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PELAGIC POLLOCK SURVEY BY MEANS OF  
HYDROACOUSTIC AND MID-WATER TRAWL GEARS  
ON THE ALEUTIAN BASIN IN 1979

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1. Methods of Japanese Hydroacoustic Survey

a) Survey Design

The survey of pelagic pollock carried out with echo sounder in the Aleutian Basin in 1979 was designed to be implemented also in June 1980 in succession to and more or less in the same manner and scale as the surveys executed with echo sounder and hand-lining in 1977 and with mid-water trawl and echo sounder in 1978.

The research area was determined to cover the whole of the Aleutian Basin but except of the northwest wards of the U.S.-Russia Convention line. The research trackline was designed to form an inward clockwise swirl unlike the preceding two years' surveys (Fig. 1).

The survey was designed to conduct an echo sounder scanning and, at the same time, mid-water trawl to confirm the spotted echogram and also to implement handling research several times.

b) Vessel and Gear

A Hokuten stern-trawler Shotoku maru No. 35 (349.58 GT; 3,000 HP) was chartered for the projected survey.

The mid-water trawl gear used was with specification of headrope length of 39.0 m and net length of 98.8 m. Codend (90 mm meshes) of threefold was used in order to prevent escape of small size fish. Otter door was in of 2.2 m x 3.4 m weighed 2,000 kg in water.

The five sets of fishing gears used for hand-lining conducted so as to support the mid-water trawl survey were with such a specification as shown in the Fig. 2.

The echo sounder with the frequency of 28 kHz was used for the survey operation with the sounding range fixed at 0 - 200 m and with a constant sensibility and paper speed (Table 1).

c) Sampling Procedure

The vessel cruised at a mean speed of 9.9 knots along the predetermined trackline for about 4,500 nautical miles in the Aleutian Basin, with scanning made all the time by the echo sounder. In every four hours, vessel position and meteorological and oceanographical conditions were recorded.

The trawling operations by use of gears shown in the Fig. 3 were carried out over 65 times in mid-water with a towing speed of 3.0 - 3.8 knots for 60 minutes with a view to confirming the spotted echogram and also estimation of fish density. In addition, the hand-lining survey was conducted eight times.

1) Biological Data

For the catch, the number and weight was recorded by species. As for pelagic pollock, the fork length was measured for each fish with length punch cards, and the majority of samples were brought back to the laboratory in frozen form for multi-purpose examination. Individuals whose stomach contents were collected as samples for the U.S. scientists were measured for their fork length and weight on board and divided by sex. As for other species than pelagic pollock, the total length or fork length and sex were recorded and the stomach contents were inspected by sight.

2) Oceanographical Data

The satellite navigation system equipment was used for the observation of vessel position made every four hours. In observing meteorologic and oceanographic conditions, weather, wind direction, wind power and surface temperature were recorded. Water temperature at various strata was also recorded by use of XBT conducted three times.

d) Age Determination

As for the pelagic pollock brought back to the laboratory, the fork length, weight, sex, the composition and wet weight of stomach contents and other characteristics were recorded.

Scales, to be examined for determining the age, and the otoliths were collected.

Data obtained from the survey consist of the scanning of echo sounder, numbers by species caught by mid-water trawl and length composition and age structure of pelagic pollock.

As for the consecutive records of echo sounder the echo grade and its distribution by depths was recorded at regular intervals with the frequency of the density and the upper and lower limits of such depth distribution. Further, the biomass of pelagic pollock inhabiting in the survey area was estimated by computation of the numbers per water quantity unit caught by tows of mid-water trawl against each of the density. The net opening height of the mid-water trawl net used for the survey was 26 m according to the record of a net recorder. The circumference of the net opening was calculated as 70 m with reference to the net specification (Fig. 3). The sectional dimension of the net opening is assumed to have formed elliptical shape.

## 2. Results of Japanese Hydroacoustic Survey

### a) Species Composition

The catch caught through the mid-water trawls conducted 65 times with a primary object for confirmation of the spotted echogram consist of 10 species of fish, 4 species of squids and 1 species of porpoise, totally 15 species in all. In addition, several species of jellyfish were caught, the species and numbers of which were not, however, recorded as most individuals were broken (Table 2).

For pelagic pollock, 4,996 were caught at all stations in 65 hauls, which constituted 93% of the entire catch. Next to the pelagic pollock were caught 242 of smooth lumpsucker (with a share of 5%; caught at 31 stations) and 107 of eight-armed squids (with a share of 2%; caught at 17 stations) primarily. These three species were 99% of the entire catch.

In addition, the following catch was made: pink salmon (7 at 7 stations); chum salmon (7 at 7 stations); squid tekagi-ika, 6 at 5 stations); northern smoothtongue (4 at 1 station); chinook salmon (3 at 3 stations); ragfish (3 at 3 stations); sockeye salmon (2 at 1 station); and spiny lumpsucker, Pacific lamprey, squid (tsume-ika), giant squid and porpoise (respectively 1 at 1 station).

The species composition of the catch obtained by mid-water trawl was almost identical to the survey results in 1978. In the hand-line survey conducted eight times, 481 pelagic pollock (with fork length ranging from 38 cm to 56 cm) were caught. The length composition of pelagic pollock obtained by hand-lining survey was also identical to that obtained from the survey executed in 1978.

b) Distribution and Abundance of Pollock

1) Distribution

The numbers of pollock caught by mid-water trawl operation with the spotted echogram in the Aleutian Basin were converted to numbers of pollock per 60 minutes haul and are shown in the Fig. 4 compared with the results obtained in 1978.

The above CPUE with no adjustment yet made on the difference in catch efficiency between day and night substantiates high density of pollock distribution primarily in the middle of the Basin through the Aleutian north. In the face of the time lag of almost half a month between the time of the survey in 1978 and that in 1979, the distribution of pollock was confirmed mostly in the entire Aleutian Basin.

2) Vertical Distribution

The responses of pollock were recorded from the spotted echogram shown by the echo sounder in the Aleutian Basin at depths of 10 - 140 m. The main distribution of responses was at the depths of 20 - 130 m, which was slightly shallower than those of 30 - 150 m recorded of the survey in 1978. Such changes in depth of the layer of response were observed that it was comparatively deeper in the daytime and shallower at night from sunset to sunrise. The depths over 200 m were unable to be observed.

c) Length Composition

The size composition of pollock caught by mid-water trawls in 1979 on the Basin are shown in the Fig. 5 compared with the results obtained in 1978. The fish schools with modes of 46 - 48 cm in 1979 were caught in the Basin and no difference was observed between the surveys in both years.

In the Fig. 5 are shown the data on length composition for pollock collected from catch of trawlers of the surimi mothership fleet operation carried on during June and July, a period corresponding to the period of this survey. Pollock caught by the commercial fisheries on the continental shelf showed a range in length distributions with modes of 36 - 38 cm in 1978 and 30 - 32 cm in 1979 with a trend of size becoming slightly smaller in 1979 than a year before.

d) Age and Sex Composition

The pelagic pollock caught in the Basin has not yet been given a complete analysis of assessing the age composition but is assumed to range mostly from 5 to 6 years of age with an application of the growth curve extracted for the stock on the continental shelf.

The sex ratio of pollock was 1.66 estimated from 1,813 samples of 34 - 75 cm fish, which showed a trend rather identical to that of 1.44 recorded in 1978 survey based on 2,353 samples of 40 - 50 cm length.

The sex ratios of pollock caught by bottom trawls on the continental shelf nearly at the same time as this survey were 1.14 (292 samples of 36 - 52 cm length) in 1978 and 1.23 (618 samples of 13 - 67 cm), which shows a lower ratio of male per female for pollock on the continental shelf than in the Basin.

All pelagic pollock were adults and their gonad conditions were at the stage of one or two months after spawning for both sexes, which was identical to the survey results observed in 1978.

e) Population Number and Biomass

The echo pattern observed during the survey period were almost identical to those recorded in the surveys executed in 1977 and 1978 (INPFC Docs. 1981 and 2076). It was, however, only the spotted echogram that was observed for this survey as the research area was limited to the Basin apart from the continental shelf.

The high density responses resulted in larger catches of pollock than low density responses both for day and night. The difference in catches between day and night was observed as in the case of 1978 with a larger catch in the daytime than in night.

The density of the spotted echogram and the number of catch per 60 minutes haul by mid-water trawl during the night are shown in the Fig. 6 in comparison with those results obtained in 1978. The number of catch per response density was smaller by

about a half to a third in 1979 than in 1978 caused by the difference of echo sounder performance and/or gears. There was still a positive correlation between the density of echogram and the number of pollock caught.

The height of the net opening of the mid-water trawl gear used for this survey was 26 m according to the confirmation made by a net recorder. The circumference of the net opening was calculated as 70 m in accordance with the specification shown in the Fig. 3 and the sectional dimension of the opening is assumed to have formed elliptical shape with calculated area of 363.5 square meters (Yamaguchi: 1980). Thus, the total volume swept by the net was 0.00229 cubic kilometers at the average trawling speed of 3.4 knots (ranging from 3.0 knots to 3.8 knots).

Provided that the average catch of pollock in numbers per hour dense responses by echo grade during night trawling is used as an estimated number value of pollock inhabiting per cubic kilometer, the number is about 20,000 fish per cubic kilometer for echo grade 80,000 fish per cubic kilometer for each grade 3 and 190,000 fish per cubic kilometer for echo grade 4 (Table 3).

The echo grade for thirty minutes was divided into 5 grades and the distribution was examined every two hours as recorded on the echo sounders operated on the continuous survey (INPFC Doc. 2076). The depth of distribution was obtained from the upper and lower limits of echogram depth. Of the total responses grade 1 echos constituted 57.3% (142 times), followed by grade 2 (25.8%) and grade 3 (8.9%) successively. No record was made for grade 5. In comparison with the results obtained in 1978, grade 1 and 2 echos increased while grade 3 and 4 decreased. Therefore, provided

that the ratio of estimated occurrence of each echo grade was related to the total area of the Aleutian Basin (797,453 square kilometers), the area for grade 1 and 2 was widened and, on the other hand, the area for grade 3 and 4 became narrower than in 1978 (Table 4). Such a trend observed in 1978 was reconfirmed that the higher becomes the echo grade the greater becomes the range of depth of the response: 49 m for grade 1 and 98 m for grade 5. The volume of grade 1 and 2 occupied 82.3% of the total volume (Table 4).

As a result of the foregoing survey, approximately 1,940 million pollock were estimated to inhabit in the Aleutian Basin from the beginning to the end of June in 1979 (Table 4). The biomass of the stock was estimated to amount to 1,269 thousand metric tons by using the mean weight of 654 g proved with the samples of fish caught (95% confidence limits were from 1,586 thousand metric tons to 953 thousand metric tons). Applying the same analytical approach, the biomass in the summer period in 1977 and 1978 was estimated to be 2,688 thousand tons and 5,442 thousand tons respectively (INPFC Doc. 2204). The above estimation is, however, deemed to be the most conservatively estimated values as the computation was made with the vulnerability of mid-water trawl gear constantly fixed at 1.0.

The area of the net opening, as one of the basic data for biomass estimation, was about 38% narrower in 1979 than in 1978. With the density of echo response having become 1.4 times as much as observed in 1978, there was no substantial difference between both years in the total volume in which distribution of pollock was supposed to exist.

The major reason why the estimated biomass showed a decrease in 1979 from a year before is assumed that the average density decreased to about a quarter of the value recorded in 1978 (Table 5).

As described above, the estimated biomass varies by year. It does, therefore, remain to be a critical question yet to be clarified in relation to fish schools inhabiting in the areas surrounding the Basin.

Table 1. Outline of vertical echo-sounder used during the acoustic survey and mid-water trawl of pelagic pollock on the Aleutian Basin in 1979.

Echo-sounder	
Brand	FURUNO ELECTRIC Co. LTD.
Transmitter/Transducer Receiver/Recorder	FTG-412A
Ultrasonic frequency	28 KHz
Directivity of transducer (half power beam angle)	fore-aft: 5.7°, left-right: 9.6°
Pulse length	3 milliseconds
Full gain	120 dB
Out put power	10 Kw
Depth range	0 - 200 m
Paper speed	10 mm/minute
Pulse repetition rate	45/minute
Recording paper	Moisture paper (A-21)

Table 2. Catch records of mid-water trawl on pelagic pollock survey on the Aleutian Basin in 1979.

English common name	Scientific name	Catch in Number & Percent	
Pollock	<i>Theragra chacogramma</i>	4,996	92.8
Smooth lumpsucker	<i>Aptocyclus ventricosus</i>	242	4.5
Eight-armed squid	<i>Gonatopsis borealis</i>	107	2.0
Pink salmon	<i>Oncorhynchus gorbuscha</i>	9	0.2
Chum salmon	<i>Oncorhynchus keta</i>	7	0.1
Squid	<i>Gonatus onyx</i>	6	0.1
Northern smoothtongue	<i>Leuroglossus stilbius</i>	4	0.1
Chinook salmon	<i>Oncorhynchus tsuawytshcha</i>	3	0.1
Ragfish	<i>Icosteus aenigmaticus</i>	3	0.1
Sockeye salmon	<i>Oncorhynchus nerka</i>	2	0.0
Spiny lumpsucker	<i>Eumicrotremus orbis</i>	1	0.0
Pacific lamprey	<i>Entosphenus tridentatus</i>	1	0.0
Squid	<i>Onychoteuthis borealijaponocus</i>	1	0.0
Giant squid	<i>Moroteuthis robusta</i>	1	0.0
Dall porpoise	<i>Phocoenoides dalli dalli</i>	1	0.0
Jellyfish		?	
TOTAL		5,384	100.0

Table 3. Number of pollock caught per hour trawled by echo grade and average density of pelagic pollock at night operation in 1979 survey.

Grade of echo	Number of haul	Number of pollock caught per hour trawled	Standard error	Number of pollock per 1 km <sup>3</sup>
0	0	0	0	0
1	8	45	22.49	19,651
2	6	123	14.35	53,712
3	3	186	20.73	81,223
4	3	437	11.15	190,830
5	0	0	0	0
Average		197		

Table 4. Population estimates for the pelagic pollock on the Aleutian Basin, 1978 and 1979 surveys.

Year	Grade of echo	Frequency of echo grade	Relative area of echo grade	Area of echo (km <sup>2</sup> )	Vertical range of echo (m)	Volume of echo (km <sup>3</sup> )	Number of pollock per 1 km <sup>3</sup>	Number of pollock (x 10 <sup>3</sup> )
1978	0	0	0	0	0	0	0	0
	1	30	0.088	70,176	45	3,158	30,728	97,039
	2	68	0.201	160,288	48	7,694	84,906	653,267
	3	105	0.310	247,210	55	13,597	153,369	2,085,358
	4	80	0.236	188,199	58	10,916	230,458	2,515,680
	5	56	0.165	131,580	60	7,895	318,329	2,513,207
	Total	339	1.000	797,453		43,260		7,864,551
1979	0	15	0.060	47,847	0	0	0	0
	1	142	0.573	456,941	49	22,390	19,651	439,986
	2	64	0.258	205,743	64	13,168	53,712	707,280
	3	22	0.089	70,973	86	6,104	81,223	495,785
	4	5	0.020	15,949	98	1,563	190,830	298,267
	5	0	0	0	0	0	0	0
	Total	248	1.000	797,453		43,225		1,941,318

Table 5. Comparison of parameters used for biomass estimation of pelagic pollock on the Aleutian Basin, 1978 and 1979 surveys.

Item	1978 Survey	1979 Survey
Area of net opening (m <sup>2</sup> )	589	364
Vertical range of echo (m)	45-60	49-98
Volume of echo (m <sup>3</sup> )	4,326 x 10 <sup>10</sup>	4,323 x 10 <sup>10</sup>
Average density (kg/m <sup>3</sup> )	12.58 x 10 <sup>-5</sup>	2.94 x 10 <sup>-5</sup>

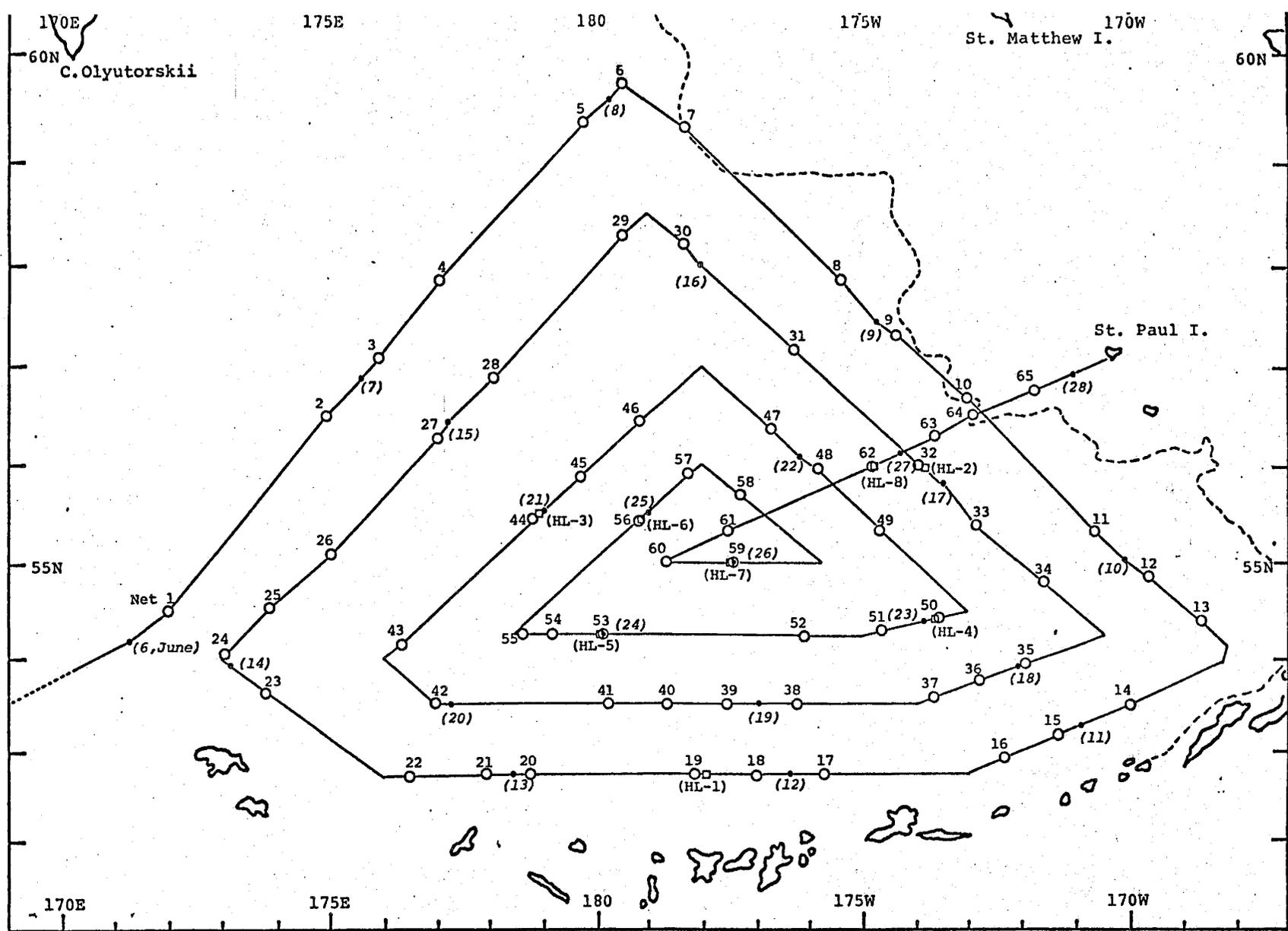


Fig. 1. Track of R/V Shotoku maru No. 35 (349.58 GRT, 3,000 HP) used for pelagic pollock survey on the Aleutian Basin in 1979.

\*Dot : Noon position, Open circle : Operation for mid-water trawl,

Square : Operation for hand line

Numeral : *Italic* - Date in Japan standard time plus 3 hours

Roman - Operation number of mid-water trawl and hand line (with parenthesis)

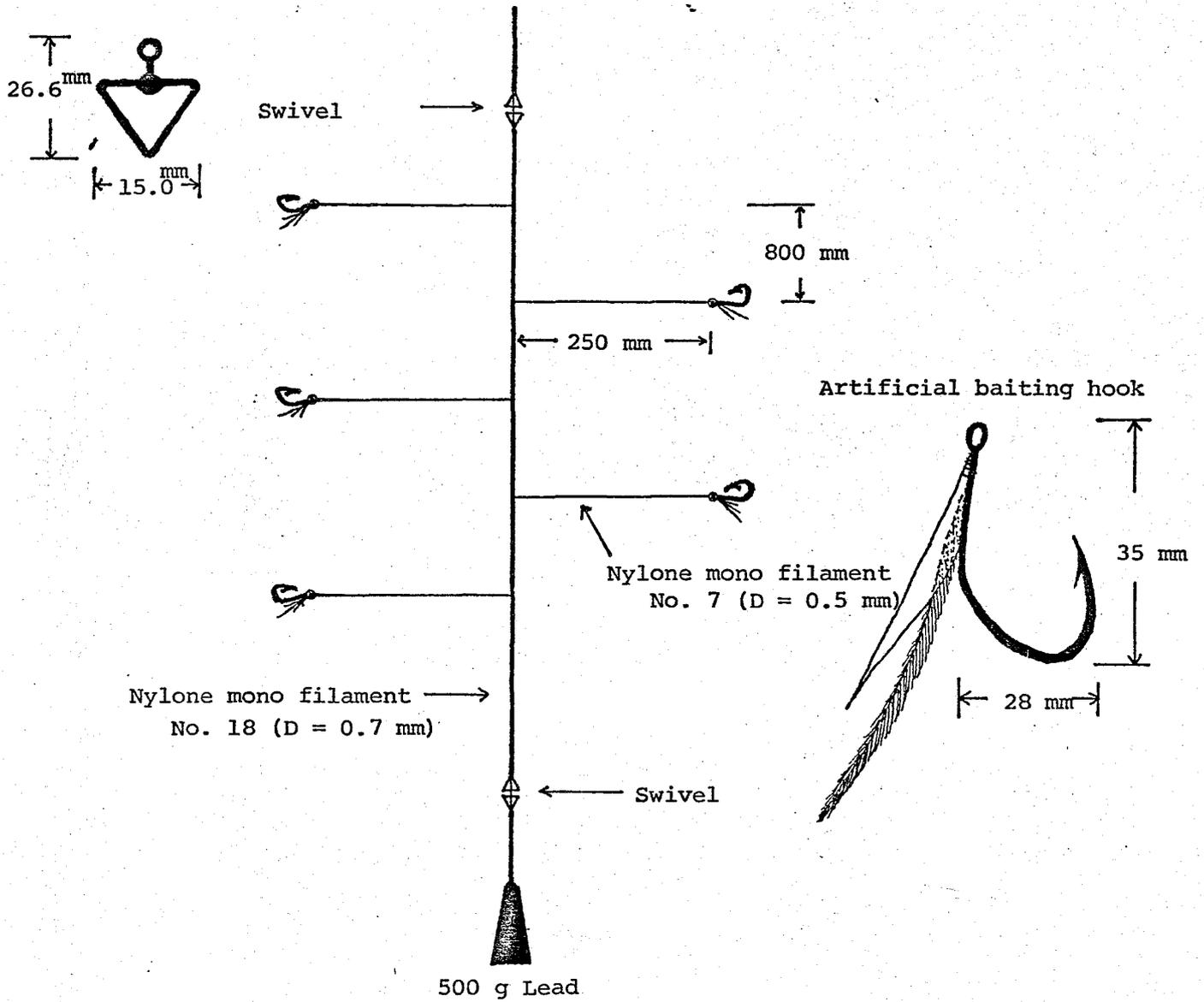


Fig. 2. Specification of hand-line used for the pelagic pollock survey on the Aleutian Basin in 1979.

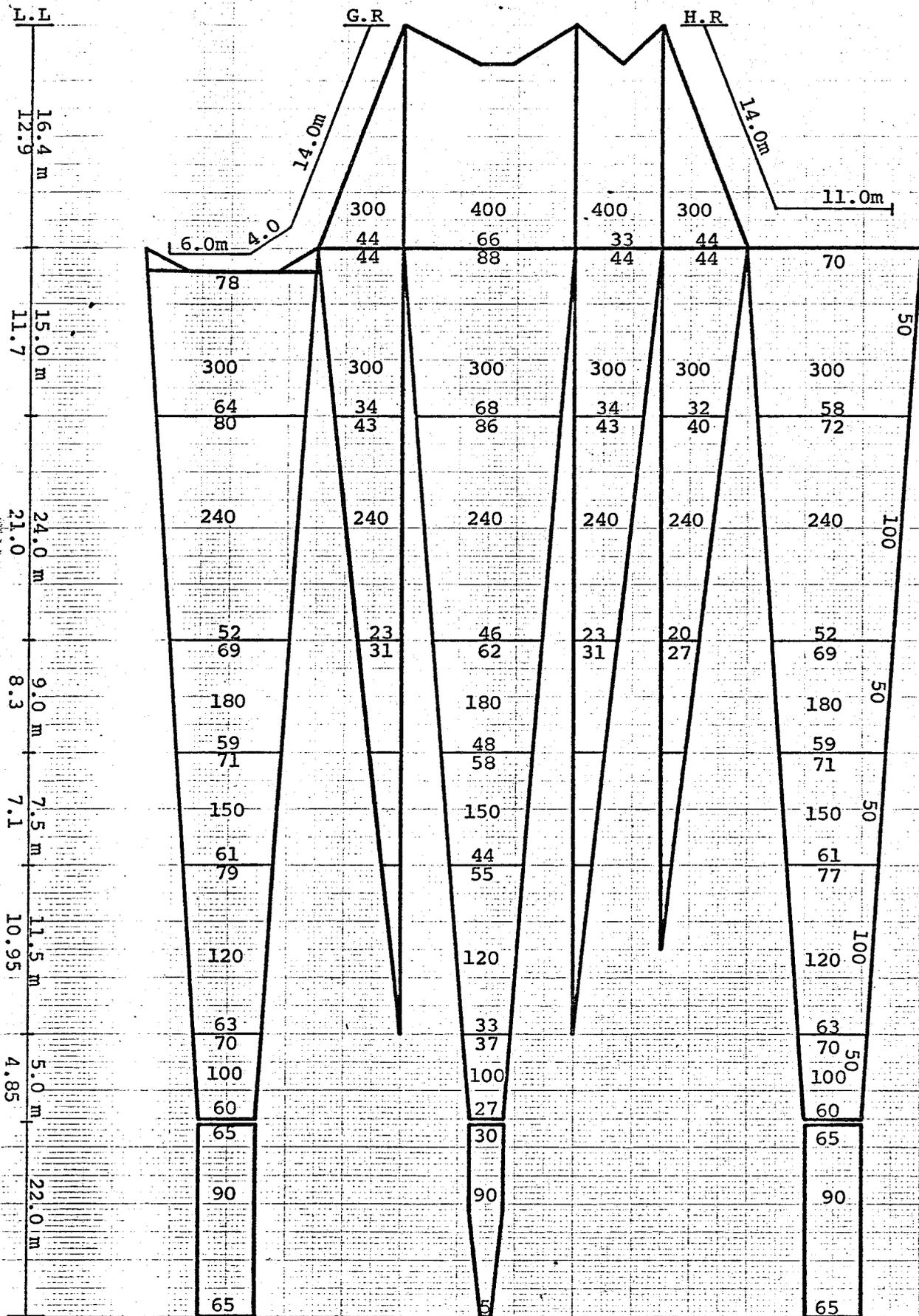


Fig. 3. Specification of mid-water trawl used for the pelagic pollock survey on the Aleutian Basin in 1979.



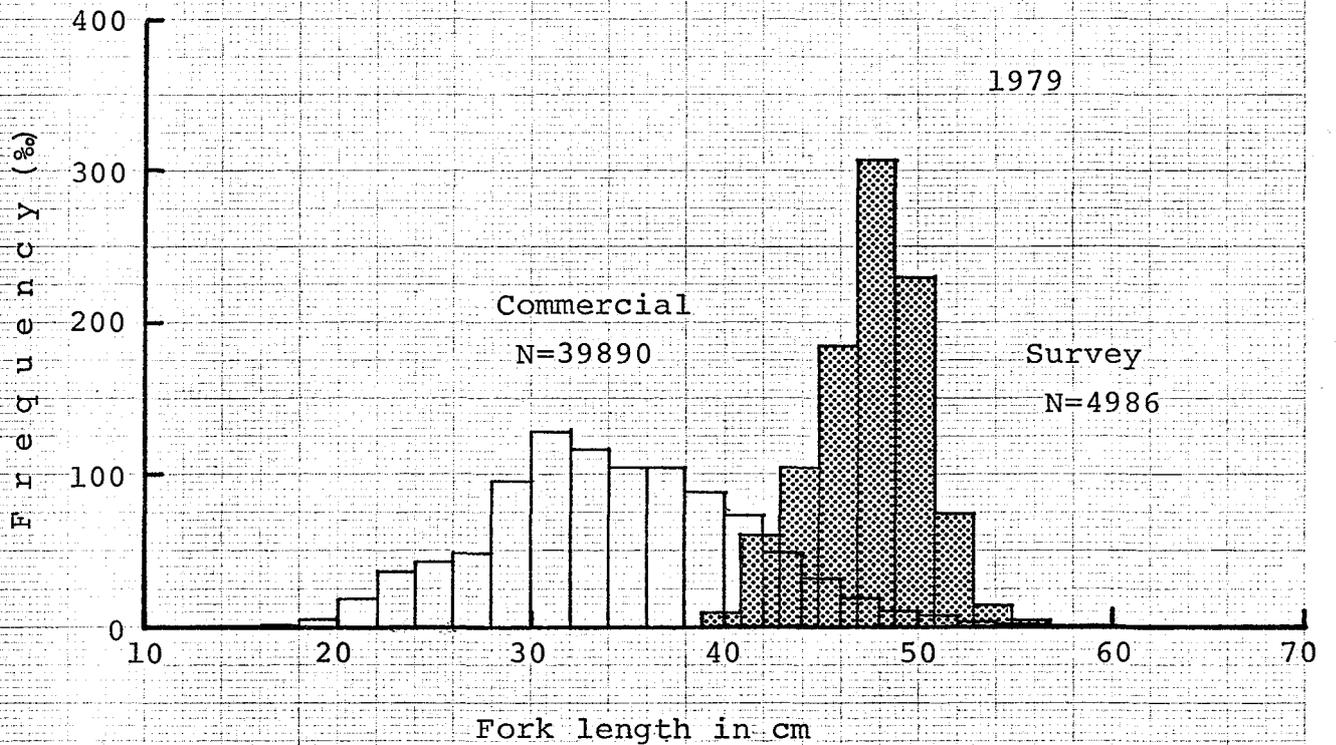
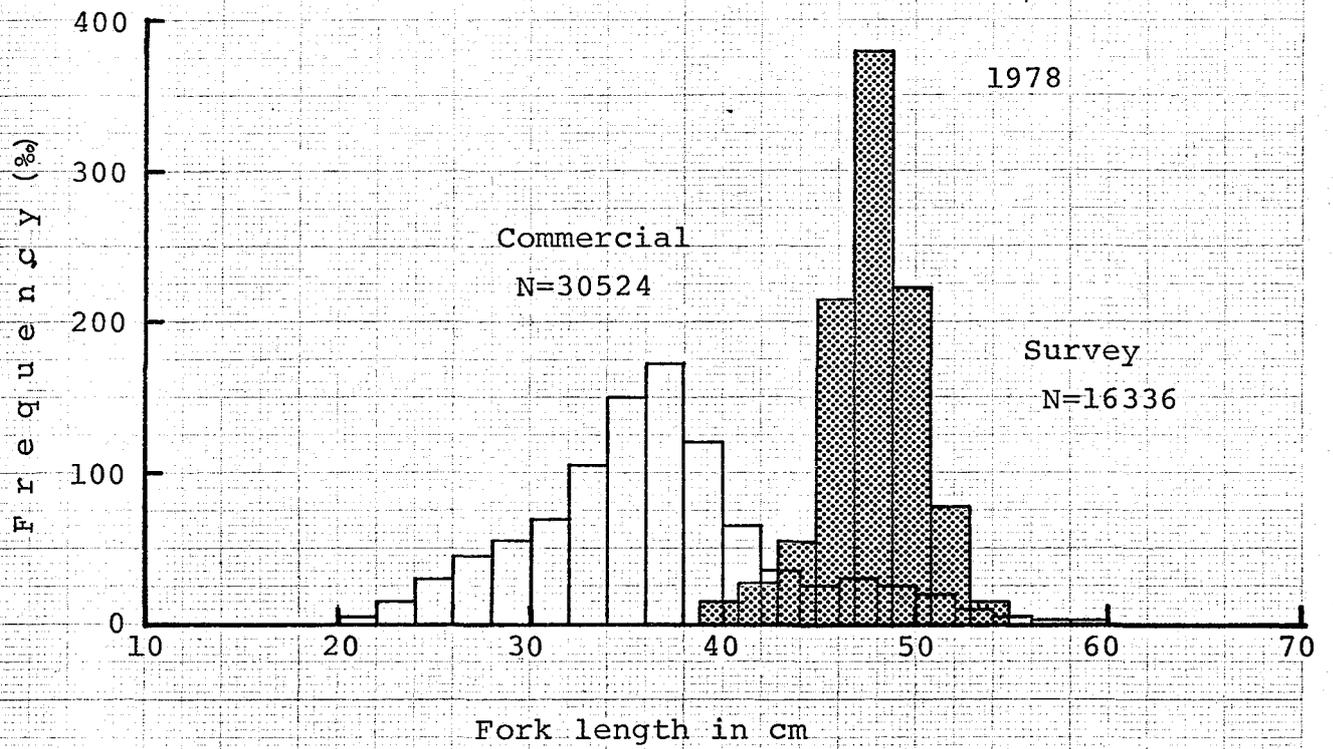


Fig. 5. Length frequency distributions of the pollock caught by mid-water trawl on the Aleutian Basin and those caught by commercial fishing operation on the continental shelf.

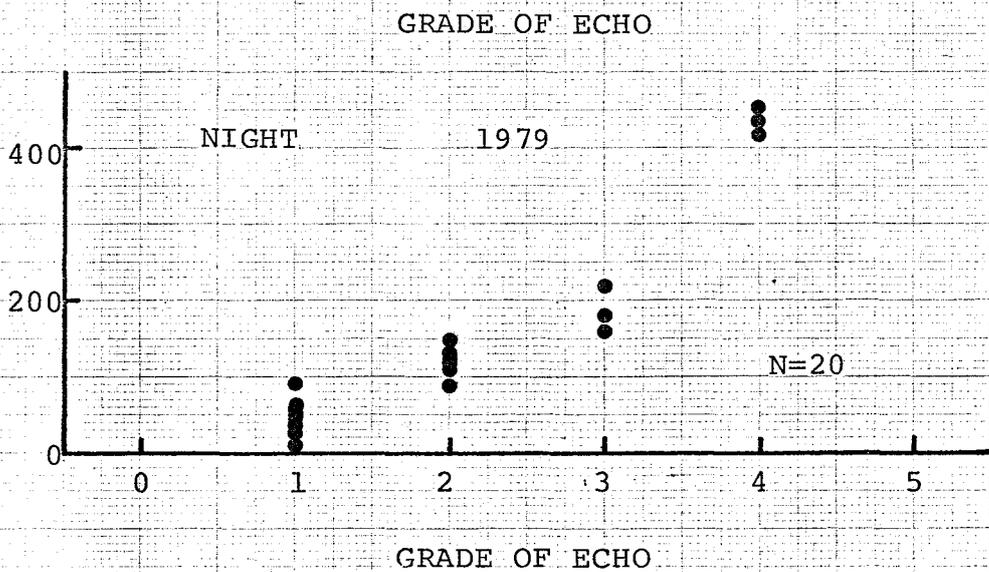
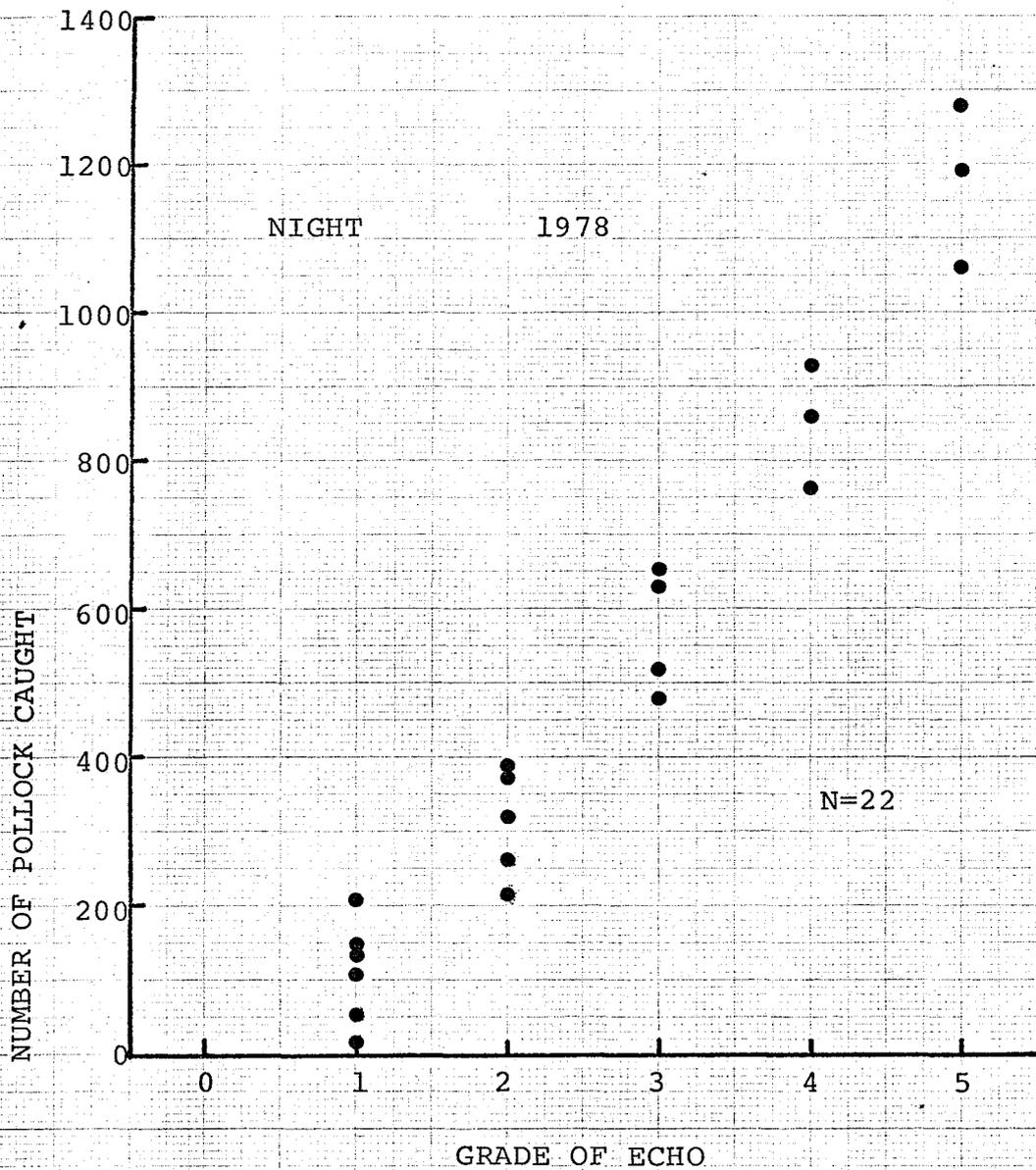


Fig. 6. Relation between grade of spotted echo and number of pollock per hour caught by mid-water trawl on the Aleutian Basin in 1978 and 1979 survey.