FOURTH ANNUAL CONFERENCE OF THE PARTIES TO THE CONVENTION ON THE CONSERVATION AND MANAGEMENT OF POLLOCK RESOURCES IN THE CENTRAL BERING SEA

NOVEMVER 8~NOVEMBER 12
PUSAN, REPUBLIC OF KOREA

Results from the 1999 Echo Integration and Midwater Trawl Survey on the Bering Sea Walleye Pollock by the *R/V Tamgu 1*

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Introduction

The National Fisheries Research and Development Institute (NFRDI) conducted an echo-integration midwater trawl survey of walleye pollock from the Bogoslof Island area to the Donut Hole area in the Bering Sea by the Korean *R/V Tamgu 1* during May~June 1999. The purposes of the survey were to grasp the biomass estimates, horizontal/vertical distribution and biological composition of walleye pollock and to understand oceanographic structure including the distribution water temperature in the Bering Sea.

The itinerary of the *R/V Tamgu 1* was as follows;

4 May~12 May : Navigation from Pusan to Dutch Harbor
13 May~14 May : Inport Dutch Harbor and supplies
15 May~22 May : Transfer to the Captain's Bay for standard sphere calibration
23 May~17 June : Acoustic-midwater trawl surveys from the Bogoslof Island area to the Donut Hole
18 June~24 June : Navigation from the Bering Sea to Pusan

Materials and Methods

Research vessel and fishing gear

The *R/V Tamgu 1* is a stern trawler with 90.2 m long and 2,550 gross tonnage built in December 1998. Midwater trawl was employed to identify the detected echosigns and to collect biological samples. The codend mesh size of midwater trawl fishing gear was 10 cm. Both headrope and footrope lengths were 53.2 m, respectively.

Survey area and oceanographic observations

The survey areas in the Bering Sea were covered from the Bogoslof Island area to the Donut Hole area (Fig. 1). A total of 40 oceanographic research stations were selected to understand oceanographic structure. Water temperature and salinity profile data were collected from surface to 500m in the 40 oceanographic research stations with a CTD system. Bongo net was used for collection of plankton samples at 100 m layer in each stations. Seawater samples for chlorophyll *a* determination were collected from the surface to 400 m layer with a Losette Sampler.

Echo intergration

Scientific quantitative echo-sounding system, Simard EK 500, was used in acoustic data collection. Data from the SIMRAD EK 500 sounder were stored and processed using a SIMRAD BI 500 Integrator with the graphic workstation, SUN sparc 5 workstation compatible with the SUN workstation, installed an echo integration and target strength data analysis software.

Since the high dense aggregation of spawning stock of walleye pollock was known to be taken place in the Bogoslof Island area during the winter, transects were spaced 20 and 10 nautical miles apart in parallel

north-southward and 50 nautical miles apart in the other areas.

The survey cruise was started from near Dutch Harbor and proceeded to the westwards with speeds of 10~12 knots. Echo integration outputs were logged each 5 nautical miles during the survey.

Midwater trawl and biological sampling

Midwater trawl hauls were made to identify fish species and biological sampling at the selected location where a good echosign was encountered in day time (Fig. 1). The towing hours and speeds were about 30~60 minutes and 4 knots. In each trawl haul, all species caught were counted and weighed. Samples of walleye pollock were treated to analyze sex ratio, maturity stage, fork length and body weight. Lengths were measured on the measuring board with a caliper scaling in 1 mm and body weight was scaled in gram.

Results

Standard sphere calibration

Calibration procedures were conducted in the Captain's Bay. The values of the split beam target strength were corrected repeatedly to find the known value of -33.6 dB and the TS transducer gain parameter. The values of the echo integration for the sphere were corrected repeatedly to find the value identical to the theoretical value and the S_V transducer gain parameter. Transducer beam pattern characteristics (longitudinal offset, transversal offset and 3 dB beam width of the beam) were used to obtain the values from EKLOBES software. Calibration results and overall system parameters were presented in Table 1.

Oceanographic conditions

The surface water temperature was 3.5 ℃~5.6 ℃ in the whole survey areas. It was higher than 4.0 ℃ in the Bogoslof Island area and lower than 4.0℃ in the Donut Hole area. There was a cold water mass of 1.0 ℃~3.0 ℃ at the 50~180 m layer from the Donut Hole area through the Bogoslof Island area (Fig. 2). It can be suggested that the cold water mass is moved from northwestern area through southeastern area in the Bering Sea. It may also influence the distribution of walleye pollock in the Central Bering Sea.

Salinity was fluctuated from 33.0 PSU to 34.0 PSU in the survey area (Fig. 2). Vertical distribution of salinity ranged from 33.1 to 33.5 PSU at the 100 m~200 m layer.

The highest values of chlorophyll *a* was shown around the Continental Shelf area in the vicinity of 170° ~173° W and 56° N. In the Bogoslof Island area it was about 1.5 *mg/l* and 3.0 *mg/l* in the Donut Hole area (Fig 3).

From the results of fish larvae identification it is considered that most of larvaes were classified to pollock larvae. It was higher at St. 8 of 8,916 *ind./1000* m^3 in the Bogoslof Island area and lower at St. 30~40 of 2,089 *ind./1000* m^3 in the Donut Hole area (Fig. 4).

Catch and CPUE

A total of 8 hauls were made in the cruise; 4 hauls in the Bogoslof island area 3 hauls in the Continental Shelf area and one haul in the Donut Hole area. The total catch and Catch Per Unit Effort (CPUE ; kg/hour) of walleye pollock was 4,058 kg and 624.9 kg.

Size compositions

Fork length compositions of walleye pollock were described in Figure 5. Three modes of 39 cm, 47 cm and 55 cm in FL were shown in the Bogoslof Island area and two modes of 38 cm and 46 cm in the Continental Shelf area. The large sized group, over 50cm, were caught in the Bogoslof Island area. The mean fork lengths of female and male were 51.3 cm and 47.5 cm in the Bogoslof Island area. However it was shown as almost same fork length between female and male in the Continental Shelf area.

The patterns of weight compositions of pollock were similar with the fork length compositions (Fig. 6). The mean body weights of female and male were 940 g and 763 g in the Bogoslof Island area. In the Continental Shelf area it was smaller than that in the Bogoslof Island area.

Relationships between fork length and body weight by area were expressed as follows;

Female of Bogoslof Island area : $BW = 0.0075 \times L^{2.966}$ (r^2=0.92)

Male of Bogoslof Island area : $BW = 0.0085 \times L^{2.940}$ (r^2=0.94)

Female of Continental Shelf area : $BW = 0.022 \times L^{2.685}$ (r^2=0.94)

Male of Continental Shelf area : $BW = 0.0159 \times L^{2.754}$ (r^2=0.92)

where, L is fork length in cm and W is body weight in g.

Relative density (S_a) and biomass estimation

Echo integrator output, S_a, was reintegrated with a Sv threshold of -69 dB currently used in the Alaska Fisheries Science Center. To convert S_a into absolute density, the above equations were used in length-target strength relationship.

Relative density (S_a) distribution of pollock was presented in Figure 7. Higher density was observed along the slope and margin of the Continental Shelf. Dispersed and poor echosigns were generally appeared in the other

areas.

The results of estimated biomass of pollock was shown in Table 2. Biomass of pollock in the whole survey areas was 416,700 mt. For the Bogoslof Island area, biomass and density (mt/n.mile^2) was 84,600 mt and 9.5 mt which is increased to 6.3 times in density compared to that of 1997 (Table 3).

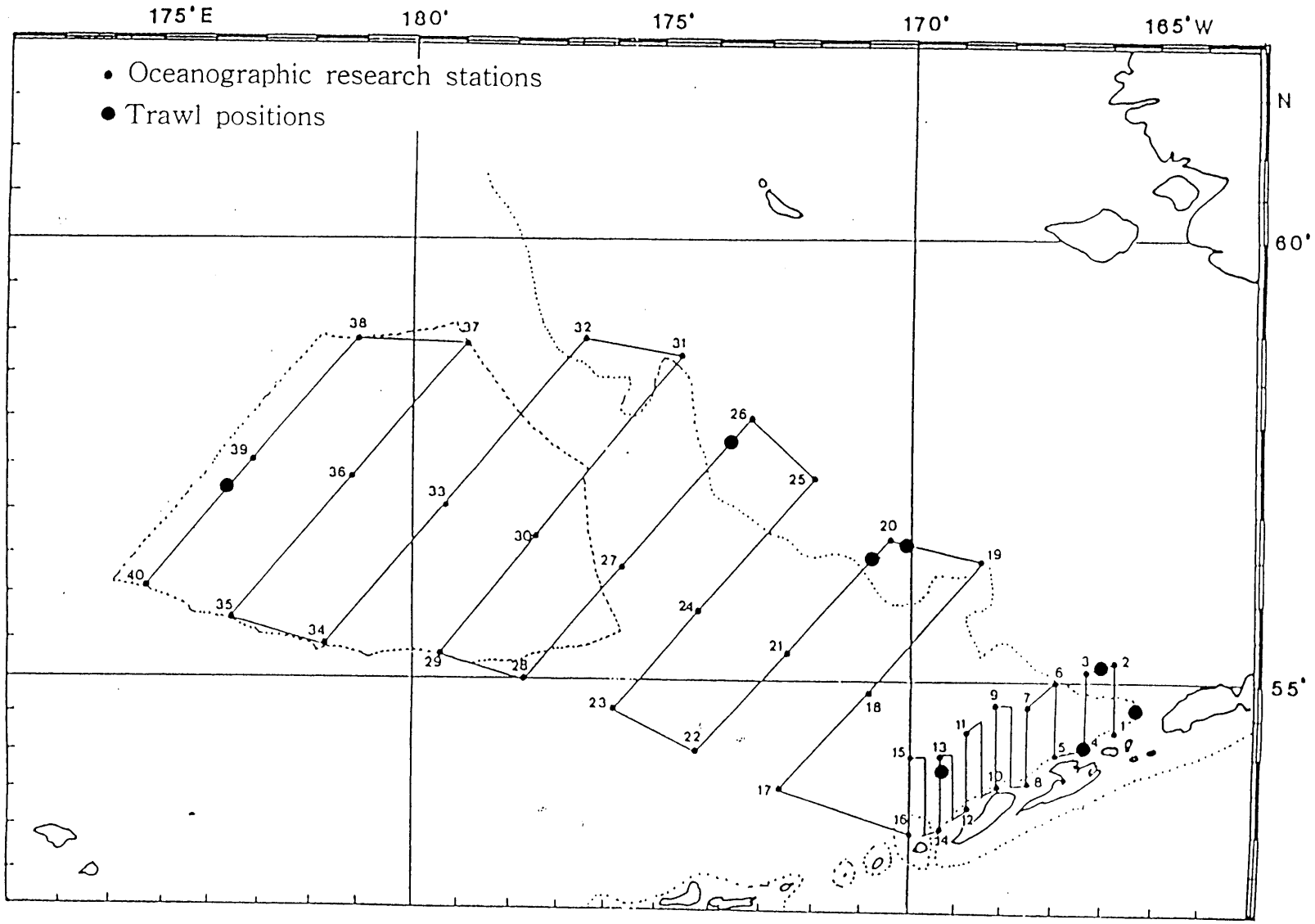

Fig. 1. Track lines and oceanographic research stations for EIMWT survey on the Bering Sea walleye pollock by Korean *R/V Tamgu 1* during May-June in 1999.

Table 1. The results from the standard sphere calibration conducted in the Captain's Bay in May 15~17, 1999 for echo integration and midwater trawl survey by the *R/V Tamgu 1* in the Bering Sea

CALIBRATION REPORT EK500

VESSEL : **R/V TAMGU 1** DATE : May 15~17, 1999
PLACE : **CAPTAIN BAY** BOTTOM DEPTH : 59.8 M
SST : 3.7 ℃. SALINITY : 32.75 PSU. SOUND VELOCITY: 1,460 M/SEC

FREQUENCY	38	120	kH
ABSORPTION COEFFICIENT	10 dB	38 dB	dB/km
TRANSDUCER	ES38B	ES120-7	Sensor type
ANGLE SENSITIVITY	21.9	21.0	
PING INTERVAL	1.0	1.0	sec
TRANSMIT POWER	Normal	Normal	
MAX. POWER	2000	1000	W
PULSE LENGTH	Medium	Medium	
BANDWIDTH	Wide	Wide	
TS OF SPHERE	-33.6	-40.4	dB
DEFAULT TS TRANSDUCER GAIN	26.5	26.5	dB
MEASURED TS	-36.1		dB
ADJUSTED TS TRANSDUCER GAIN	**27.08**	**31.40**	dB
CALIBRATED TS	-33.6	-40.4	dB
DEFAULT EQUIVALENT 2-Way Beam Angle	-20.6	-20.8	dB
Transducer Data 2-Way Beam Angle	-20.6	-20.8	dB
Depth to Sphere	**31.8**	**33.6**	m
Default Sv Transducer Gain	26.5	26.5	dB
Theoretical Sa	2,904	545	m^2/nm^2
Measured Sa			
Calibrated Sv Transducer Gain	**26.83**	**31.07**	dB
Calibrated Sa	≒2,901	≒544	m^2/nm^2
Default -3dB Beamwidth Fore-Aft*	7.1	7.1	degrees
Default -3dB Beamwidth Athwart*	7.1	7.1	degrees
Calibrated -3dB Beamwidth Fore-Aft*	6.98	6.72	degrees
Calibrated -3dB Beamwidth Athwart*	6.84	6.67	degrees
Fore - Aft. Offset*	-0.08	-0.73	degrees
Athwartship Offset*	-0.07	-0.06	degrees

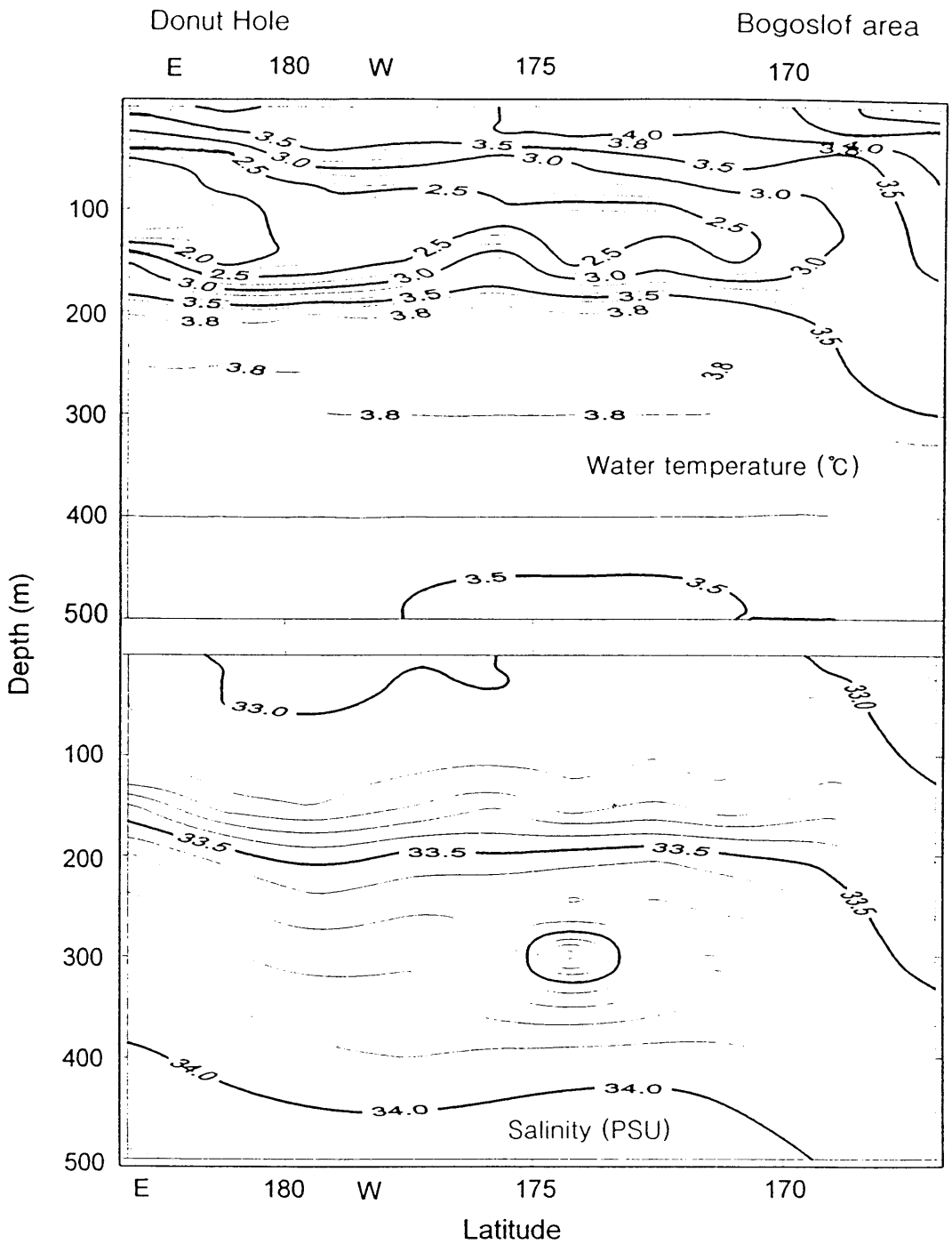

Fig. 2. Vertical distribution of water temperature (℃, upper) and salinity (PSU, lower) by depth from the survey of Tamgu 1 in the Bering Sea from May to June in 1999.

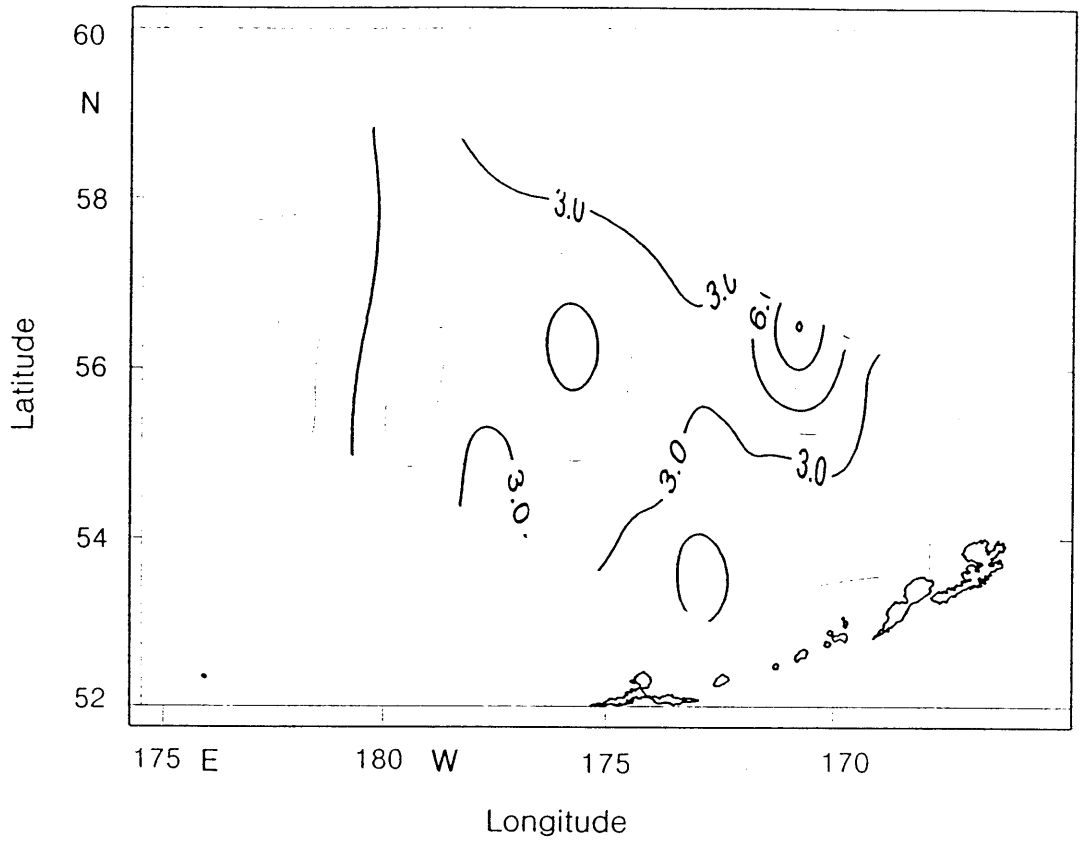

Fig. 3. Ditribution of chlorophyll a from the survey of Tamgu 1 in the Bering Sea from May to June in1999.

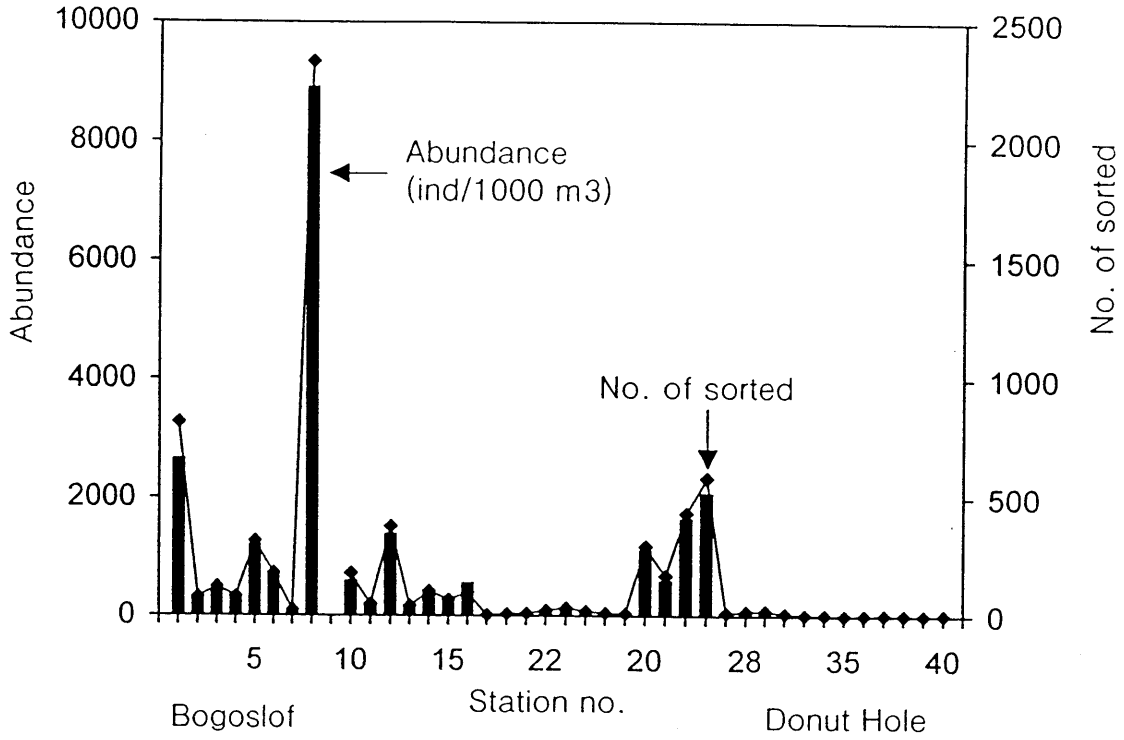

Fig. 4. Abundance of fish larvae from the survey of Tamgu 1 in the Bering from May to June in 1999.

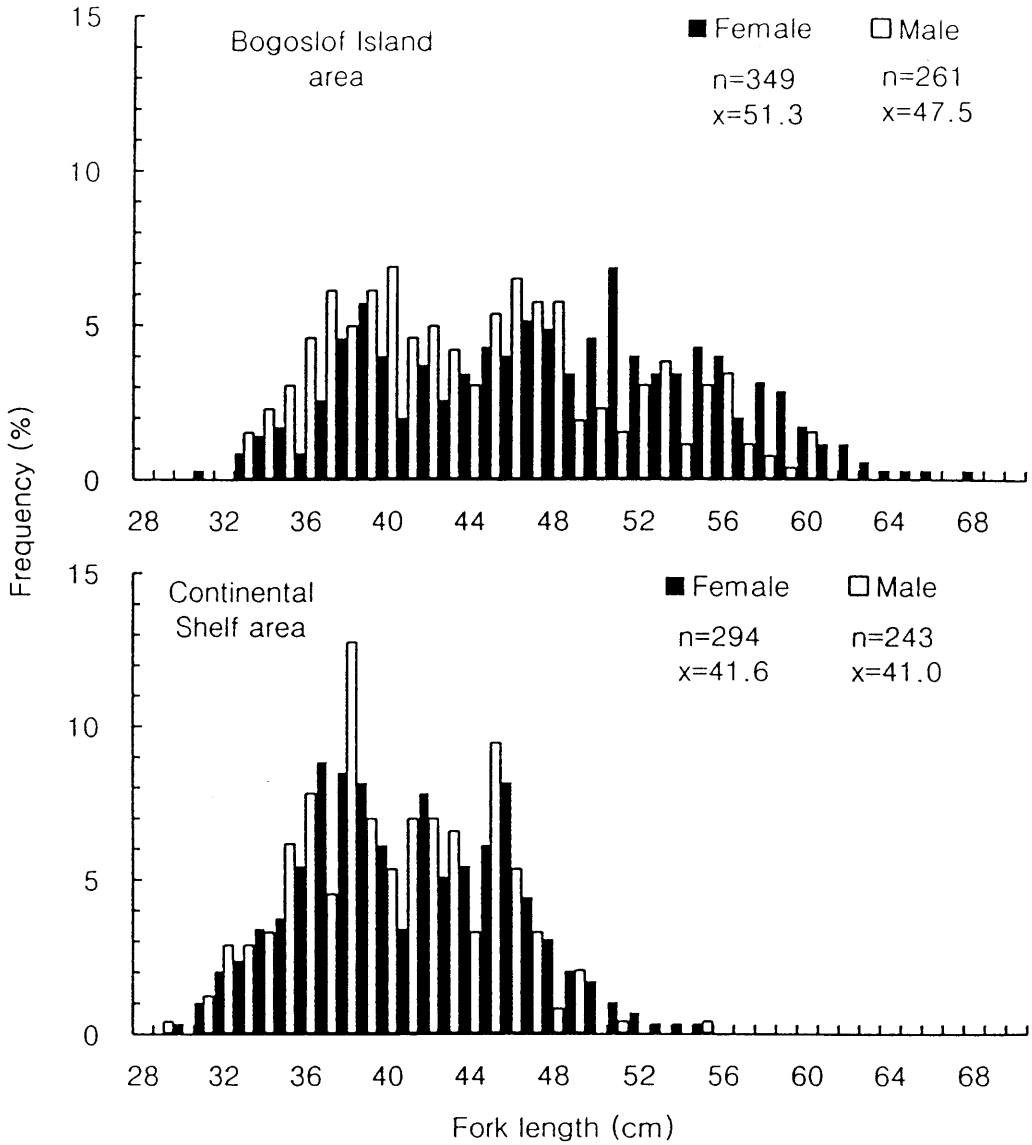

Fig. 5. Fork length composition of pollock taken from the suvey of R/V Tamgu 1 in the Bering Sea from May to June in 1999.

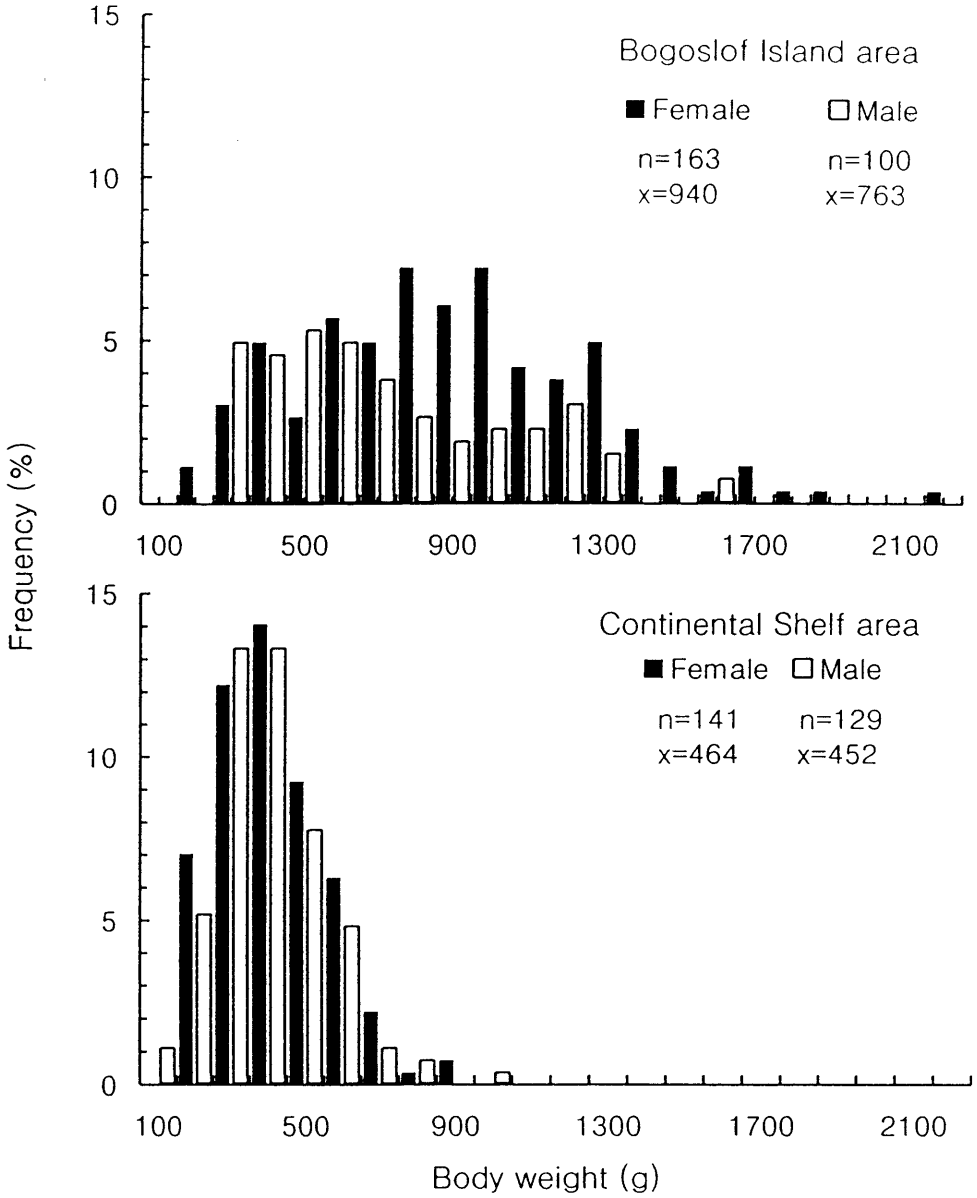

Fig. 6. Body weight composition of pollock taken from the suvey of R/V Tamgu 1 in the Bering Sea from May to June in 1999.

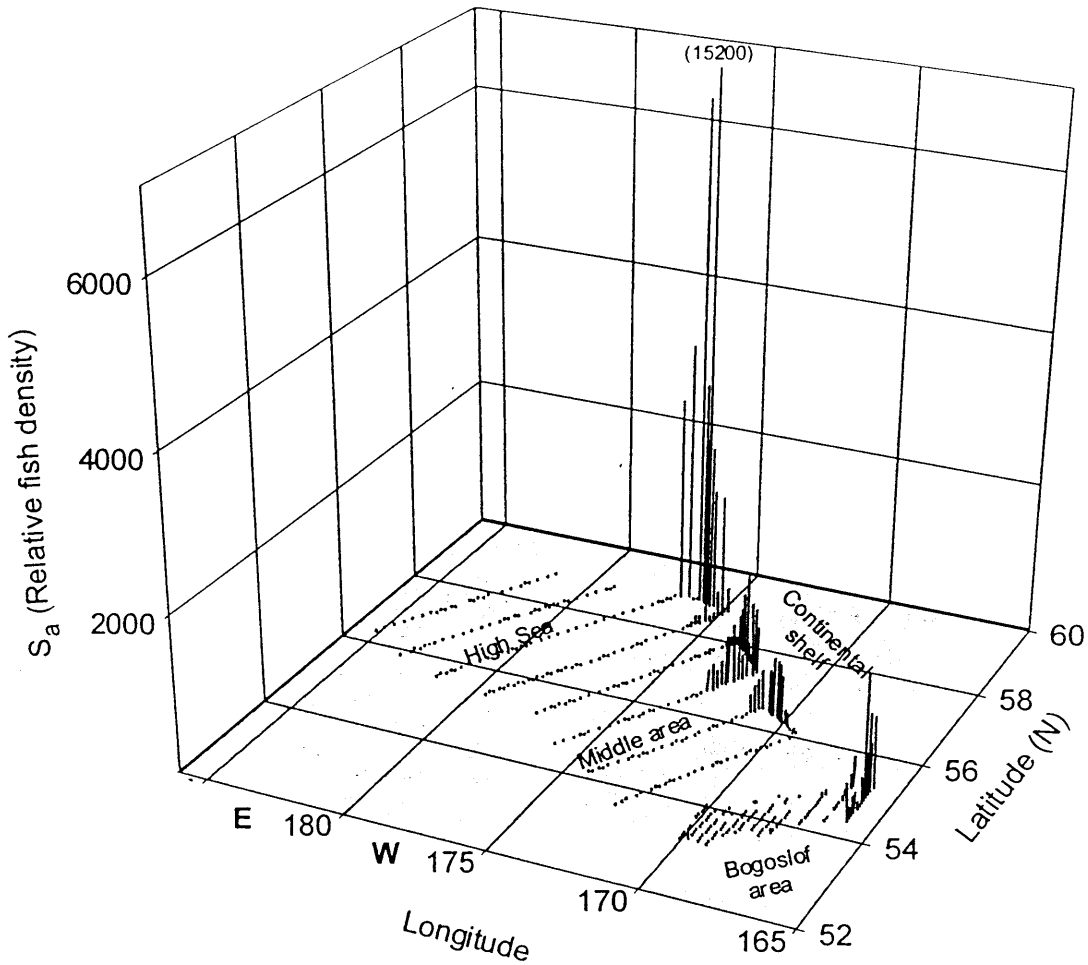

Fig. 7. Relative density of walleye pollock along the transects with the vertical histogram from the echo integration-midwater trawl survey by R/V Tamgu 1 in the Bering Sea from May to June' in1999.

Table 2. Estimated biomass of walleye pollock during the survey of *R/V Tamgu 1* in the Bering Sea during May~June in 1999

Item	Total	Bogoslof area	Other areas	(C. Shelf)
Area swept (n.mile^2)	97,625	8.875	88,750	(9,500)
Transect length (n.mile^2)	2,460	685	1,775	(180)
Mean Sa (m^2 /n.mile^2)		56.2	44.0	(410.8)
Population (x10^6)	821.8	96.9	724.9	(724.9)
Biomass (mt)	416,700	84,600	332,100	(332,100)

Table 3. Density (mt/n.mile^2) of walleye pollock during the survey of 1994~1999 by the *R/V Pusan 851 and Tamgu 1* in the Bogoslof Island area

Year	Density (mt/n.mile^2)
1994	3.5
1995	3.1
1996	2.0
1997	1.5
1998	
1999	9.5