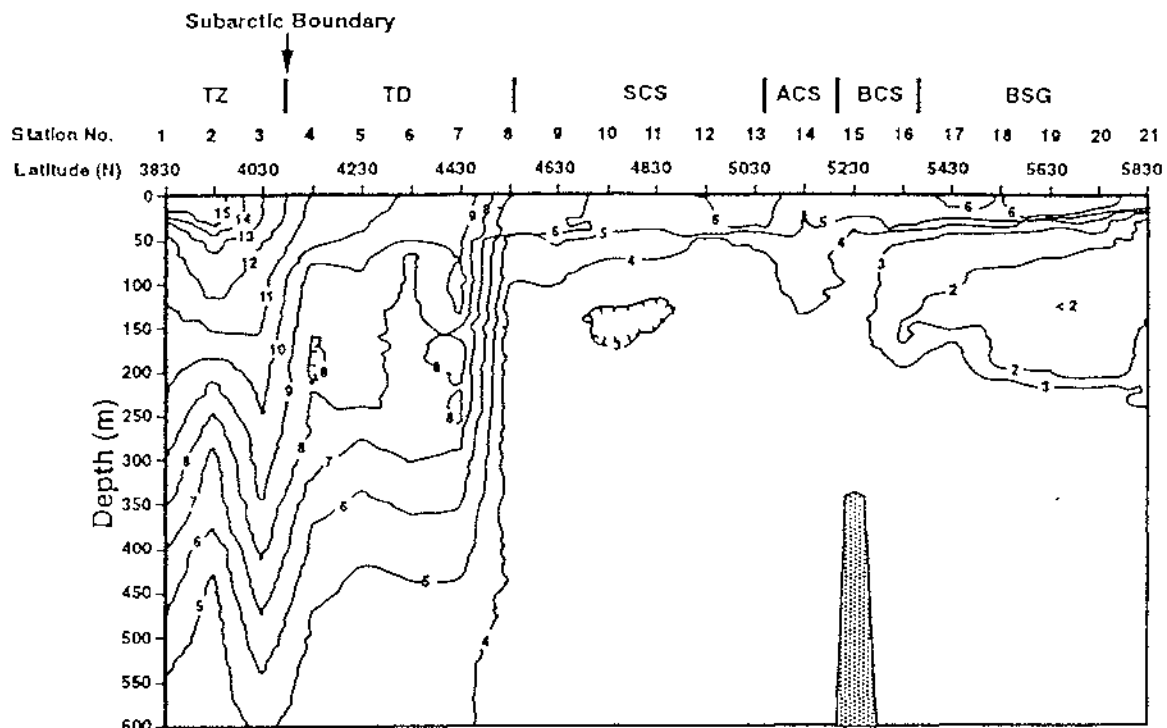


Figure 2. Vertical profile of temperature (top, °C) and salinity (bottom, psu, practical salinity units) found in surface waters along a north-south transect at 179°30'W longitude. The subarctic boundary is denoted by the vertical 34.0 psu isohaline. TZ=Transition Zone, TD=Transition Domain, SCS=Subarctic Current System, ACS=Alaska Current System, BCS=Bering Current System, and BSG=Bering Sea Gyre. Stippled area is the sea bottom.

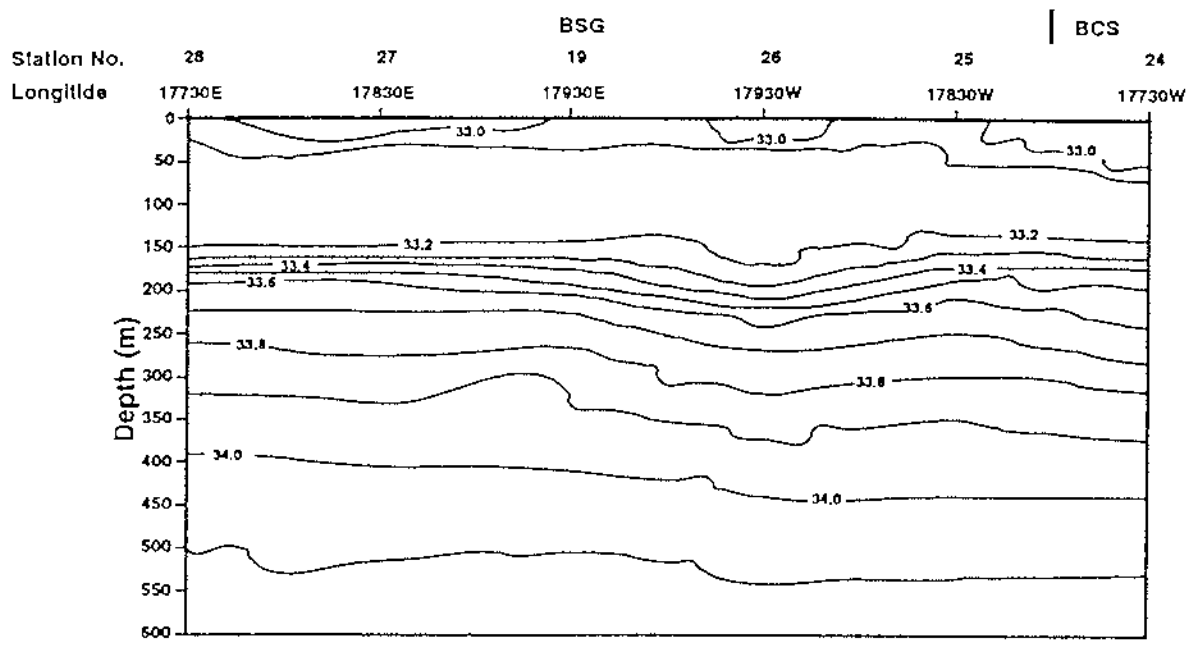
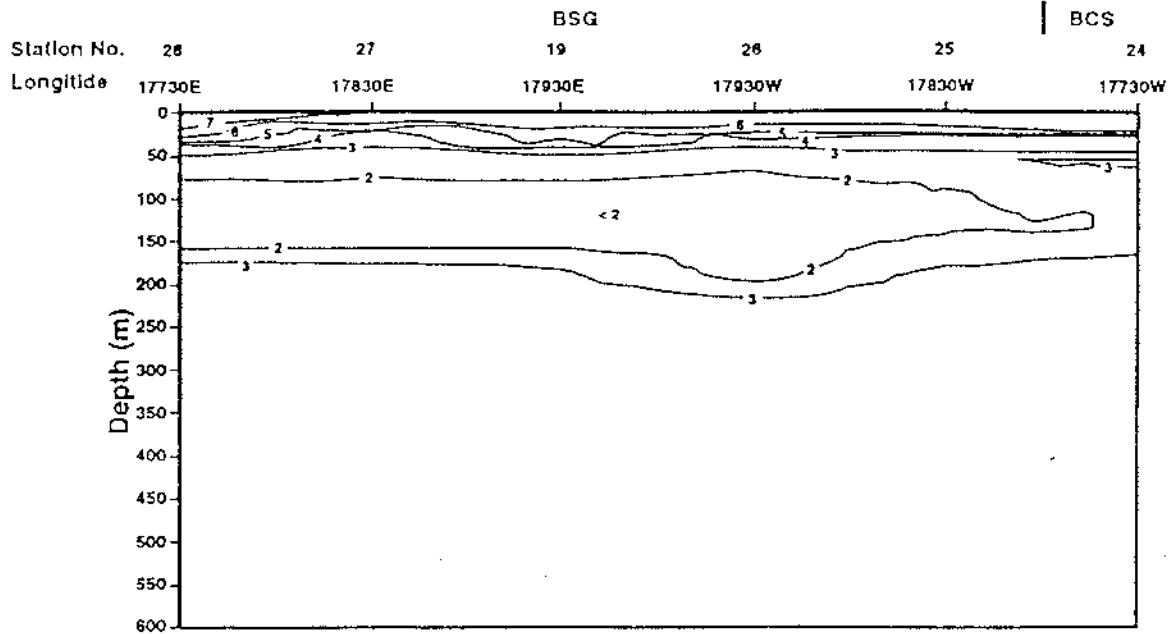


Figure 3. Vertical profile of temperature (top, °C) and salinity (bottom, psu, practical salinity units) found in surface waters along an east-west transect at 56°30'N latitude. BSG=Bering Sea Gyre, BCS=Bering Current System.

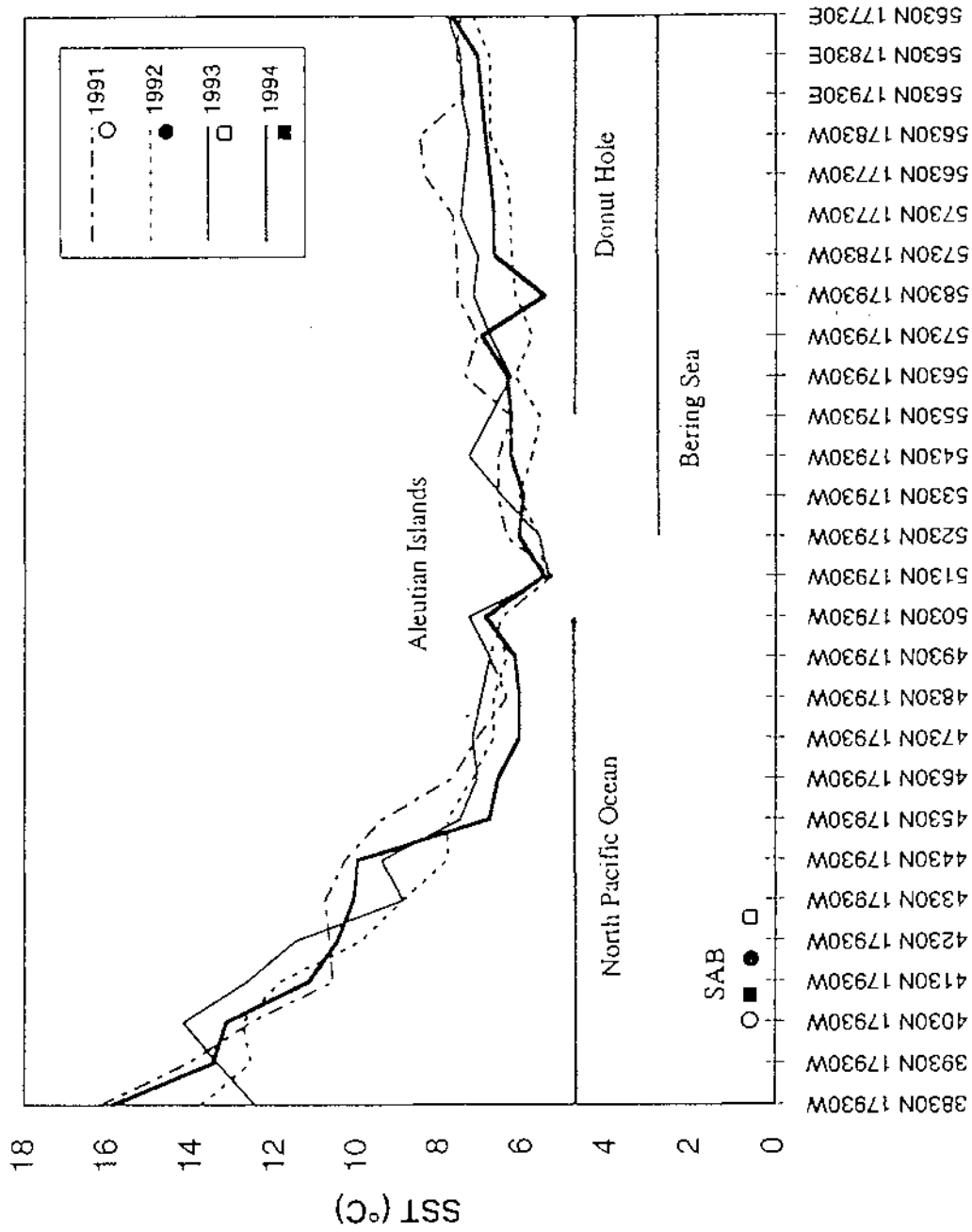


Figure 4. Approximate location of the subarctic boundary (SAB) where it intersects the cruise track and sea surface temperature in the North Pacific Ocean and Bering Sea during the salmon research cruises of the *Wakatake maru* in June and July, 1991-1994.

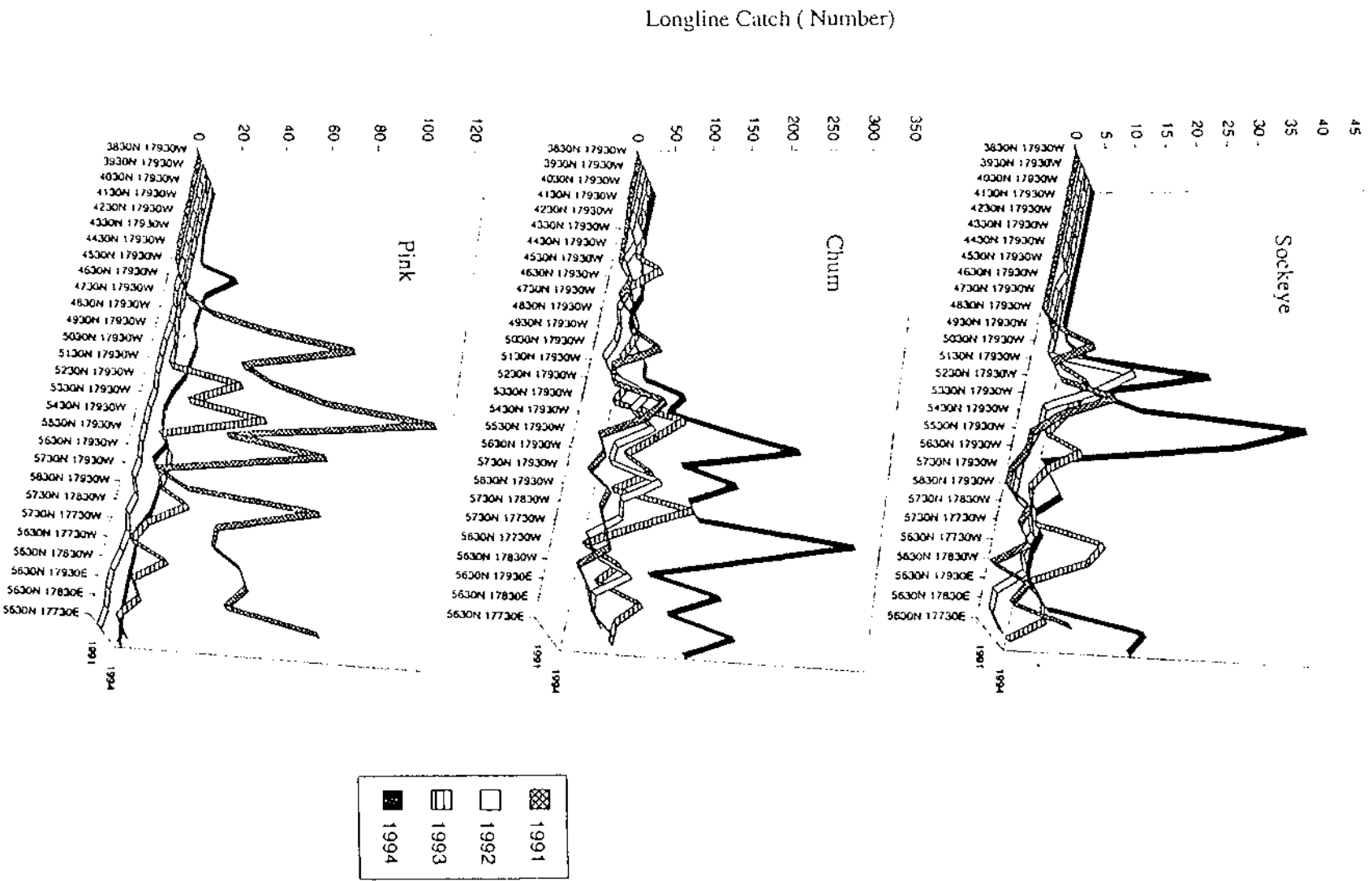


Figure 5. Number of salmonids caught by longline along the transect at 179°30'N (stations 1-21) and in the central Bering Sea (stations 22-28) in June and July 1991-1994. Longline fishing effort was the same 1991-1994.

Longline Catch (Number)

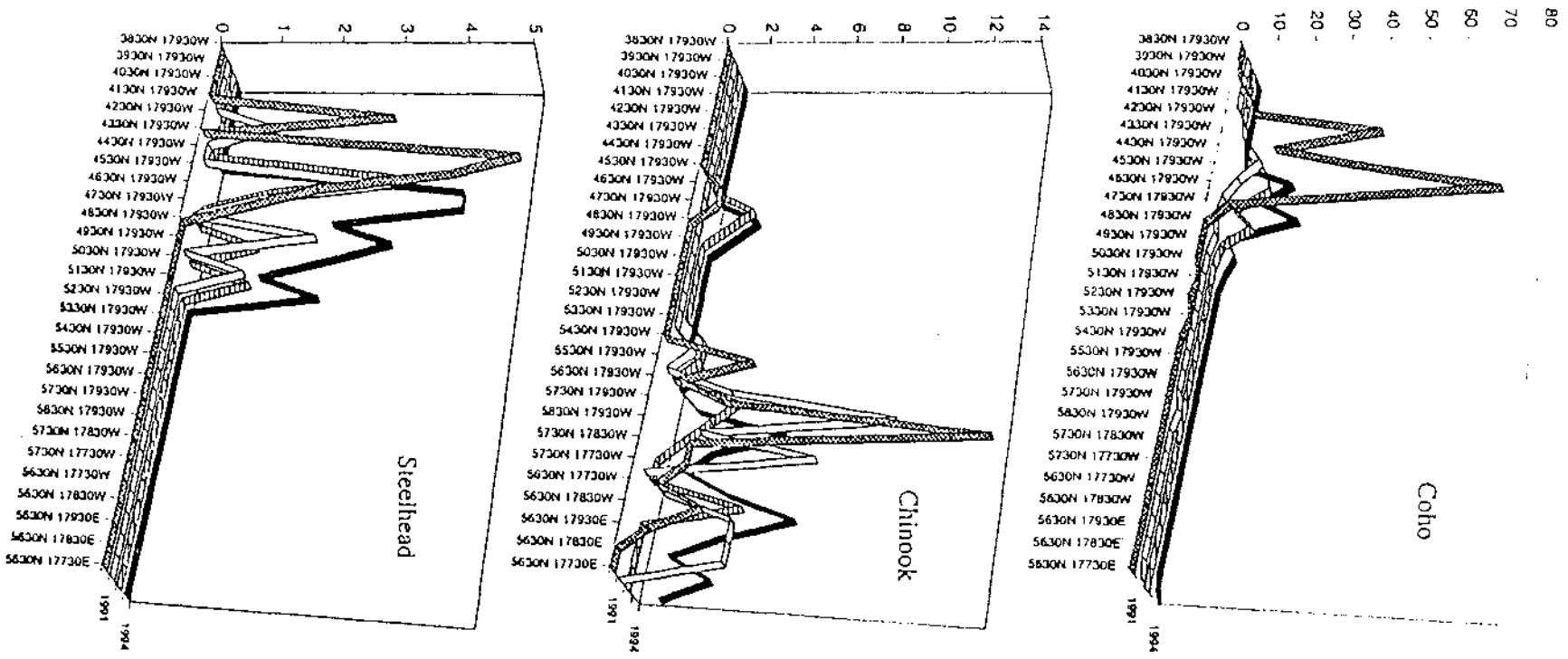


Figure 5. Continued.

Commercial-mesh Gillnet CPUE

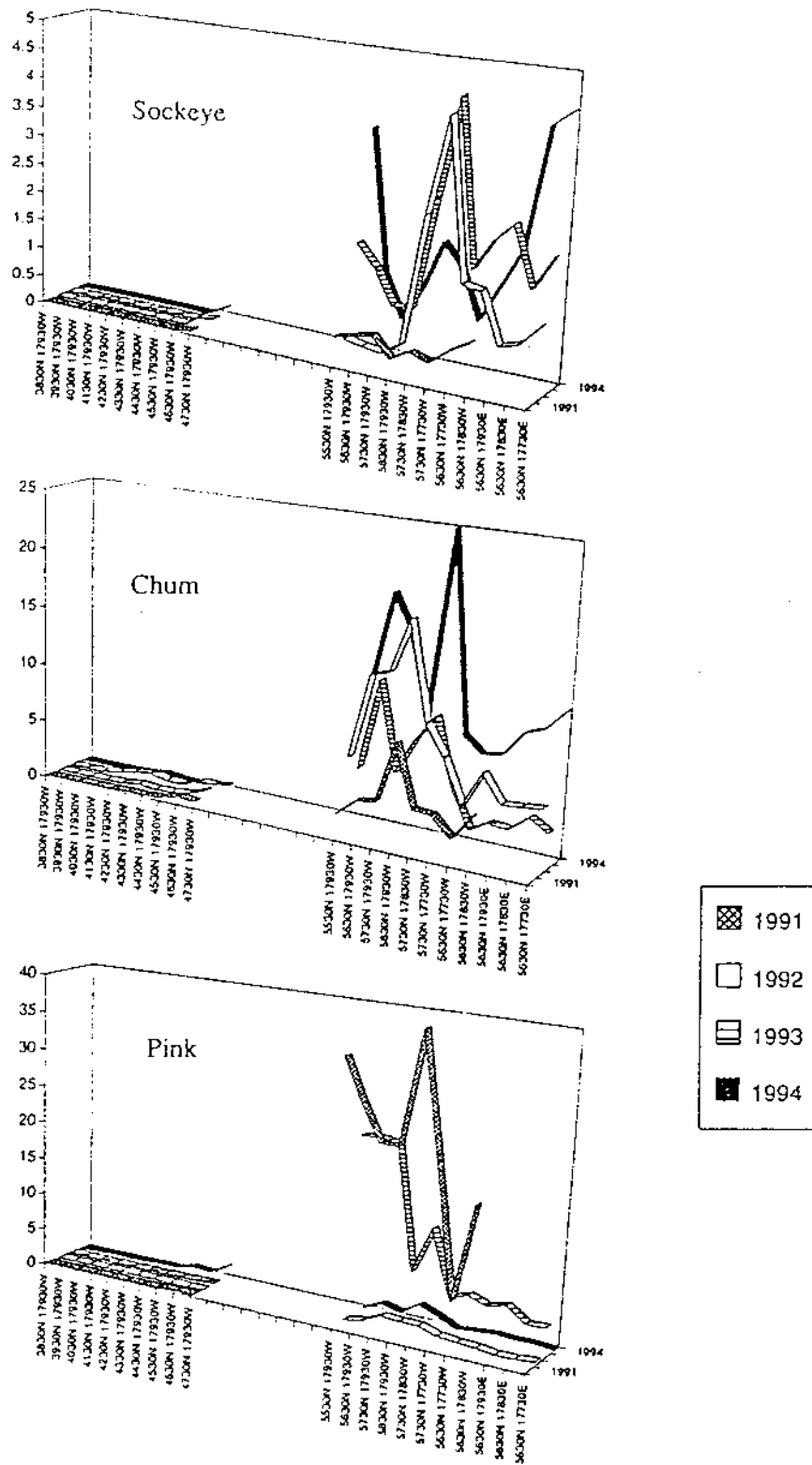


Figure 6. Catch per unit of effort (CPUE, number of fish caught per tow) for salmonids and neon flying squid caught at stations along a transect at 179°30'W longitude (stations 1-21) and in the central Bering Sea (stations 22-28) in June and July 1991-1994. Gillnets were not fished between 48°30'N and 54°30'N because these stations were within the U. S. 200-mile EEZ. Commercial-mesh size is 115 mm.

Commercial-mesh Gillnet CPUE

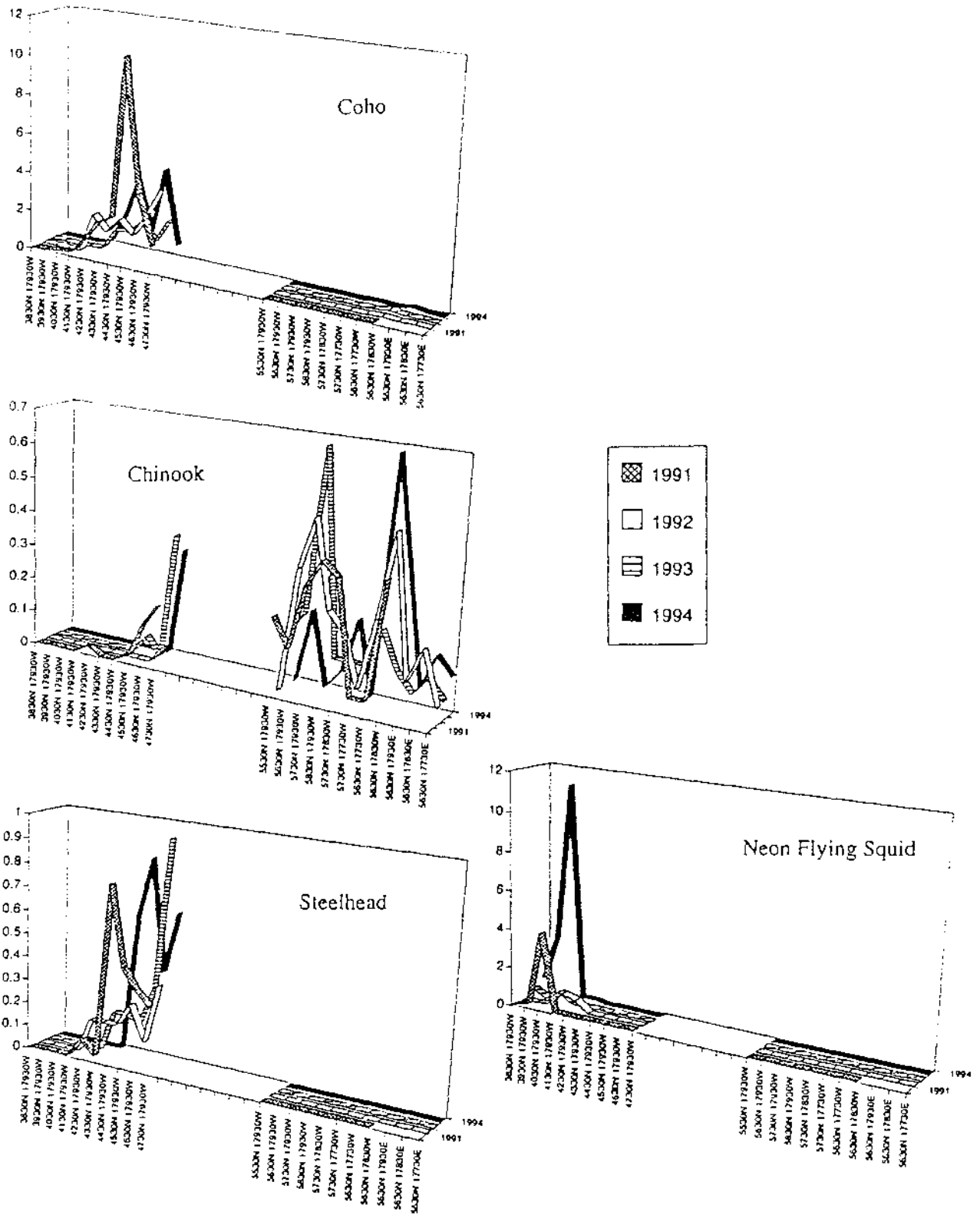


Figure 6. Continued.

Research-mesh Gillnet CPUE

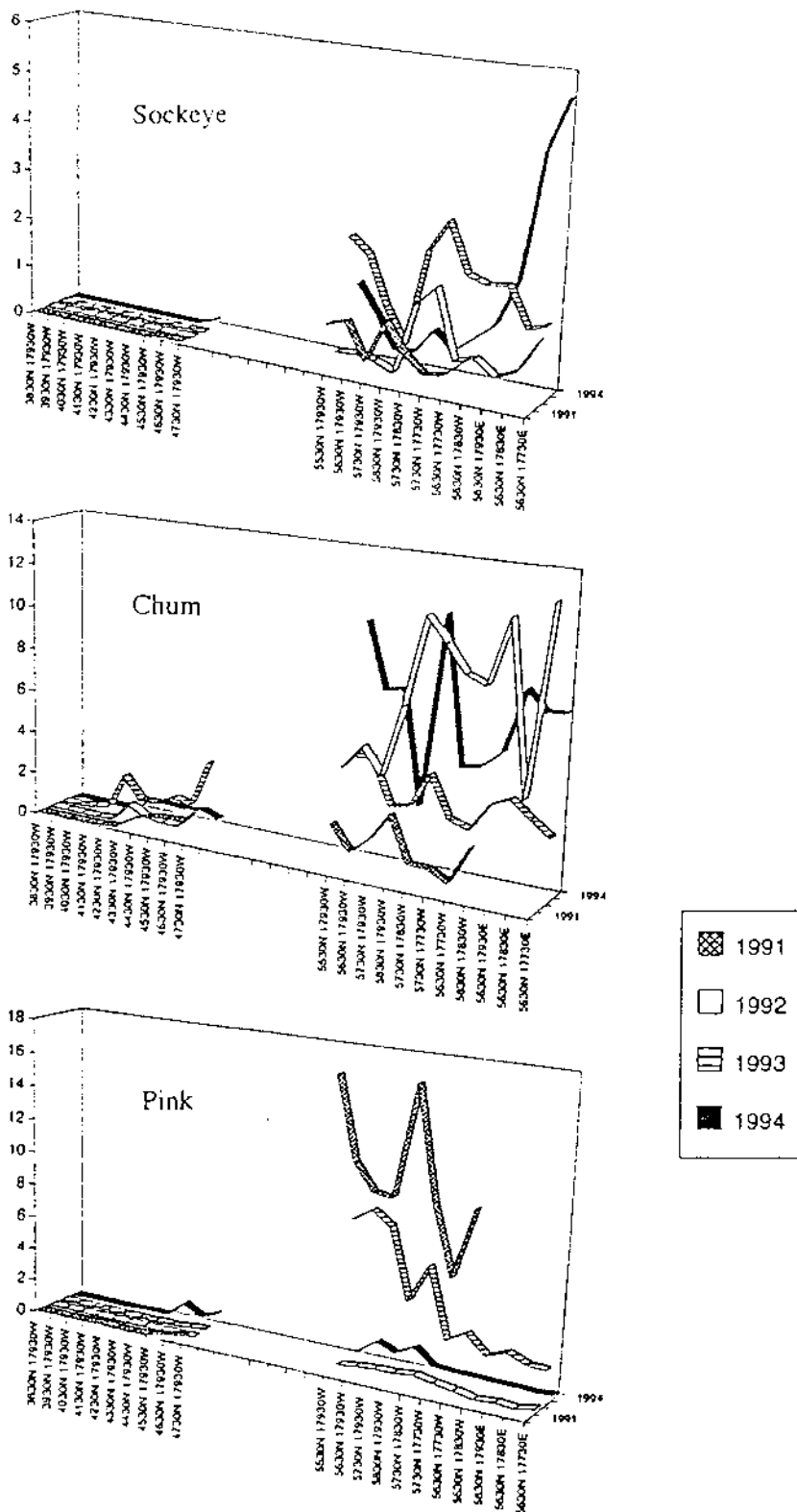


Figure 7. Catch per unit of effort (CPUE, number of fish caught per ton) for salmonids and neon flying squid caught at stations along a transect at 179°30'W longitude (stations 1-21) and in the central Bering Sea (stations 22-28) in June and July 1991-1994. Gillnets were not fished between 48°30'N and 54°30'N because these stations were within the U. S. 200-mile EEZ. Research-mesh sizes include the following: 48 mm, 55 mm, 63 mm, 72 mm, 82 mm, 93 mm, 106 mm, 121 mm, 138 m, and 157 mm.

Research-mesh Gillnet CPUE

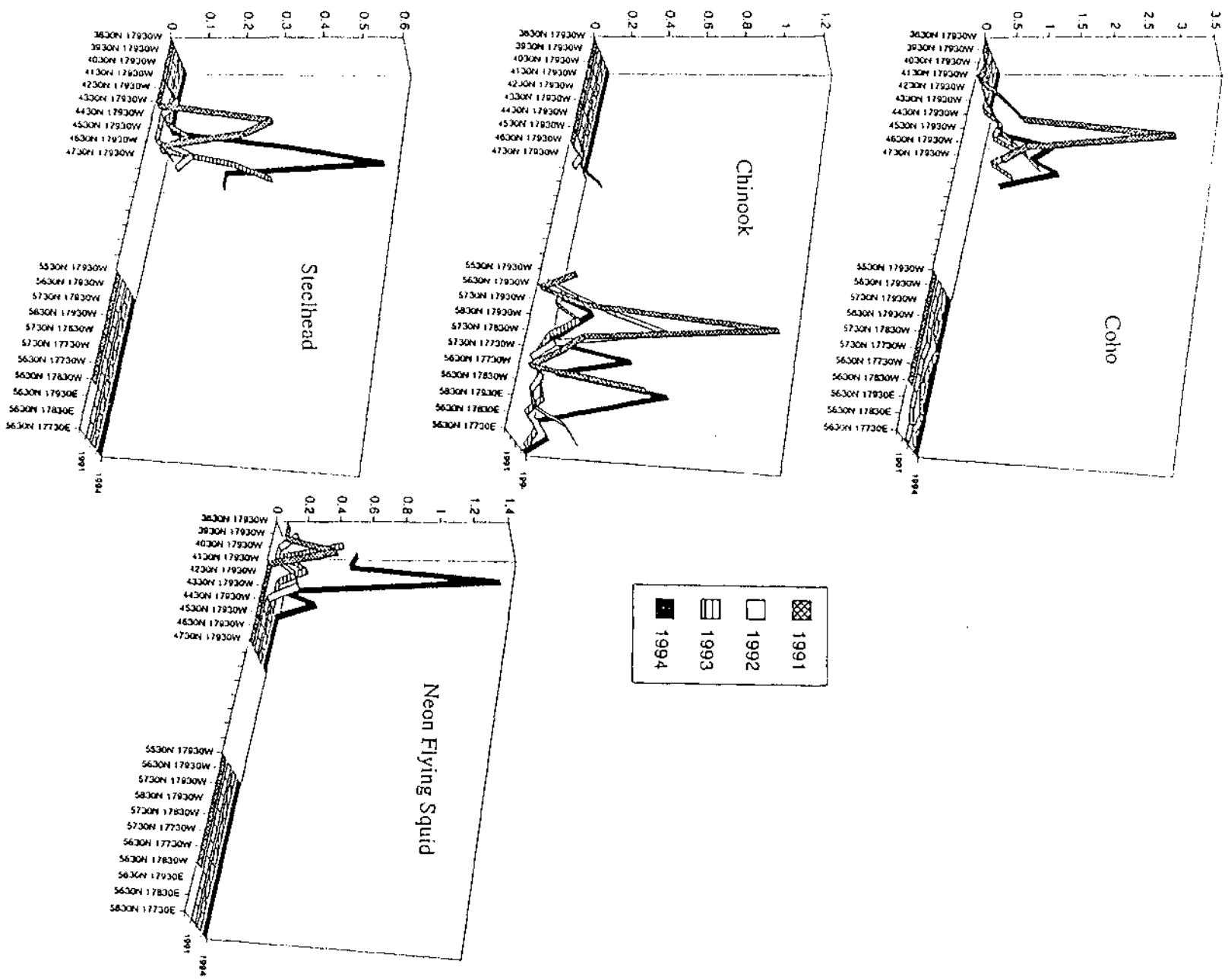


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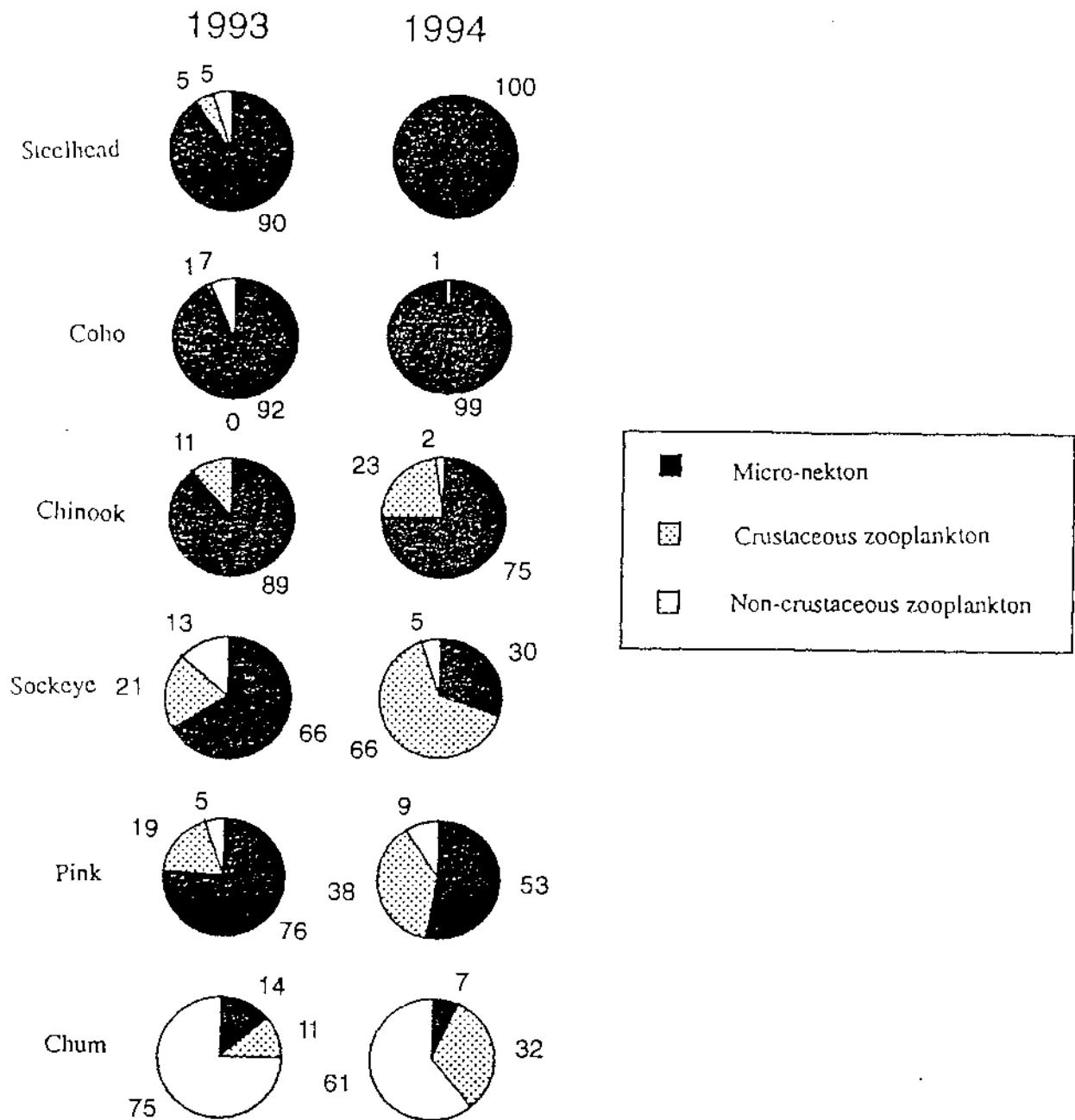


Figure 8. Percentage of prey types found in the stomachs of salmonids caught along the transect at 179°30'W longitude and in the central Bering Sea in 1993 and 1994. Micro-nekton includes fish and squid. Crustaceous zooplankton includes euphausiids, copepods, amphipods, ostracods, and decapods. Non-crustaceous zooplankton includes pteropods, gelatinous zooplankton, appendicularians, polychaetes, chaetognaths, and salps.

Table 1. Continued.

Sta	Date	Location	SST Salinity	Gear	Sockeye	Chum	Pink	Coho	Chinook	Steelhead	Dolly Vardien	Neon Flying Squid	Other Squids	Pacific Pomfret	Atka Mackerel	Lancet Fish	Walleye Pollock	Sharks	Pacific Seury	Dagger Tooth	Other Fishes	Sea Birds	Marine Mammals
8	6-23	45°30'N 179°30'W	6.8 32.92	B	0	14	7	7	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
				C	0	15	30	25	0	17	0	0	25	0	0	0	0	5	0	0	0	3	0
				A	0	2	14	20	0	16	0	0	1	0	0	0	0	2	0	0	0	1	0
				Total	0	31	51	52	0	37	0	0	26	0	0	0	0	7	0	0	0	4	0
9	6-26	46°30'N 179°30'W	6.6 32.95	B	0	3	6	18	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
				C	0	20	12	38	0	5	0	0	6	0	0	0	0	0	0	0	0	0	2
				A	0	5	9	85	0	7	0	0	0	0	0	0	0	2	0	0	0	1	0
				Total	0	30	27	141	2	14	0	0	6	0	0	0	0	2	0	0	0	3	0
10	6-27	47°30'N 179°30'W	6.1 32.94	B	0	8	5	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0
				C	4	11	34	12	3	5	0	0	1	0	0	0	0	0	0	0	0	0	0
				A	3	8	32	13	6	12	0	0	0	0	0	0	0	0	0	0	0	1	0
				Total	7	27	61	25	10	20	0	0	1	0	0	0	0	0	0	0	0	1	0
11	6-28	48°30'N 179°30'W	6.1 32.96	B	1	19	8	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
12*	6-29	49°30'N 179°30'W	6.2 32.79	B	20	179	41	2	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0
13	6-30	50°30'N 179°30'W	6.9 32.46	B	25	38	6	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0
14	7-1	51°30'N 179°30'W	5.5 33.07	B	7	95	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	7-2	52°30'N 179°30'W	6.1 33.02	B	15	78	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0
16	7-3	53°30'N 179°30'W	6.0 33.10	B	41	159	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17*	7-4	54°30'N 179°30'W	6.3 33.13	B	60	435	7	0	2	0	0	0	0	0	0	0	2	0	0	0	0	4	0

Table 1. Continued.

Sta	Date	Location	SST		Sockeye	Chum	Pink	Coho	Chinook	Steelhead	Dolly	Neon		Pacific	Atka	Lancet	Walleye	Sharks	Pacific	Dagger	Other	Sea	Marine			
			Salinity	Gear								Flying	Squid											Pomfret	Mackerel	Fish
18	7-5	55°30 N 179°30 W	6.3	B	1	107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			33.00	C	45	324	10	0	0	0	0	0	1	0	7	0	0	0	0	0	0	0	0	16	0	
				A	71	237	7	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0
				Total	117	668	17	0	0	0	0	0	0	1	0	7	0	0	1	0	0	0	0	19	0	0
19	7-6	56°30 N 179°30 W	6.4	B	3	178	5	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0		
			32.96	C	29	235	25	0	6	0	0	0	6	0	1	0	0	0	0	0	0	0	0	6	0	
				A	25	368	28	0	4	0	0	0	0	0	0	0	0	9	0	0	0	0	0	3	0	
				Total	57	781	58	0	11	0	0	0	6	0	1	0	12	0	0	0	0	0	0	9	0	0
20	7-7	57°30 N 179°30 W	7.0	B	5	124	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			33.07	C	9	241	21	0	3	0	0	0	0	0	0	0	0	6	0	0	0	0	0	36	0	
				A	12	313	15	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	147	0	
				Total	26	678	41	0	8	0	0	0	0	0	0	0	0	14	0	0	0	0	0	183	0	0
21	7-8	58°30 N 179°30 W	5.5	B	1	138	4	0	2	0	0	0	0	0	0	0	98	0	0	0	0	0	0	0		
			32.21	C	9	86	39	0	0	0	2	0	1	0	2	0	70	0	0	0	0	0	0	1	0	
				A	23	189	46	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	
				Total	33	413	89	0	3	0	2	0	1	0	2	0	172	0	0	0	0	0	0	2	0	0
22	7-9	57°30 N 178°30 W	6.7	B	3	334	0	0	1	0	0	0	0	0	0	0	8	0	0	0	0	0	1	0		
			32.47	C	25	348	11	0	13	0	0	0	1	0	12	0	7	0	0	0	0	0	0	5	0	
				A	39	475	26	0	4	0	0	0	0	0	0	0	10	0	0	0	0	0	0	3	0	
				Total	67	1147	37	0	18	0	0	0	1	0	12	0	25	0	0	0	0	0	0	9	0	0
23	7-10	57°30 N 177°30 W	6.7	B	2	205	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		
			32.90	C	14	149	8	0	2	0	0	0	0	0	4	0	1	0	0	0	0	0	0	8	0	
				A	32	168	3	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	1	8	0	
				Total	48	522	12	0	5	0	0	0	0	0	4	0	7	0	0	0	0	0	1	17	0	0
24	7-11	56°30 N 177°30 W	6.8	B	2	92	1	0	6	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0		
			32.71	C	24	155	8	0	19	0	0	0	1	0	0	0	1	0	0	0	0	0	0	9	0	
				A	16	143	8	1	13	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	
				Total	42	390	17	1	38	0	0	0	2	0	0	0	4	0	0	0	0	0	0	10	0	0
25	7-12	56°30 N 178°30 W	6.9	B	3	179	1	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0		
			33.06	C	34	178	6	0	10	0	0	0	4	0	1	0	2	0	0	0	0	0	0	0	0	
				A	28	149	12	0	7	0	0	0	1	0	0	0	5	1	0	0	0	0	0	4	0	
				Total	65	506	19	0	20	0	0	0	5	0	1	0	8	1	0	0	0	0	0	4	0	0

Table 1. Continued.

Sta	Date	Location	SST		Gear	Sockeye	Chum	Pink	Coho	Chinook	Steelhead	Dolly	Neon		Pacific	Atka	Lancel	Walleye	Pacific	Dagger	Other	Sea	Marine			
			Salinity										Flying	Squid										Pomfret	Mackerel	Fish
26	7-13	56°30' N 179°30' E	7.0	B	6	122	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			33.09	C	67	266	6	0	1	0	0	0	5	0	3	0	0	0	0	0	0	0	0	1	0	
				A	40	188	9	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
				Total	108	576	16	2	3	0	0	0	5	0	3	0	0	0	0	0	0	0	0	4	0	0
27	7-14	56°30' N 178°30' E	7.1	B	21	203	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			33.20	C	136	240	4	0	3	0	0	0	7	0	81	0	0	0	0	0	0	0	0	0	0	
				A	79	199	10	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
				Total	236	642	16	0	9	0	0	0	7	0	81	0	0	0	0	0	0	0	0	3	0	0
28	7-15	56°30' N 177°30' E	7.7	B	19	149	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			33.10	C	166	242	6	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	5	0	
				A	84	231	6	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	19	0	0
				Total	269	622	15	1	3	0	0	0	5	0	5	0	0	0	0	0	0	0	3	24	0	0
		Subtotal		B	235	2902	148	68	32	38	0	0	3	159	1	0	124	2	0	0	0	6	0	0		
				C	557	2546	215	119	60	37	2	72	88	54	116	0	87	10	521	0	1	92	0	0		
				A	452	2685	230	214	41	45	0	259	3	24	0	0	44	12	0	0	4	198	0	0		
		Total			1244	8133	593	401	133	120	2	331	94	237	117	0	255	24	521	0	5	296	0	0		

*B is a total of five longline operations: four 20-hachi operations and one 30-hachi operation.

Table 2. Research activities conducted on the *Wakatake maru* in 1994.

A. Activities conducted at T (transit) stations:

Subject	Location	Sampling Device	Sampling Depth	Data or Samples Collected
Oceanography	5° longitude intervals	CTD	0-600 m	depth, temperature, and salinity
	1° longitude intervals	XBT	0-460 m	
Primary Production	5° longitude intervals	bucket	0 m	amount of chl-a/l liter of seawater, identification of phytoplankton
Secondary Production	5° longitude intervals	Norpac	0-150 m	biomass and identification of macro-zooplankton

B. Activities conducted at F (fishing) stations:

Subject	Location	Sampling Device	Sampling Depth	Data or Samples Collected
Oceanography	1° latitude intervals	CTD	0-600 m	depth, temperature, and salinity
Primary Production	1° latitude intervals	Go-Flow water sampler	0, 10, 20, 30, 50, 75, 100 m	amount of chl-a/l liter of seawater, nutrient analysis, identification of phytoplankton
Secondary Production	1° latitude intervals	Norpac	0-150 m	biomass and identification of macro-zooplankton, fish larvae, and micro-nekton
		Bongo	0-150 m	
		ORI	0-250 m	
		fish larval net	0 m	

Table 2. Continued.

C. Activities conducted at F (fishing) stations:

Subject	Location	Fishing Gear	Method	Data or Samples Collected
Salmonid Studies	1° latitude intervals	longline is 3330 m and 1470 hooks in overall length (30-hatchi)	set at the surface for 30 minutes at dusk in the evening*	distribution and abundance, stomach contents, diurnal feeding activity, scales and otoliths, chum salmon isozyme, fat, protein, and RNA/DNA contents, examination of fish for salmon lice, fin-clips and slash marks
	1° latitude intervals (38°N-44°N) (38°N-44°N) (44°N-58°N) (44°N-58°N)	gillnet is 2450 m in overall length; 32-tans research 17-tans commercial, 30-tans research 19-tans commercial	12-hour soak 4 pm to 4 am	distribution and abundance, scales and otoliths, chum salmon isozyme, fat, protein, and RNA-DNA contents, examination of fish for salmon lice, fin-clips, and slash marks
Non-salmonid Studies	1° latitude intervals	longline gillnet	same as above	saury and pomfret length frequencies, and round samples

* except stations 7, 12, and 17 where four additional 20-hatchi longline operations were conducted over a 24-hour period.

Table 3. Description of the sampling equipment and methodology used to collect macro-zooplankton and micro-nekton by the *Wakatake maru* in 1994.

Net	Purpose	Ring Diameter	Overall Length	Mesh Size	Depression Weight	Towing Method	Wire Angle	Ship Speed	Wire Speed	Sample Preservation	Comments
Norpac	catches macro-zooplankton; long time series in the North Pacific	0.45 m	1.95 m	0.335 mm	10 kg	0-150 m vertical	measured and added wire length recorded	0 knots; drifting	1.0m/sec	bottled with formalin	flow meter used and calibrated 3X at first and last T-station
Bongo	catches macro-zooplankton; does not use a bridal maybe less net avoidance by zooplankton	0.70 m (2 rings: 1 designated red, 1 designated blue)	3.5 m	red=0.330 mm blue=0.600 mm	20 kg	0-150 m oblique	45°; wire length is 210 m	setting and retrieval is 1.5 knots	setting is 0.6m/sec retrieval is 0.3m/sec	bottled with formalin	flowmeter used and calibrated 3X at first and last F-station
ORI	catches mega-zooplankton and micro-nekton	2.0 m	8.66 m	2.0 mm	50 kg	0-250 m oblique	60°; wire length is 500 m	setting is 2.0 knots retrieval is 1.5 knots	1.0 m/sec	bottled with formalin	flowmeter used and calibrated 3X at first and last F-station
Fish larval net	catches fish larvae, micro-nekton, and small squid	1.3 m	4.5 m	2.0 mm (frontal portion), 0.335 mm (codend)	N/A	surface horizontal	N/A	2.0 knots	stationary	cotton bag put in a bucket of formalin	towed for 10 minutes; flowmeter broken

Table 4. Catch location and biological data for fin-clipped salmonids caught by the *Wakatake maru* in 1994 (N=67).

Date	Location	Species	Length (mm)	Weight (gms)	Sex	Gonad Weight	Gear	Sample Number
6-24	44°30N179°30W	Sthd	525	1610	M	1	B	15-02
6-24	44°30N179°30W	Sthd	541	1580	F	4	B	15-07
6-24	44°30N179°30W	Sthd	590	2000	M	1	B	15-08
6-24	44°30N179°30W	Sthd	564	1920	M	2	B	15-11
6-24	44°30N179°30W	Sthd	561	1850	M	10	B	15-12
6-24	44°30N179°30W	Coho	600	2450	M	17	B	15-17
6-24	44°30N179°30W	Sthd	530	1520	M	10	B	15-19
6-24	44°30N179°30W	Sthd	534	1540	M	6	B	16-06
6-24	44°30N179°30W	Sthd	546	1750	F	6	B	16-07
6-24	44°30N179°30W	Sthd	558	1800	F	5	B	16-08
6-24	44°30N179°30W	Sthd	598	1960	M	2	B	16-09
6-24	44°30N179°30W	Sthd	598	2150	M	10	B	16-10
6-24	44°30N179°30W	Sthd	570	1940	F	13	B	16-11
6-24	44°30N179°30W	Sthd	572	1820	M	8	B	17-26
6-24	44°30N179°30W	Sthd	574	2100	F	13	B	18-12
6-24	44°30N179°30W	Sthd	558	1880	F	15	B	18-13
6-24	44°30N179°30W	Sthd	590	1980	M	5	B	18-14
6-25	44°30N179°30W	Sthd	540	1540	M	2	A115	22-02
6-25	44°30N179°30W	Sthd	600	1740	M	3	A115	22-03
6-25	44°30N179°30W	Sthd	560	1640	M	2	A115	22-04
6-25	44°30N179°30W	Sthd	581	2200	M	2	C121	23-01
6-25	44°30N179°30W	Sthd	580	1900	F	5	C121	23-02
6-25	44°30N179°30W	Sthd	576	1850	F	5	C121	23-04
6-25	44°30N179°30W	Sthd	561	1850	F	16	C121	23-05
6-25	44°30N179°30W	Sthd	570	1880	M	2	C106	25-02
6-25	44°30N179°30W	Sthd	530	1560	F	3	C093	27-01

Table 4. Continued.

Date	Location	Species	Length (mm)	Weight (gms)	Sex	Gonad Weight	Gear	Sample Number
6-25	44°30N179°30W	Sthd	560	1600	F	15	C093	27-02
6-25	44°30N179°30W	Sthd	566	1720	M	5	C093	27-03
6-25	45°30N179°30W	Sthd	548	1700	M	5	B	33-13
6-25	45°30N179°30W	Sthd	682	3250	F	43	B	33-22
6-26	45°30N179°30W	Sthd	570	1720	M	62	A115	36-01
6-26	45°30N179°30W	Sthd	644	2550	F	22	A115	36-02
6-26	45°30N179°30W	Sthd	536	1600	F	4	A115	36-03
6-26	45°30N179°30W	Sthd	540	1620	M	1	A115	36-04
6-26	45°30N179°30W	Sthd	540	1540	M	2	A115	36-05
6-26	45°30N179°30W	Sthd	594	1920	F	3	A115	36-06
6-26	45°30N179°30W	Sthd	638	2330	M	5	A115	36-07
6-26	45°30N179°30W	Sthd	678	1680	M	4	A115	36-15
6-26	45°30N179°30W	Sthd	544	1600	F	13	A115	36-16
6-26	45°30N179°30W	Sthd	590	2010	F	5	C121	39-09
6-26	45°30N179°30W	Sthd	586	1930	F	13	C121	39-10
6-26	45°30N179°30W	Sthd	550	1750	M	7	C121	39-11
6-26	45°30N179°30W	Sthd	460	1650	M	3	C106	40-04
6-26	45°30N179°30W	Sthd	600	2200	M	13	C106	40-05
6-26	45°30N179°30W	Sthd	552	1750	M	18	C093	41-01
6-26	45°30N179°30W	Sthd	580	2100	F	18	C093	41-02
6-26	45°30N179°30W	Sthd	554	1720	F	14	C138	42-05
6-26	45°30N179°30W	Sthd	666	1980	F	12	C082	44-12
6-27	46°30N179°30W	Sthd	554	1900	M	2	C093	52-20
6-27	46°30N179°30W	Sthd	558	1640	M	2	A115	53-11
6-27	46°30N179°30W	Sthd	568	1840	F	7	A115	53-12
6-27	47°30N179°30W	Sthd	592	2100	F	15	B	58-07
6-28	47°30N179°30W	Sthd	781	5150	M	10	C121	60-05
6-28	47°30N179°30W	Sthd	781	4800	M	10	C138	61-06
6-28	47°30N179°30W	Sthd	604	2150	M	2	A115	64-01

Table 4. Continued.

Date	Location	Species	Length (mm)	Weight (gms)	Sex	Gonad Weight	Gear	Sample Number
6-28	47°30N179°30W	Sthd	776	4950	M	7	A115	64-02
6-28	47°30N179°30W	Sthd	688	3300	F	10	A115	64-03
6-28	47°30N179°30W	Sthd	582	2050	M	2	A115	64-04
6-28	47°30N179°30W	Sthd	618	2200	M	2	A115	64-05
6-28	47°30N179°30W	Sthd	508	1860	F	12	A115	64-06
6-28	47°30N179°30W	Sthd	672	3150	M	5	A115	64-07
6-28*	47°30N179°30W	Sthd	672	3000	F	23	A115	VClip
6-28	48°30N179°30W	Sthd	796	5750	F	21	B	70-26
6-29	49°30N179°30W	Sthd	724	3950	F	41	B	72-30
6-29	49°30N179°30W	Sthd	712	3600	F	45	B	81-13
6-30	50°30N179°30W	Sthd	712	3800	F	42	B	83-10
6-30	50°30N179°30W	Sthd	737	3650	M	7	B	84-15

*This fish was lacking a ventral fin, but it had an adipose fin. The absence of a ventral fin may indicate the fish originated from the Columbia River. A snout was not collected from this steelhead trout. The Columbia Basin steelhead policy states that a left ventral clip (single or in combination) is reserved for coded-wire tags placed in Columbia River Basin steelhead and may not be used without a coded-wire tag (Johnson and Longwill 1993). An adipose clip may be used in conjunction with the left-ventral clip and coded-wire tag to indicate a harvestable coded-wire tagged steelhead. The adipose clip (single or in combination) on steelhead in the Columbia Basin is reserved (effective 9/83) to identify harvestable fish and is no longer a flag indicating a coded-wire tag.

Table 5. Catch location and biological data for Dolly Varden (*Salvelinus malma*) caught by the *Wakatake maru* in 1994.

Date	Location	Length (mm)	Weight (gms)	Mesh Size	Sample Number
7-9	58°30N179°30W	450	780	C072	189-01
7-9	58°30N179°30W	484	920	C082	190-13

Table 6. Mean percent volume of prey found in salmonid stomach contents summarized by oceanographic region and prey category. The mean percent volume was visually estimated for each prey category. Index of stomach content weight (SCI=prey weight X 100/body weight) includes empty stomachs. TZ=Transition Zone, TD=Transition Domain, SCS=Subarctic Current System, ACS=Alaska Current System, BCS=Bering Current System, BSG=Bering Sea Gyre, SQ=squid, FI=fish, EU=euphausiids, CO=copepods, AM=amphipods, MY=mysids, OS=ostracods, DE=decapods, PT=pteropods, Coel=coelenterates, Cten=ctenophores, AP=appendicularia, PO=polychaetes, CH=chaetognaths, SA=salps, CL=*Clione*, HE=heteropods, OC=octopus, UN=unidentified material.

Sockeye

Region	N	SCI	SQ	FI	EU	CO	AM	MY	OS	DE	PT	Coel	Cten	AP	PO	CH	SA	CL	HE	OC	UN
SCS	26	0.87	65	0	19	6	7	0	0	0	3	0	0	0	0	0	0	0	0	0	0
ACS	7	0.83	2	0	0	0	61	24	0	3	10	0	0	0	0	0	0	0	0	0	0
BCS	34	0.45	0	1	38	3	51	3	0	1	1	0	0	0	0	2	0	0	0	0	0
BSG	74	0.99	20	6	14	40	14	0	0	0	4	1	0	0	0	0	0	0	0	0	0
Total	141																				
Mean		0.83	25	4	17	27	20	2	0	0	4	1	0	0	0	0	0	0	0	0	0

Chum

Region	N	SCI	SQ	FI	EU	CO	AM	MY	OS	DE	PT	Coel	Cten	AP	PO	CH	SA	CL	HE	OC	UN
TD	32	1.05	4	1	1	1	2	0	4	0	2	5	33	0	0	35	0	0	2	0	10
SCS	72	0.85	2	1	9	1	4	0	0	0	21	13	2	0	0	3	0	2	0	0	42
ACS	20	1.23	22	13	22	4	19	6	0	0	1	9	4	0	0	0	0	0	0	0	1
BCS	60	0.83	4	3	6	5	21	6	0	0	6	22	2	0	1	4	0	0	0	0	21
BSG	218	1.01	4	2	18	7	12	0	0	0	7	40	1	0	0	3	0	0	0	0	6
Total	402																				
Mean		0.97	5	2	14	5	12	1	0	0	8	28	4	0	0	6	0	0	0	0	14

Pink

Region	N	SCI	SQ	FI	EU	CO	AM	MY	OS	DE	PT	Coel	Cten	AP	PO	CH	SA	CL	HE	OC	UN
TD	29	0.66	0	6	1	44	11	0	5	0	7	0	0	0	0	25	0	0	0	0	0
SCS	32	2.34	69	1	11	9	4	0	0	0	6	0	0	0	0	1	0	0	0	0	0
ACS	2	0.96	0	17	0	0	27	37	0	0	20	0	0	0	0	0	0	0	0	0	0
BCS	2	0.52	48	14	3	3	25	0	0	0	3	0	0	0	0	3	0	0	0	0	0
BSG	24	1.50	30	16	39	11	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Total	89																				
Mean		1.49	47	6	17	14	5	1	1	0	5	0	0	0	0	4	0	0	0	0	0

Table 6. Continued.

Coho

Region	N	SCI	SQ	FI	EU	CO	AM	MY	OS	DE	PT	Coel	Cten	AP	PO	CH	SA	CL	HE	OC	UN
TD	23	1.22	74	23	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
SCS	22	2.91	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	45																				
Mean		2.05	92	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Chinook

Region	N	SCI	SQ	FI	EU	CO	AM	MY	OS	DE	PT	Coel	Cten	AP	PO	CH	SA	CL	HE	OC	UN
SCS	3	0.28	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BCS	6	0.50	53	24	0	0	20	0	0	0	2	0	0	0	0	2	0	0	0	0	0
BSG	20	1.13	45	7	10	8	9	2	0	0	4	5	2	0	0	4	0	0	0	0	4
Total	29																				
Mean		0.35	66	8	17	0	6	0	0	0	1	1	0	0	0	1	0	0	0	0	0

Steelhead

Region	N	SCI	SQ	FI	EU	CO	AM	MY	OS	DE	PT	Coel	Cten	AP	PO	CH	SA	CL	HE	OC	UN
TD	8	0.78	55	43	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SCS	10	1.28	92	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	18																				
Mean		1.05	80	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Salmon Research aboard the *Hokko maru* in the Western North Pacific Ocean in 1994

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Abstract

Fishing operations and oceanographic observations were conducted on board the *Hokko maru* to monitor salmon abundance and ocean environments at 11 stations along 165° E from 51° N to 41° N in the western North Pacific from July 1 to July 25, 1994. Average sea surface temperature was 11.0° C, which was 1.4° C higher in 1994 than in 1993 and 3.1° C higher than in 1992. A total of 8,207 salmon were caught. Pink salmon (*Oncorhynchus gorbuscha*) were the most abundant species (84%) followed by sockeye (*O. nerka*, 4%), chum (*O. keta*, 4%) and coho salmon (*O. kisutch*, 3%). CPUE (number of fish per tan) for pink salmon was higher in 1994 than in the previous two years, but CPUEs of other species were lower than in the previous two years.

Introduction

The National Research Institute of Far Seas Fisheries has started a new salmon research to monitor salmon abundance and ocean environments along 179° 30'W in the central North Pacific and Bering Sea in 1991 and along 165° E in the western North Pacific in 1992 (Ishida et al. 1991, 1992, 1994; Azuma 1992; Nagasawa et al. 1994). This report summarizes the survey conducted by the *Hokko maru* along 165° E in July, 1994.

Methods

The salmon research was conducted along 165° E from 51° N to 41° N in the western North Pacific from July 1 to July 25, 1994, on board the *Hokko maru* (466.49 ton, belonging to the Hokkaido National Fisheries Research Institute) (Fig.1). A total of 49-tan gillnets, which consisted 30-tan research nets (48, 55, 63, 72, 82, 93, 106, 121, 138, and 157mm, 3 tans of each mesh size), 15-tan commercial type nets (115mm), and 4 gillnets for saury survey, was used for collecting fish. The gillnets were set around 17:00 and retrieved around 03:00 the next morning. The direction of gillnet setting was between 000-045 or 180-225. Fish numbers were recorded by species and by mesh size, and fork length, body weight, and gonad weight were measured for up to 60 individuals per species and by mesh size after collecting scale samples. Stomach content weight and composition was investigated for up to 12 salmon per species collected in the 115mm mesh gillnets.

For zooplankton investigation, one vertical tow of a NORPAC net from 150 m to the surface and one oblique tow of a Bongo net from 150 m to the surface, and 10-minute horizontal tow of a fish larval net were conducted at each station after sunset. Samples were preserved in 10% formalin

solution. Sea water temperature, dissolved oxygen, and salinity were measured using a CTD from 1500 m to the surface. The investigation of primary production was also conducted.

Results and Discussion

Oceanographic Conditions

Average sea surface temperature was 11.0° C, which was 1.4° C higher in 1994 than in 1993 and 3.1° C higher than in 1991. Thermocline was located at 100m depth at Station 1 (51° N) and 4 (48° N), 75m at Station 2 (50° N) and 3 (49° N), 150m at Station 5 (47° N), which were shallower than that last year. Thermocline was not found at southern locations (46° N-41° N). Sea surface salinity varied from 32.7 to 33.1, and a surface value over 34.0 was observed at Station 11 (41° N), indicating the subarctic boundary.

Salmon Distribution

A total of 8,207 salmon were caught, pink salmon (*O. gorbuscha*) were the most abundant species (84%) followed by sockeye (*O. nerka*, 4%), chum (*O. keta*, 4%) and coho salmon (*O. kisutch*, 3%). Except pink and coho salmon, other salmon were abundant in northern stations (Table 1). CPUE (number of fish per tan) of pink salmon was about 3 times higher in 1994 than in 1992, but CPUEs of other species were lower than those in the previous two years (Table 2). Other than salmon, neon frying squid (*Ommastrephes bartramii*) (N=234) and blue shark (*Prionace glauca*) (N=447) were caught abundantly at Station 10 (42° N) and 11 (41° N), respectively (Table 3).

Feeding Ecology of Salmon

Stomach content indices for pink and coho salmon were higher than those for other salmon species. Stomach content composition indicated that sockeye salmon fed on squids and crustaceans (copepods, euphausiids, and amphipods). Major stomach contents of chum salmon were amphipods and unidentified digested materials, although they fed on pteropods in northern locations last year (Ishida et al. 1993). Pink salmon fed on crustaceans such as copepods and amphipods. Fishes and squids were also found in coho salmon stomachs. The single chinook salmon fed on fishes and steelhead trout fed on fishes and squids (Table 4).

Acknowledgments

We thank Captain Y. Kikuchi, and the officers and crew of the *Hokko maru* for their hard work and cooperations.

References

- Azuma, T. 1992. Summary of the high seas salmon research cruise by the *Hokko maru* in 1992. Salmon Research Report 36: 31-44. National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka 424, Japan.

- Ishida, Y., N. D. Davis, and K. Tadokoro. 1991. Cooperative Japan-U.S. high seas salmonid research in 1991: summary of research aboard the Japanese research vessel *Wakatake maru*, 4 June to 23 July. (Document submitted to the Annual Meeting of the International North Pacific Fisheries Commission, Tokyo, Japan, October 1991). National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1, Orido, Orido, Shimizu, Shizuoka 424, Japan. FRI-UW-9113, Fish. Res. Inst., Univ. Washington, Seattle, 35 p.
- Ishida, Y., N. D. Davis, and K. Monaka. 1992. Japan-U.S. cooperative salmon research by the *Wakatake maru* in 1992. Salmon Report Series 36:31-44. National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka 4224, Japan.
- Ishida, Y., and M. Tamakai. 1994. Salmon research by the *Hokko maru* in the western North Pacific in 1993. Salmon Report Series 37:42-56. National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka 424, Japan.
- Nagasawa, K., N. D. Davis, and K. Tadokoro. 1994. Japan-U.S. cooperative salmon research in 1993: summary of research aboard the Japanese research vessel *Wakatake maru*, 10 June to 25 July. Salmon Research Report 37: 57-84. National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka 424, Japan.

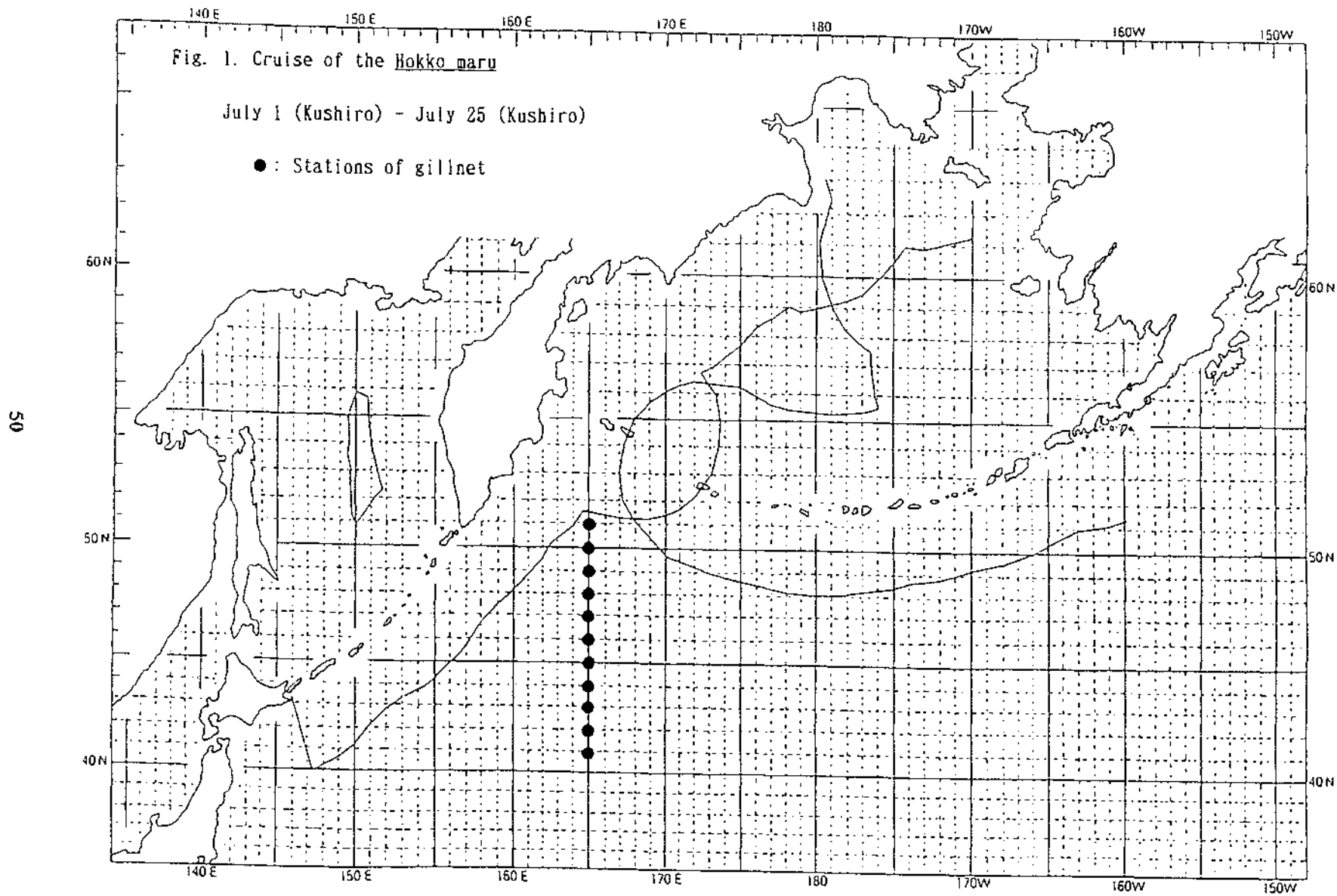


Fig. 1. Map of the western North Pacific Ocean, indicating sapling locations

Table 1. Location, sea surface temperature (SST, °C), surface salinity, and number of salmon caught by salmon research gillnets (C), and commercial-mesh gillnet (A) for each station.

St.	Date	Location	SST		Tan	Species						Total
			Sal	Gear		Sock	Chum	Pink	Coho	Chin	Steel	
1	7-7	50-57N	6.9	A	15	67	58	203	0	0	0	328
		165-00E	32.7	C	30	89	32	135	0	0	0	256
2	7-8	50-00N	7.2	A	15	33	34	417	1	0	0	485
		165-00E	32.7	C	30	42	31	284	2	0	0	359
3	7-9	49-00N	7.5	A	15	61	9	699	2	1	0	772
		165-00E	32.8	C	30	46	9	337	8	0	0	400
4	7-10	48-00N	7.9	A	15	3	10	1890	31	0	0	1934
		165-00E	32.7	C	30	3	9	1342	28	0	3	1385
5	7-11	47-00N	9.0	A	15	0	22	327	20	0	0	369
		165-00E	32.8	C	30	1	28	178	18	0	0	225
6	7-12	46-00N	10.0	A	15	0	2	407	34	0	1	444
		165-00E	33.0	C	30	0	7	306	21	0	0	334
7	7-13	45-00N	11.9	A	15	0	0	54	17	0	0	71
		165-00E	33.1	C	30	0	0	37	9	0	0	46
8	7-14	44-00N	12.2	A	15	0	3	2	4	0	0	9
		165-00E	33.0	C	30	0	5	2	8	0	0	15
9	7-15	43-00N	12.6	A	15	0	10	0	3	0	0	13
		165-00E	33.0	C	30	0	1	0	2	0	0	3
10	7-16	42-00N	13.5	A	15	0	2	0	0	0	0	2
		165-00E	32.9	C	30	0	1	0	0	0	0	1
11	7-17	41-00N	18.2	A	15	0	0	0	0	0	0	0
		165-00E	34.0	C	30	0	0	0	0	0	0	0
5	7-19	47-00N	18.2	A	15	0	12	205	34	0	1	252
		165-00E	34.0	C	30	0	9	101	15	0	1	126
Total				A	180	164	162	4204	146	1	2	4679
				C	360	181	132	2722	111	0	4	3150
				Total	540	345	294	6926	257	1	6	7829

Table 2 Salmon abundance (CPUE) along 165°E between 41°N and 50°N from 1992 to 1994.

Year	Gear	Species							Total
		Tan	Sock	Chum	Pink	Coho	Chin	Steel	
1992	A	170	271	108	1261	324	17	5	1986
	C	300	217	194	805	153	12	4	1385
	Total	470	488	302	2066	477	29	9	3371
	CPUE		1.04	0.64	4.40	1.01	0.06	0.02	7.17
1993	A	150	137	368	198	105	13	1	822
	C	300	91	364	128	78	10	2	673
	Total	450	228	732	326	183	23	3	1495
	CPUE		0.51	1.63	0.72	0.41	0.05	0.01	3.32
1994	A	150	97	92	3796	112	1	1	4099
	C	300	92	91	2486	96	0	3	2768
	Total	450	189	183	6282	208	1	4	6867
	CPUE		0.42	0.41	13.96	0.46	0.00	0.01	15.26

Table 3. Location and catch of non-salmonid fishes, squids, birds, and marine mammals.

St.	Gear	Neon Flying Squid	Other Squids	Pacific Pomfret	Atka Mackerel	Sharks	Pacific Saury	Other Fishes	Sea Birds	Marine Mammals
1	A	0	0	0	0	0	0	0	5	0
	C	0	8	0	1867	0	0	0	0	0
2	A	0	0	0	0	0	0	0	0	0
	C	0	4	0	125	0	0	0	2	0
3	A	0	0	0	0	0	0	0	0	0
	C	0	13	0	0	0	0	0	0	0
4	A	0	0	0	0	0	0	0	0	0
	C	0	38	0	0	0	0	0	0	0
5	A	0	0	0	0	0	0	0	1	0
	C	0	20	0	0	0	0	0	0	0
6	A	0	0	0	0	3	0	0	0	0
	C	0	33	0	0	2	9	0	0	0
7	A	0	0	4	0	0	0	0	0	0
	C	0	27	21	0	1	121	1	0	0
8	A	1	0	2	0	0	0	0	1	0
	C	1	50	0	0	1	17	0	4	0
9	A	7	0	5	0	0	0	0	3	1
	C	3	46	43	0	1	0	0	0	0
10	A	120	0	50	0	0	0	2	3	0
	C	114	160	83	0	0	0	0	7	0
11	A	3	0	1	0	190	0	1	0	0
	C	6	0	7	0	259	0	4	0	0
5	A	0	0	0	0	0	0	0	2	0
	C	0	7	0	0	1	19	0	1	0
A		131	0	62	0	193	0	3	15	1
C		124	406	154	1992	265	166	5	14	0
Total		255	406	216	1992	458	166	8	29	1

Table 4. Mean percent volume of prey found in salmon stomach contents. N=number of fish examined, Index of stomach content weight (SCI=prey weight x 100 / body weight) includes empty stomachs. EU=euphausiids, CO=copepods, AM=amphipods, SQ=squids, FI=fishes, PT=pteropods, PO=polychaets, UN=unidentified materials.

Species	N	SCI	EU	CO	AM	SQ	FI	PT	PO	UN
Sockeye	32	0.42	6	12	38	33	4	0	3	2
Chum	72	0.28	9	4	34	3	2	8	2	37
Pink	83	0.62	8	37	44	5	6	0	0	0
Coho	56	0.53	0	2	10	51	37	0	0	0
Chinook	1	0.23	0	0	0	100	0	0	0	0
Steelhead	2	0.23	0	0	10	45	45	0	0	0

Summary of Japan-Russia Cooperative Juvenile Salmon Research aboard the Research Vessel *Wakashio maru* in 1994

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Abstract

To make clear the distribution and migration routes of juvenile salmon, we planned to conduct drift-net operations in the southern and central parts of the Sea of Okhotsk using the research vessel *Wakashio maru*. However, because the permission to enter the central and southern waters of the Okhotsk Sea could not be obtained, we were compelled to conduct a survey in the Okhotsk coastal waters (40-12 nautical miles off) off the Kuril Islands and the Pacific waters off the Kuril Islands. We conducted 8 drift-net operations in the Okhotsk coastal waters and 13 drift-net operations in the Pacific waters off the Kuril Islands. We caught 13 juvenile chum, 1 juvenile sockeye, and 2 juvenile Dolly Varden at 4 stations in the Okhotsk coastal waters. In the Pacific waters, no juvenile salmon were found at 13 stations. This indicates that juvenile chum may not migrate to the Pacific waters off the Kuril Islands but to the Okhotsk waters in early summer.

Introduction

The purpose of this research is to make clear the distribution and migration routes of juvenile chum salmon originating in Japanese rivers. Juvenile chum are believed to migrate northwards along the coastal belt of northern Japan from spring to early summer (Irie, 1990). The juvenile chum are known to arrive in the southeastern part of Hokkaido in early summer. However, it is unknown where the juveniles migrate after leaving Hokkaido. The results of the 1993 *Kaiyo maru* and *Wakashio maru* juvenile salmon research shows that a large number of juvenile chum, the origins of which were not identified yet, were distributed in central part of the Sea of Okhotsk in late summer and early autumn (Ueno et al., 1994a and 1994b). Assuming that the origin of these juveniles was Japanese rivers, juvenile chum were thought to migrate northwards in the southern part of the Okhotsk Sea leaving from coastal waters off Hokkaido in early summer. For confirming the distribution of juvenile salmonids in the southern part of the Okhotsk Sea in early summer, we planned to conduct a survey in the southern part of the Okhotsk Sea from mid-July to early August. However, we could not get a permission to enter offshore waters of the central and southern parts of the Okhotsk Sea which was the main target areas. We obtained a permission to enter only the Okhotsk coastal waters off the Kuril Islands (40-12 nautical miles off the coasts) and the Pacific waters. Considering that the above-mentioned situation on the permission, we were compelled to change the purpose of this research to confirm the distribution of juvenile salmon in the Pacific coastal waters off the Kuril Islands. We also aimed to collect juvenile salmon in the Okhotsk coastal waters which were limitedly permitted.

Methods

The survey was conducted at a total of 21 sampling stations (two stations off south eastern Hokkaido, six stations in Okhotsk coastal waters off the Kuril Islands, and 13 stations in the Pacific waters off the Kuril Islands) using the research vessel *Wakashio maru* (199.51 gross tons) from July 15 to August 7. Driftnet operations for sampling salmonids, CTD oceanographic observations, plankton net samplings were conducted at all stations. Sixteen tans of drift-nets (test nets) with 8 mesh sizes (22, 26, 30, 35, 42, 48, 55, 63mm) were used for collecting juvenile salmonids. Six tans of drift-nets with mesh size (156mm) were bound to both edges of the test nets for stretching the test nets. We set the drift-nets at 9 p.m. and lifted at 4 a.m. at each station. Fork lengths (FL) and body weights (BW) of juvenile salmon collected were measured and recorded. We also took scales from juvenile salmon for stock identification. All of juvenile salmon collected were wrapped using sheets of plastic wrap and frozen for examination in the laboratory. On immature and mature salmonids, measurement of FL and BW, and scale samplings were conducted. We recorded the body lengths of the other by-catch animals at each mesh size drift-nets (a maximum number for measurement were 30 individuals at each mesh size.)

Results

Numbers of main animals caught in the present research are shown in Table 1. A total of 3 juvenile chum were collected in the Okhotsk coastal waters off the Kuril Islands (Fig). On the other hand, no juvenile salmon and but many Pacific sauries *Cololabis saira*, and Japanese flying squids *Todarodes pacificus pacificus* were caught in the Pacific waters off the Kuril Islands. FLs, BWs, and mesh sizes of chum salmon collected are shown in Table 2. FLs of chum juveniles ranged from 140 mm to 201 mm with a mean of 169.1 mm and BWs from 27 g to 82 g with a mean of 48.3 g. The small mesh size of drift-nets, which ranged from 26 mm to 42mm, were effective for catching juvenile chum.

Adult chum and pink were abundant in the Pacific coastal waters off southeastern Hokkaido and the Okhotsk coastal waters off the Kuril Islands. Pacific saury were widely distributed in the Pacific coastal waters and abundant off the southern Kuril Islands. Knob lengths (KBL) of Pacific saury ranged from 160 mm to 355 mm with two modes of 255 mm and 315 mm. Saury of the mode of 315 mm in KBL were especially abundant. Japanese flying squids were widely distributed in the survey areas including the Okhotsk Sea and abundant in the coastal waters off Hokkaido and the southern Kuril Islands.

Discussion

Juvenile chum were collected not in the Pacific waters but in the Okhotsk coastal waters off the Kuril Islands. This supports the assumption that juvenile chum originated in Japanese rivers migrate to the Okhotsk Sea from coastal waters off Hokkaido. The FL range of juvenile chum collected in the present survey were intermediate between that of juvenile chum in coastal waters off Hokkaido in June and July (70-150 mm, Irie, 1990) and that of juvenile chum collected in central waters of the Okhotsk Sea in early autumn (about 220 mm, Ueno et al. 1994a and 1994b). This may also support our

assumption.

Many Pacific sauries, Japanese flying squids and other temperate-zone pelagic animals were distributed in the Pacific waters. On the other hand, numbers of such pelagic animals collected in the Okhotsk Sea were very few. This suggests that numbers of the competitors of juvenile chum were not be many in the Okhotsk Sea in early summer and the ecological situation of the Okhotsk Sea may be suitable for juvenile chum.

We guess that distribution of chum juvenile extends to offshore waters (especially, a southern part) of the Okhotsk Sea in early summer. We should conduct a survey in offshore waters of the Okhotsk Sea for collecting juvenile chum in the future research.

References

- Irie, T. 1990. Ecological studies on the migration of juvenile chum salmon *Oncorhynchus keta*, during early ocean life. Bull. Seikai Nat. Fish. Res. Inst.68:1-142.
- Ueno, Y., T., Azuma, M., Ogura, J., Seki, I., Shimizu, Y., Kawasaki, and T. Kono. 1994a. Summary of Japan-Russia-Canada cooperative juvenile salmon research aboard the research vessel *Kaiyo maru* in 1993. 19p. (Document submitted to the Annual Meeting of the North Pacific Anadromous Fish Commission, November 1994, Vladivostok, Russia.) National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, Shimizu, Shizuoka 424, Japan.
- Ueno, Y., and I. Shimizu. 1994b. Summary of Japan-Russia cooperative salmon research aboard the research vessel *Wakashio-maru* in 1994. 4p. (Document submitted to the Annual Meeting of the North Pacific Anadromous Fish Commission, November, 1994, Vladivostok, Russia.) National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, Shimizu, Shizuoka 424, Japan.

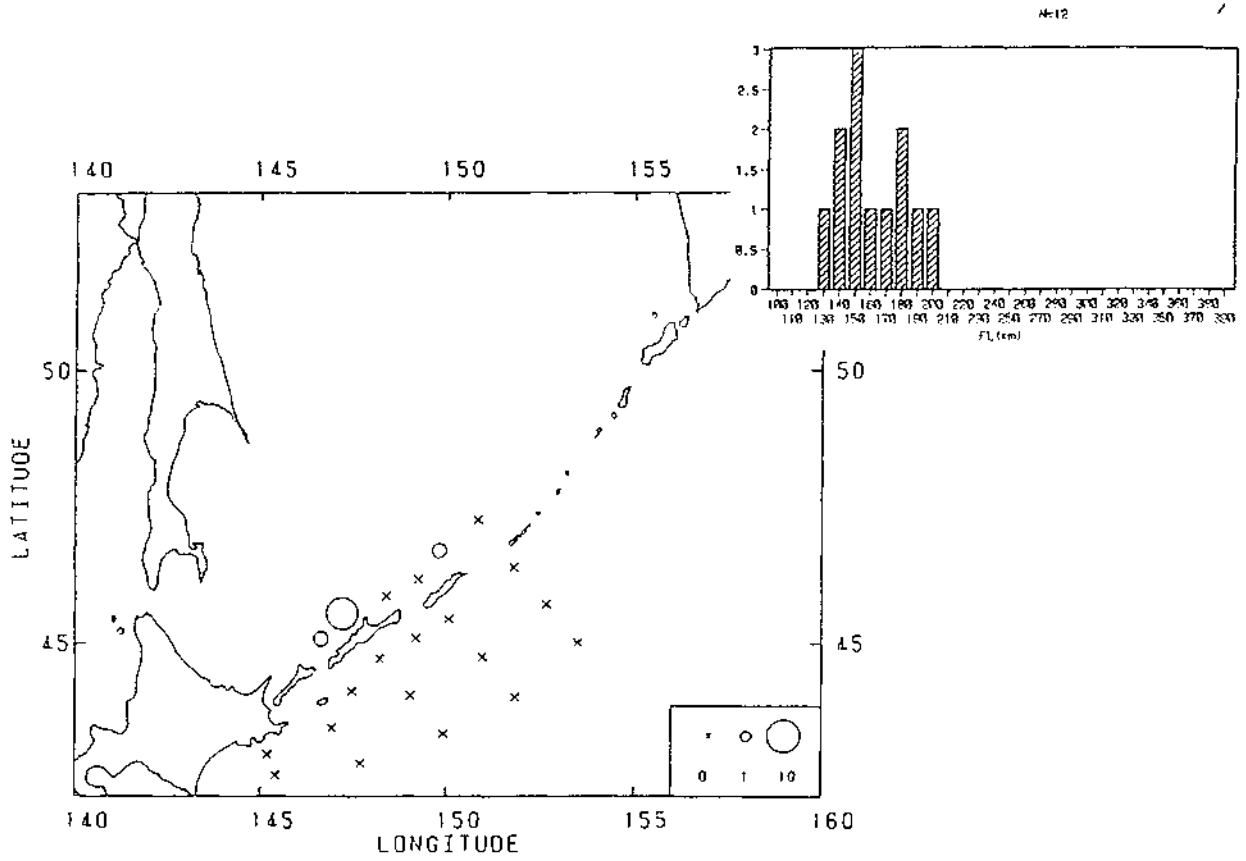


Fig. Distribution and fork length frequencies of juvenile chum salmon.

Table 1. Number of salmonids and other major animals caught by the drift-net operations (* JFS; Japanese flying squid *Todarodes pacificus pacificus*)

ST	Date	Location		SST (°C)	No. of tans	Catch												
		Lat.	Long.			Mature/	Immature	Juvenile	Saury	*JFS	Chum	Pink	Coho	Sock	Chum	Dolly	-eye	barden
1	940716	4250N	14512E	12.3	22	6	32				4	147						
2	940717	4225N	14525E	14.2	22						109	37						
3	940719	4505N	14640E	12.8	22		3			2	2141							
4	940720	4533N	14714E	13.1	22	1	10			1	8	1						
5	940721	4553N	14825E	12.5	22		21				1	71						
6	940722	4613N	14917E	11.0	22	3	24					6						
7	940724	4645N	14950E	11.6	22	3	28			2		1						
8	940725	4719N	15051E	8.7	22	15	18	1										
9	940731	4626N	15148E	4.2	22	3		1										
10	940801	4544N	15240E	10.3	22	1	1	1			375	5						
11	940802	4500N	15331E	11.9	22	2	4	2			715	2						
12	940803	4358N	15151E	14.4	22	1	3	2			375	3						
13	940804	4445N	15058E	10.1	22	1	6				3	6						
14	940726	4527N	15005E	6.2	22	2	3											
15	940730	4506N	14912E	11.0	22	3	13	6			1203	16						
16	940729	4442N	14815E	10.6	22	1	25	3			2322	121						
17	940805	4400N	14904E	16.8	22	1	1				2	12						
18	940806	4315N	14955E	17.6	22						1341	74						
19	940727	4405N	14730E	9.4	22	29	54				3194	106						
20	940728	4322N	14657E	9.1	22	7	13				1081	247						
21	940807	4240N	14744E	18.0	22						17	2						
Total					462	79	259	16	1	12	2	10741	861					

Table 2. Details of juvenile chum caught by the drift net operations

ST	Date	Location		FL	BW	Mesh size of the drift net	
		-----		(mm)	(g)	(mm)	
		Lat.	Long.				
3	940719	4505N	14640E	188	67	42	
				158	40	30	
4	940720	4533N	14714E	140	27	26	
				153	29		
				149	29		
				149	28		
				158	34		
				178	51	35	
				195	77	42	
7	940721	4645N	14950E	170	44	30	
				201	82	42	
Mean				169.1	48.3		

Salmon with Missing Adipose Fin Collected by Japanese Salmon Research Vessels in 1994

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Abstract

Seventy-four steelhead trout, 1 pink and 3 coho salmon with missing adipose fin were found by Japanese salmon research vessels in 1994. The percentage of steelhead trout with missing adipose fin (30.5% of the total steelhead catch) was higher in 1994 than in the previous two years (21.9% in 1992; 26.1% in 1993).

Introduction

Salmon hatcheries in North America have released a lot of salmon juveniles with coded wire tag (CWT) to investigate juvenile ecology and interception by fisheries. Adipose fin of coded-wire tagged fish were usually clipped to be found out easily. This report summarizes information on salmon with missing adipose fin collected by Japanese salmon research vessels in the North Pacific Ocean in 1994.

Material and Methods

Four salmon research vessels (except the *Wakashio maru* in the Okhotsk Sea) caught 25,236 salmonids in the western North Pacific, Bering Sea, and Gulf of Alaska in 1994, using biological measurements, fish were examined whether an adipose fin was missing or not. If an adipose fin was missing, a snout sample was collected from the fish for later examination of CWT.

Results and Discussion

Seventy-four steelhead trout, 1 pink and 3 coho salmon with missing adipose fin were found by Japanese salmon research vessels in 1994. The percentage of steelhead trout with missing adipose fin (74/243; 30.5% of the total steelhead catch) was higher in 1994 than in the previous two years (21.9% in 1992, 26.1% in 1993; Ito and Ishida 1992, 1993). Eight steelhead trout with missing adipose fin were caught in waters west of 180° (Table 1).

References

- Ito, S. and Y. Ishida. 1992. Steelhead trout with missing adipose fin collected by Japanese salmon research vessels in 1992. Salmon Report Series 36:89-92. National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka 424, Japan.
- Ito, S. and Y. Ishida. 1993. Steelhead trout with missing adipose fin collected by Japanese salmon research vessels in 1993. Salmon Report Series 37:90-93. National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka 424, Japan.

Table 1. Catch location and biological data for salmon with missing adipose fin caught by Japanese salmon research vessels in 1994.

Date	Location	Length	Weight	Sex	Gonad Weight	Vessel Code	Gear	Sample No.	Species Code
7-01	49-59N, 151-00W	538	1610	M	10	R05	A115	61-02	7
7-01	49-59N, 151-00W	530	1720	M	3	R05	C093	70-13	7
7-02	50-00N, 145-59W	630	3400	M	40	R05	A115	77-02	4
7-02	50-00N, 145-59W	684	3500	F	29	R05	A115	78-24	7
7-02	50-00N, 145-59W	480	1100	M	3	R05	C106	87-17	7
7-02	50-00N, 145-59W	726	4500	F	34	R05	C157	90-06	7
7-02	49-59N, 144-58W	490	2880	F	78	R05	C055	94-02	3
7-03	51-00N, 145-00W	580	2620	M	14	R05	A121	106-17	4
7-03	51-00N, 145-00W	324	350	M	1	R05	C072	111-07	7
7-03	51-00N, 145-00W	320	300	M	1	R05	C072	111-08	7
7-03	51-00N, 145-00W	330	400	M	1	R05	C082	112-20	7
7-04	51-59N, 145-00W	330	320	F	1	R05	C063	124-05	7
7-05	52-59N, 144-59W	326	380	M	1	R05	C072	136-10	7
7-08	56-00N, 145-00W	558	2270	F	36	R05	A115	180-01	4
7-17	47-30N, 170-01E	590	2100	M	10	R06	A121	3-19	7
7-17	47-30N, 170-01E	830	12100	M	50	R06	C138	15-02	7
7-18	46-00N, 170-03E	540	1500	F	2	R06	C106	20-10	7
7-31	47-30N, 175-31E	576	2220	M	7	R06	C138	61-14	7
7-31	47-30N, 175-31E	580	2180	F	16	R06	C138	61-15	7
8-01	47-59N, 173-28E	580	2100	M	10	R06	A115	63-12	7
8-01	47-59N, 173-28E	572	2100	M	10	R06	A115	63-13	7
8-01	47-59N, 173-28E	616	2660	M	10	R06	C048	66-01	7
7-19	47-00N, 165-00E	554	1650	M	1	R08	A115	151-13	7
6-24	44-30N, 179-30W	572	1820	M	8	R32	B000	17-26	7
6-24	44-30N, 179-30W	574	2100	F	13	R32	B000	18-12	7
6-24	44-30N, 179-30W	558	1880	F	15	R32	B000	18-13	7
6-24	44-30N, 179-30W	590	1980	M	5	R32	B000	18-14	7
6-25	44-30N, 179-30W	540	1540	M	2	R32	A115	22-02	7
6-25	44-30N, 179-30W	600	1740	M	3	R32	A115	22-03	7
6-25	44-30N, 179-30W	560	1640	M	2	R32	A115	22-04	7

Table 1. Continued.

Date	Location	Length	Weight	Sex	Gonad Weight	Vessel Code	Gear	Sample No.	Species Code
6-25	44-30N, 179-30W	581	2200	M	2	R32	C121	23-01	7
6-25	44-30N, 179-30W	580	1900	F	5	R32	C121	23-02	7
6-25	44-30N, 179-30W	576	1850	F	5	R32	C121	23-04	7
6-25	44-30N, 179-30W	561	1850	F	16	R32	C121	23-05	7
6-25	44-30N, 179-30W	570	1880	M	2	R32	C106	25-02	7
6-25	44-30N, 179-30W	530	1560	F	3	R32	C093	27-01	7
6-25	44-30N, 179-30W	560	1600	F	15	R32	C093	27-02	7
6-25	44-30N, 179-30W	566	1720	M	5	R32	C093	27-03	7
6-25	45-30N, 179-30W	548	1700	M	5	R32	B000	33-13	7
6-25	45-30N, 179-30W	682	3250	F	43	R32	B000	33-22	7
6-26	45-30N, 179-30W	570	1720	M	62	R32	A115	36-01	7
6-26	45-30N, 179-30W	644	2550	F	22	R32	A115	36-02	7
6-26	45-30N, 179-30W	536	1600	F	4	R32	A115	36-03	7
6-26	45-30N, 179-30W	540	1620	M	1	R32	A115	36-04	7
6-26	45-30N, 179-30W	540	1540	M	2	R32	A115	36-05	7
6-26	45-30N, 179-30W	594	1920	F	3	R32	A115	36-06	7
6-26	45-30N, 179-30W	638	2330	M	5	R32	A115	36-07	7
6-26	45-30N, 179-30W	678	1680	M	4	R32	A115	36-15	7
6-26	45-30N, 179-30W	544	1600	F	13	R32	A115	36-16	7
6-26	45-30N, 179-30W	590	2010	F	5	R32	C121	39-09	7
6-26	45-30N, 179-30W	586	1930	F	13	R32	C121	39-10	7
6-26	45-30N, 179-30W	550	1750	M	7	R32	C121	39-11	7
6-26	45-30N, 179-30W	564	1780	M	8	R32	C121	39-12	7
6-26	45-30N, 179-30W	460	1650	M	3	R32	C106	40-04	7
6-26	45-30N, 179-30W	600	2200	M	13	R32	C106	40-05	7
6-26	45-30N, 179-30W	552	1750	M	18	R32	C093	41-01	7
6-26	45-30N, 179-30W	580	2100	F	18	R32	C093	41-02	7
6-26	45-30N, 179-30W	554	1720	F	14	R32	C138	42-05	7
6-26	45-30N, 179-30W	666	1980	F	12	R32	C082	44-12	7
6-27	46-30N, 179-30W	554	1900	M	2	R32	C093	52-20	7
6-27	46-30N, 179-30W	558	1640	M	2	R32	A115	53-11	7

Table 1. Continued.

Date	Location	Length	Weight	Sex	Gonad Weight	Vessel Code	Gear	Sample No.	Species Code
6-27	46-30N, 179-30W	568	1840	F	7	R32	A115	53-12	7
6-27	47-30N, 179-30W	592	2100	F	15	R32	B000	58-07	7
6-28	47-30N, 179-30W	781	5150	M	10	R32	C121	60-05	7
6-28	47-30N, 179-30W	781	4800	M	10	R32	C138	61-06	7
6-28	47-30N, 179-30W	604	2150	M	2	R32	A115	64-01	7
6-28	47-30N, 179-30W	776	4950	M	7	R32	A115	64-02	7
6-28	47-30N, 179-30W	688	3300	F	10	R32	A115	64-03	7
6-28	47-30N, 179-30W	582	2050	M	2	R32	A115	64-04	7
6-28	47-30N, 179-30W	618	2200	M	2	R32	A115	64-05	7
6-28	47-30N, 179-30W	508	1860	F	12	R32	A115	64-06	7
6-28	47-30N, 179-30W	672	3150	M	5	R32	A115	64-07	7
6-28	48-30N, 179-30W	796	5750	F	21	R32	B000	70-26	7
6-29	49-30N, 179-30W	724	3950	F	41	R32	B000	72-30	7
6-29	49-30N, 179-30W	712	3600	F	45	R32	B000	81-13	7
6-30	50-30N, 179-30W	712	3800	F	42	R32	B000	83-10	7
6-30	50-30N, 179-30W	737	3650	M	7	R32	B000	84-15	7

Vessel Code : R05=Oshoro maru, R06=Hokusei maru, R08=Hokko maru, R32=Wakatake maru

Species Code: 3=Pink salmon, 4=Coho salmon, 7=Steelhead trout

Changes in Average Size of Pink Salmon (*Oncorhynchus gorbuscha*) in the Western North Pacific Ocean and Bering Sea

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Abstract

Changes in fish density and body size of pink salmon (*Oncorhynchus gorbuscha*) were analyzed based on data collected by Japanese salmon research vessels in the western North Pacific (45° N-51° N, 164° E-166° E) and Bering Sea (55° N-59° N, 175° E-175° W) between July 1 and 15 from 1972 to 1993. Average catch-per-unit-effort (CPUE) of pink salmon was higher in odd years than in even years in both regions. Pink salmon in odd years showed a significant negative correlation between average body weight and CPUE, although pink salmon in even years did not show such a relationship. These results suggest that there is a density-dependent component to the causes of the growth variation of pink salmon in the western North Pacific and Bering Sea.

Introduction

Annual pink salmon (*Oncorhynchus gorbuscha*) catches in Asia have exhibited periodic fluctuations. The average total catch of pink salmon during 1960 to 1971 was 84 million fish in odd years and 43 million in even years (Takagi et al. 1981). The purpose of this paper is to describe changes in average size of pink salmon in the western North Pacific Ocean and Bering Sea and to examine the relationship between size and fish density.

Materials and Methods

Data collected by Japanese salmon research vessels in the western North Pacific (45° N-51° N, 164° E-166° E) and Bering Sea (55° N-59° N, 175° E-175° W) between July 1 and 15 from 1972 to 1993 were analyzed. Catch-per-unit-effort (CPUE) is calculated as the number of fish caught by 30-tan non-selective gillnets (Takagi et al. 1975). Average fork length and body weight were also calculated.

Results and Discussion

Mean CPUEs of pink salmon caught in odd years were similar in the western North Pacific (121.9) and Bering Sea (125.9). Mean CPUEs in even years were 42.1 and 5.7, respectively, much lower than in odd years. The body size of pink salmon in the western North Pacific was smaller in odd years than in even years. On the other hand, the body size of pink salmon in the Bering Sea was larger in odd years than in even years. Based on tagging, pink salmon in the Bering Sea are thought to originate from eastern Kamchatka and across north to the Anadyr Gulf, and pink salmon found in the western North Pacific from western Kamchatka, the northern Okhotsk coast, eastern Sakhalin, the Kuril Islands, and Hokkaido (Takagi et al. 1981). So differences in body size between odd and even years may be due to

genetic differences (Tables 1 and 2).

Pink salmon in odd years showed a significant negative relationship between body weight and CPUE ($r=-0.88$ in the western North Pacific and $r=-0.72$ in the Bering Sea), although pink salmon in even years did not show such a relationship ($r=-0.33$ and $r=-0.23$, respectively). In British Columbia waters, there is some evidence of a negative influence of salmon abundance on marine growth rates for all salmon species but pink salmon (Welch and Noakes 1993). However, the present results suggest that there is a density-dependent component contributing to the growth variation of pink salmon in the western North Pacific and Bering Sea (Figs. 1 and 2).

References

- Takagi, K. 1975. A non-selective salmon gillnet for research operations. *Int. North Pac. Fish. Comm. Bull.* 32:13-41.
- Takagi, K., K. V. Aro, A. C. Hartt, and M. B. Dell. 1981. Distribution and origin of pink salmon (*Oncorhynchus gorbuscha*) in offshore waters of the North Pacific Ocean. *Int. North Pac. Fish. Comm. Bull.* 40:195p.
- Welch, D. W., and D. J. Noakes. 1993. Trends in catch and average size of Pacific salmon in Canada, with a report on 1992 escapement levels. Document submitted to the Annual Meeting of the North Pacific Anadromous Fish Commission, Vancouver, Canada, November, 1993. 48p.

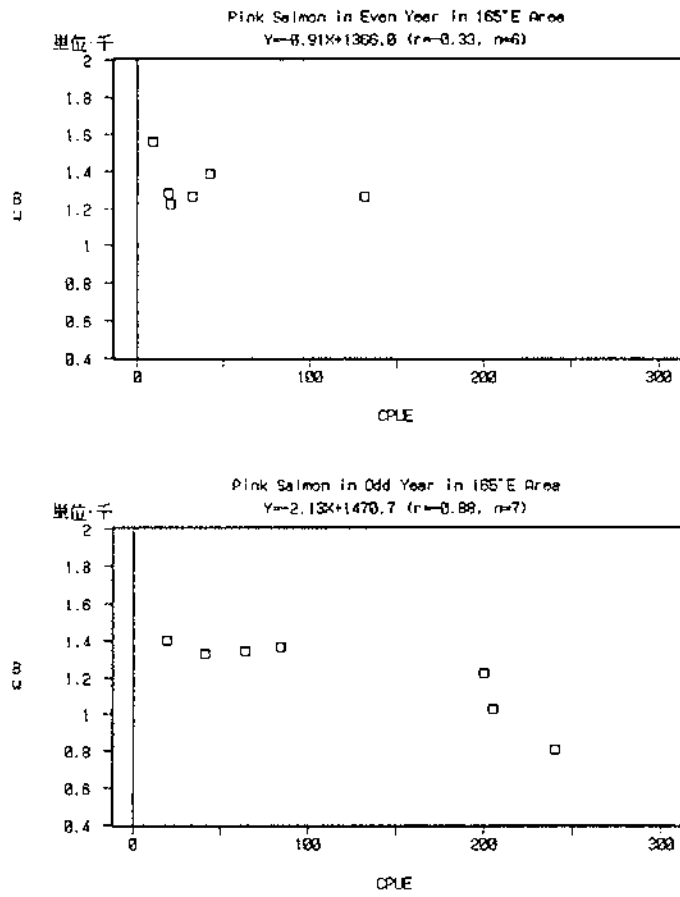


Fig. 1. Relationship between average body weight and CPUE of pink salmon in even years (top) and odd years (bottom) in the western North Pacific.

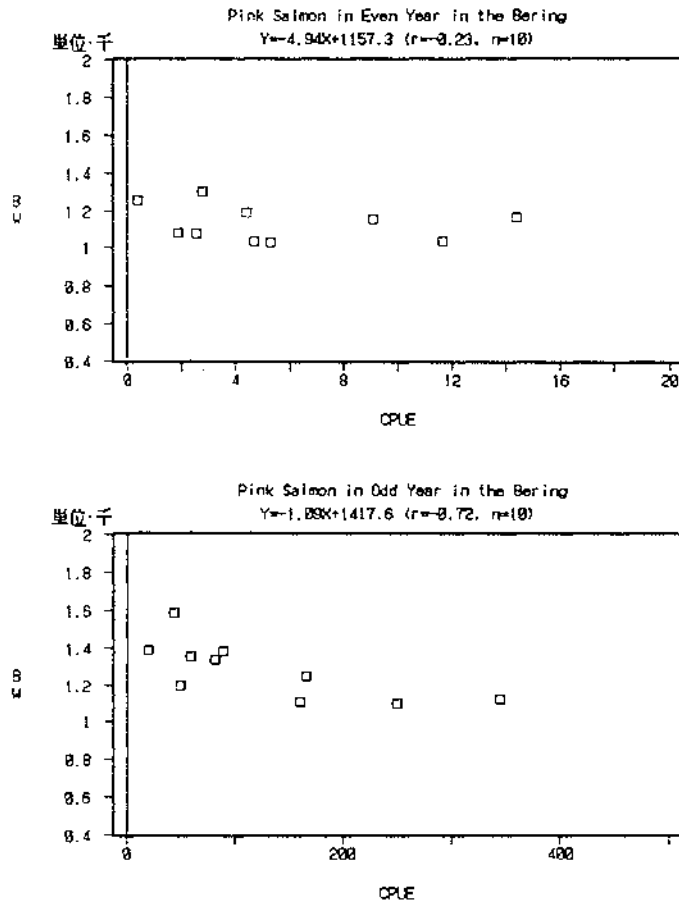


Fig. 2. Relationship between average body weight and CPUE of pink salmon in even years (top) and odd years (bottom) in the Bering Sea.

Table 1. Changes in CPUE, fork length, and body weight of pink salmon in the Bering Sea.
 CPUE=number of fish / 30 tan of research gillnet
 FL=fork length in mm
 BW=body weight in g
 N=number of fish measured

Year	CPUE	FL	BW	N
1974	0.4	447.2	1252.0	5
1975	58.2	473.5	1351.4	284
1976	4.4	456.4	1187.7	22
1977	43.5	488.7	1589.5	479
1978	14.4	454.0	1164.3	287
1979	49.6	463.1	1195.8	403
1980	2.8	472.7	1295.8	12
1981	165.8	463.1	1241.7	455
1982	1.9	454.7	1081.9	27
1983	80.8	477.4	1334.4	513
1984	4.7	436.9	1028.8	107
1985	19.1	473.5	1388.2	266
1986	5.3	440.3	1024.1	54
1987	88.5	472.6	1381.2	1087
1988	2.6	447.8	1074.2	12
1989	249.2	448.6	1095.7	1574
1990	11.7	441.2	1033.8	139
1991	344.3	449.4	1122.3	1764
1992	9.1	450.2	1147.4	99
1993	159.8	448.7	1105.9	1311
Mean				
1974-1993	65.8	458.0	1204.8	
Even year	5.7	450.1	1129.0	
Odd year	125.9	465.9	1280.6	

Table 2. Changes in CPUE, fork length, and body weight of pink salmon in the western North Pacific.
 CPUE=number of fish / 30 tan of research gillnet
 FL=fork length in mm
 BW=body weight in g
 N=number of fish measured

Year	CPUE	FL	BW	N
1972	9.0	486.4	1556.7	9
1973	64.1	473.9	1336.1	212
1974	18.0	471.5	1278.3	36
1975	205.0	442.5	1028.2	204
1976	-	-	-	-
1977	239.8	408.6	805.8	436
1978	-	-	-	-
1979	-	-	-	-
1980	-	-	-	-
1981	-	-	-	-
1982	32.0	461.7	1260	32
1983	-	-	-	-
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	84.0	468.9	1363.8	162
1988	19.5	451.8	1222.7	22
1989	41.2	471.8	1326.9	137
1990	42.0	474.6	1388.5	54
1991	200.3	454.0	1220.5	210
1992	132.0	458.2	1259.6	527
1993	18.8	476.6	1398.8	111
Mean				
1972-1993	85.1	461.6	1265.1	
Even year	42.1	467.4	1327.6	
Odd year	121.9	456.6	1211.4	