Northwest Atlantic Fisheries Organization

Serial No. N066

NAFO SCR Doc. 80/II/35

SPECIAL MEETING OF SCIENTIFIC COUNCIL - FEBRUARY 1980

Assessment of the Short-finned Squid (*Illex illecebrosus*) in Subarea 3 for 1979

by

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Introduction

This paper represents the second assessment of squid using sequential population analysis. The method,first used to estimate the 1978 squid population in ICNAF Subarea 3, (Hurley and Beck 1979) is a modification of Pope's cohort analysis (Pope 1972).

Population size, estimated by sequential analysis is compared to other measures of abundance. Catch per unit effort is used as an index of relative abundance, and a spring random stratified survey was undertaken to estimate pre-season offshore abundance (Squires 1957).

Catch Statistics

Catch, effort, and CPUE for 1979 are presented in Table 1. Catch statistics are broken down by ICNAF division and biweekly intervals.

Catch

Inshore landings are reported to the Economics and Intelligence Branch (E&I), Department of Fisheries and Oceans, on sales receipts or 'purchase slips'. Landings were made available on a monthly basis. Monthly quantities were divided into two equal portions to give landings for biweekly intervals.

Offshore landings in Subarea 3 were obtained monthly from the FLASH information system and catch reports of developmental charters. These also were divided into biweekly quantities. Offshore landings are underestimated since landings were not reported from a substantial fishery

in ICNAF Div. 3M. Offshore landings from the other ICNAF divisions are probably incomplete.

Using mean weights (sexes combined) calculated for samples from each ICNAF division (Fig. 1), landings in kilograms were converted to number of squid (Table 1).

For divisions and time intervals where no samples were taken, mean weights from Holyrood (Div. 3L) for the same time interval were used to calculate numbers of squid. For the month of June and for the period ending November 15, no samples were available from Holyrood. Mean weights for June were calculated from samples collected offshore during the periods ending June 15 (ICNAF Div. 3Ps) and June 30 (ICNAF Div. 3O). These were applied to landings from all ICNAF divisions. November 15 mean weight was estimated by averaging Holyrood data for periods ending October 31 and November 30.

Effort

In 1979 only sample effort was obtained. Effort was not estimated from purchase slips as it had been in 1978. Since offshore effort could not be standardized to inshore effort, only inshore effort was used in the analysis. Sample effort was collected daily at each inshore sampling site by the local weighmaster. A record was kept of the number of fishermen landing squid, number of hours fished and number of reels and jiggers used.

The unit of effort for 1979 is the fisherman-hour. This is believed to be a more accurate measure of effort than the fisherman-day used in 1978 (Hurley and Beck 1979), since fishermen jig for varying periods of time each day.

The most reliable effort data is from Holyrood (ICNAF Div. 3L, Table 2). Inshore effort was estimated for other ICNAF divisions by dividing landings from each division by Holyrood CPUE. This assumes that CPUE does not vary among the ICNAF divisions. Holyrood effort for 1979 is presented in Table 2 and is compared to that of the previous year. Effort was lower in 1979 than in 1978.

Catch per unit effort

CPUE for Holyrood was highest during July (Fig. 2). This agrees with the opinion of fishermen, that squid were most plentiful in that month. CPUE declined sharply after July but decreased only slightly throughout the rest of the season.

High early season CPUE was associated with mean daily water temperature of less than 5°C (Fig. 3). Such low temperatures are not normally associated with high squid abundance. While temperatures were often low, it is possible that other factors such as wind direction were more favourable. Further, temperatures may have exceeded 5°C during daily maxima. Relatively stable CPUE throughout the rest of the season may be associated with temperatures remaining favourable throughout this period.

Landings in 1979 were less severely restricted than in the previous year. Therefore, any comparison of relative abundance between the two years based on CPUE is invalid.

Population Parameters

Natural Mortality Rate

The natural mortality rate was calculated assuming a mean life span of nine months. Hurley and Beck (1979) reasoned that assuming a one-year life span and the fact that many animals are removed from the fishery before the age of one is attained, nine months is a likely mean life span. Therefore, biweekly mortality rate can be calculated as follows:

$$M = \frac{1}{L..S..X\ 2} = 0.06 \qquad (1)$$

Sensitivity analysis of terminal F

A sequential population analysis was done following the method of Pope (1972). Input values of terminal F varied within the range 0.01 - 0.4, whereas M remained constant at .06. The resulting population estimates are given in Table 3.

As in the previous year, 1979 assessment input data were only for

the period ending September 30 and earlier. The use of catch data for later periods may result in erroneous population estimates due to the possibility of late-season emigration from inshore areas (Hurley and Beck 1979).

F vs. Effort

An examination of the relationship of F to effort was undertaken in order to choose the optimal terminal F for the sequential population analysis. F-values were derived from analyses run at different terminal F's ranging from 0.01 to 0.4. The highest correlation coefficient r = 0.98) was found using a terminal F = 0.01. It was also found that the terminal F value predicted by this regression corresponded to the true value. Further, it was for terminal F = 0.01 that the Y-intercept was closest to the origin (Fig. 4).

Sequential Population Analysis

Results of the sequential population analysis using terminal F = 0.01 are given in Table 4. The analysis was initiated using catch data from the period ending September 30 and earlier.

Stock projection and projected F values for biweekly periods in October and November are listed also in Table 4. These projections were made iteratively using the following equations:

$$u = \frac{F}{F + M} \left(1 - e^{-(F + M)}\right) \qquad (2)$$

and

$$N_{t+1} = N_t \left(e^{-(F + M)}\right) \qquad (3)$$

Also shown in Table 4 is population at biweekly intervals converted into squid biomass.

Exploitation Rate

The exploitation rate was calculated using the equation

u = C/N where C = summed biweekly catches

N = population estimate at the beginning of the fishing season

$$\therefore \quad u = \frac{279,927,000}{9,590,152,000} = 0.03$$

Spring Random-Stratified Survey

During the period June 16-26, a random-stratified survey was conducted along the southern edge of the Grand Bank and partial bank areas (ICNAF Div. 3N, 3O, and 3PS). The area covered by the survey (Fig. 5) was determined according to guidelines detailed by Pitt (1976).

A commercial Engels high-opening bottom trawl was used for this survey. It was modified by the captain by adding extra pieces to the square. The average wing tip to wing tip opening was 15.4 meters.

Calculations were based on survey sets made during daylight hours only, as squid move upward in the water column at night. Inclusion of nighttime sets would bias a biomass estimate (Hurley and Beck 1979).

The spring survey resulted in an estimated high number of squid (Table 5). The 1979 offshore estimate was an order of magnitude higher than that for 1978 (Hurley and Beck 1979). This was followed by record high catches inshore later in the season (unpublished data) Therefore, results of the 1979 survey further support the hypothesis of Squires (1959) that early season offshore catch rates correlates with inshore landings later in the season.

Squid were relatively abundant in all survey areas, especially in ICNAF Div. 3N and 3O (Table 5). Squid were most abundant in Div. 3O, where greatest single catches also occurred. The commercial offshore fishery indicates that squid were present in the survey area for a substantial portion of the year.

The distribution of squid was more widespread than in 1978, and appeared to follow warmer water extending over the banks. As a result, the biomass estimate was for 15,947 square miles, compared to 10,445 square miles surveyed in 1978.

With the exception of Div. 3N, more squid were caught at lower water temperatures than in 1978 (Fig. 6). This is directly related to more complete infiltration of warm water before the survey period in 1979.

Discussion

The calculated rate of exploitation for ICNAF Subarea 3 squid, 1979 was 0.03. This is far below the suggested optimal rate for squid of 0.4 (ICNAF Summ. Doc. 78/VI/3). This value is also far below that calculated for 1978 of 0.21 (Hurley and Beck 1979). Similarly biweekly F values for 1979 are below those of 1978.

The 1979 estimated squid population (9,590,152,000) was almost nine times greater than that of 1978 (1,112,281,152). This agrees well with results of the June random survey for these years. The 1979 pre-season population estimate (570,465,536) was an order of magnitude higher than that of 1978 (52,436,120).

Minimum estimated spawning escapement for 1979 (4,844,273,515 animals) was much higher than for the previous year (413,583,000 animals).

In conclusion, sequential population analysis together with the June random survey probably gives a fair indication of differences in relative abundance among years. Exploitation of the 1979 squid population was very light. It is likely that real squid abundance in 1979 was much higher than in the previous year.

Literature Cited

Hurley, G.V. and P. Beck. 1979. Assessment of the short-finned squid (Illex illecebrosus) in ICNAF Subarea 3 for 1978. ICNAF Res. Doc. 79/II/25.

Pitt, T.K. 1976. Contributions to a manual on ICNAF groundfish survey. ICNAF Res. Doc. 76/VI/119.

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Squires, H.J. 1957. Squid, Illex illecebrosus (Le Sueur) in the Newfoundland fishing area. J. Fish. Res. Board Can. 14: 693-728.

Squires, H.J. 1959. Squid inshore in Newfoundland and on the Grand Bank, 1953 to 1958. Progress Reports of the Atlantic Coast Stations of the Fisheries Research Board of Canada, No. 72: 23-26.

Table 1. Estimated squid landings in numbers and weight during the 1979 fishing season (June-November) in Subarea 3.

MONTH	ICNAF Division	C/E (Holyrood) Period ending 15	C/E (Holyrood) Period ending 30	Landings (kg) Period ending 15	Landings (kg) Period ending 30	Average wt/animal(g) both sexes combined Period ending 15	Average wt/animal(g) both sexes combined Period ending 30	Landings No. of animals Period ending 15	Landings No. of animals Period ending 30
June	3K								
	3L			6,500	6,500	77.63	98.63	83,731	65,903
	3P, 4R			2,000	2,000	77.63	79.06	25,763	25,297
	Offshore			10,100	10,100	77.63	98.63	130,104	102,403
	Total							239,598	193,603
July	3K			36,500	36,500	122.21	130.66	298,666	279,351
	3L	114.4	102.3	2,501,500	2,501,000	122.21	130.66	20,464,774	19,141,283
	3P, 4R			960,000	960,000	122.21	172.61	7,855,331	5,561,671
	Offshore			185,000	185,000	122.21	154.94	1,513,788	1,194,011
	Total							30,132,559	26,176,316
August	3K			893,500	893,500	182.91	214.52	4,884,916	4,165,113
	3L	57.5	45.7	5,520,000	5,520,000	182.91	214.52	30,178,776	25,731,866
	3P, 4R			3,455,000	3,455,000	170.53	219.04	20,260,365	15,773,375
	Offshore			163,900	163,900	182.91	214.52	896,069	764,031
	Total							56,220,126	46,434,385
September	3K			4,354,000	4,354,000	271.56	268.32	16,033,289	16,226.893
	3L	38.3	27.2	8,802,000	8,802,000	269.35	280.39	32,678,671	31,391,990
	3P, 4R			2,673,000	2,673,000	215.75	266.33	12,389,340	10,036,421
	Offshore			349,600	349,000	269.35	280.39	1,297,939	1,246,835
	Total							62,399,239	58,902,139
October	3K			1,813,000	1,813,000	290.40	265.16	6,244,835	6,839,267
	3L	28.8	26.3	6,200,500	6,200,500	271.05	265.16	22,875,853	23,383,995
	3P, 4R			1,012,000	1,012,000	235.71	265.16	4,293,411	3,816,564
	Offshore			262,000	262,000	240.29	265.16	1,093,678	991,100
	Total							34,507,777	35,030,926
November	3K			5,500	5,500	275.79	287.03	19,943	19,161
	3L	24.8	20.4	1,413,500	1,413,500	275.79	287.03	5,125,276	4,924,572
	3P, 4R			39,500	39,500	275.79	287.03	143,226	137,616
	Offshore			26,650	26,650	232.84	287.03	114,456	92,847
	Total							5,402,901	5,174,196

Table 2. Holyrood effort (fisherman-hours), 1978 and 1979

	Period Ending									
Year	July 15	July 31	Aug. 15	Aug. 31	Sept. 15	Sept. 30	Oct. 15	Oct. 30	Nov. 15	Nov. 30
1978			2431	11280	4495	5745	640	2405		
1979	3355	8527	4170	4750	3735	5390	3155	2285	3275	1295

Table 3. Sensitivity of various population estimates to varying terminal F values

F	M	Population
.010	0.06	9,590,152,000
.020	0.06	4,966,673,000
.025	0.06	4,042,000,000
.030	0.06	3,425,563,000
.040	0.06	2,655,046,000
.050	0.06	2,192,765,000
.075	0.06	1,576,478,000
.10	0.06	1,268,428,000
.125	0.06	1,083,673,000
.15	0.06	960,564,000
.20	0.06	806,819,000
.30	0.06	653,444,000
.40	0.06	577,126,000

Table 4. Projection of stock size and F values in Subarea 3 for October and November 1979. (Analysis based on catches for twice-monthly periods with terminal F = 0.01 at end of September 1979 and M assumed to be 0.06)

Period	No. of animals		Average Wt (kg)	Biomass (kg)	F
	Catch	Population			
June 1-15	83,763	9,590,152,000	0.0776	744,195,795	.000
16-30	65,923	9,031,430,000	0.0986	890,498,998	.000
July 1-15	20,466,448	8,505,290,000	0.1222	1,039,346,438	.004
16-31	19,150,076	7,980,513,000	0.1306	1,042,254,998	.003
August 1-15	30,180,426	7,491,838,000	0.1829	1,370,257,170	.008
16-31	25,734,266	7,001,069,000	0.2145	1,501,729,301	.007
September 1-15	32,684,738	6,547,960,000	0.2693	1,763,365,628	.010
16-30	31,390,870	6,105,906,000	0.2804	1,712,096,042	.010
October 1-15	22,880,073	5,693,109,000[1]	0.2710	1,542,834,539	.010[2]
16-31	23,380,467	5,308,219,648[1]	0.2652	1,407,739,851	.010[2]
November 1-15	5,125,091	5,148,973,059[1]	0.2758	1,420,086,770	0.001[2]
16-30	4,925,087	4,844,273,515[1]	0.2870	1,390,306,499	0.001[2]

[1] Projected stock size
[2] Projected F values

Table 5. Population and biomass estimates for squid from June random survey in 1979 (upper and lower confidence limits are given for each ICNAF Division)

ICNAF	Population (Number of Animals)	Upper	Lower	Biomass (kg)	Upper	Lower
3N	193,281,760	833,153,792	-446,590,464	21,412,736	93,802,272	-50,976,800
30	332,977,664	472,551,680	193,403,584	29,032,464	42,983,264	15,081,660
3Ps	44,206,112	59,943,504	28,468,704	3,599,986	5,168,849	2,031,123
Total	570,465,536 animals			54,045,186 kg		

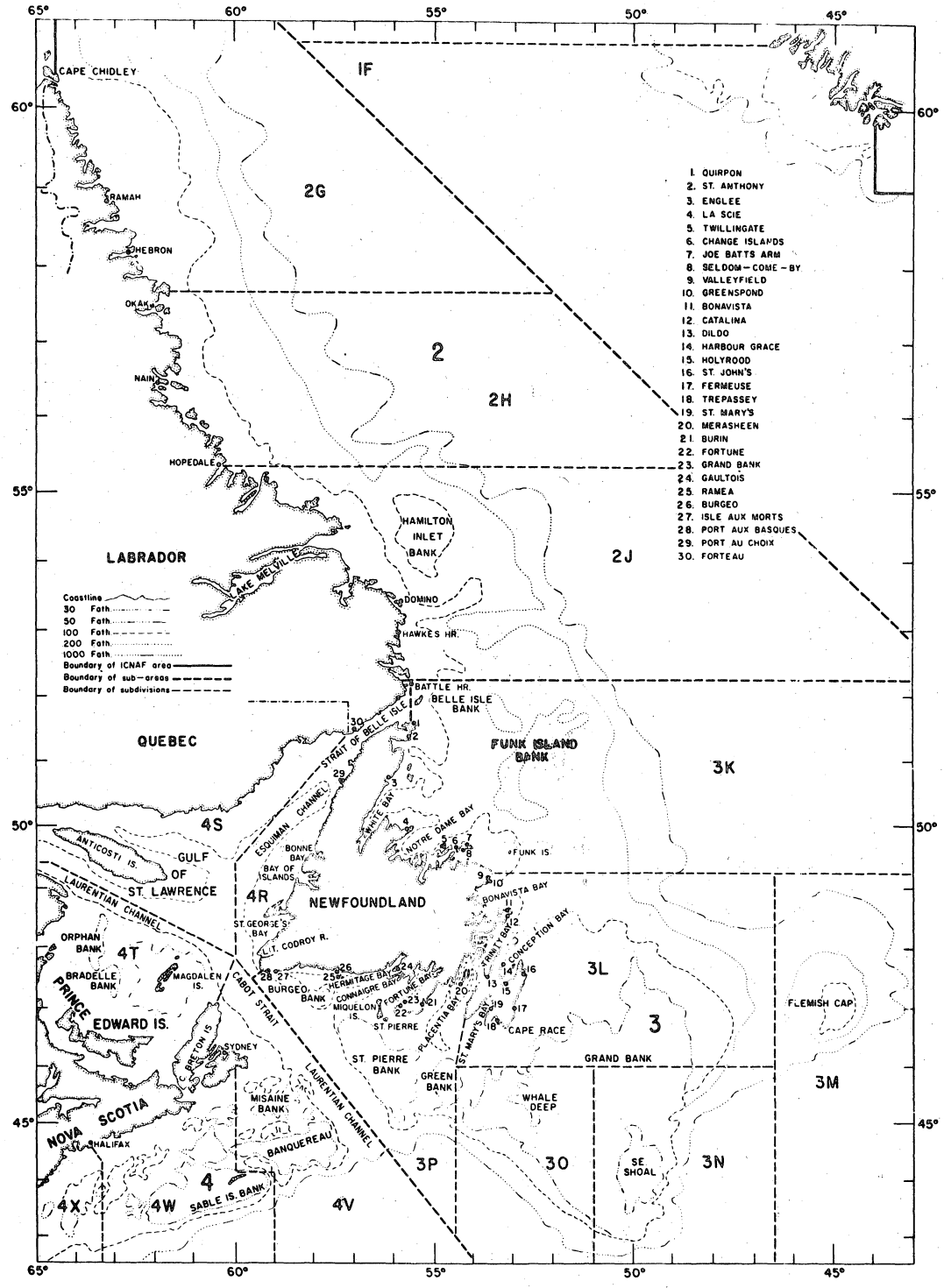

Fig. 1. Map of Northwest Atlantic Subareas.

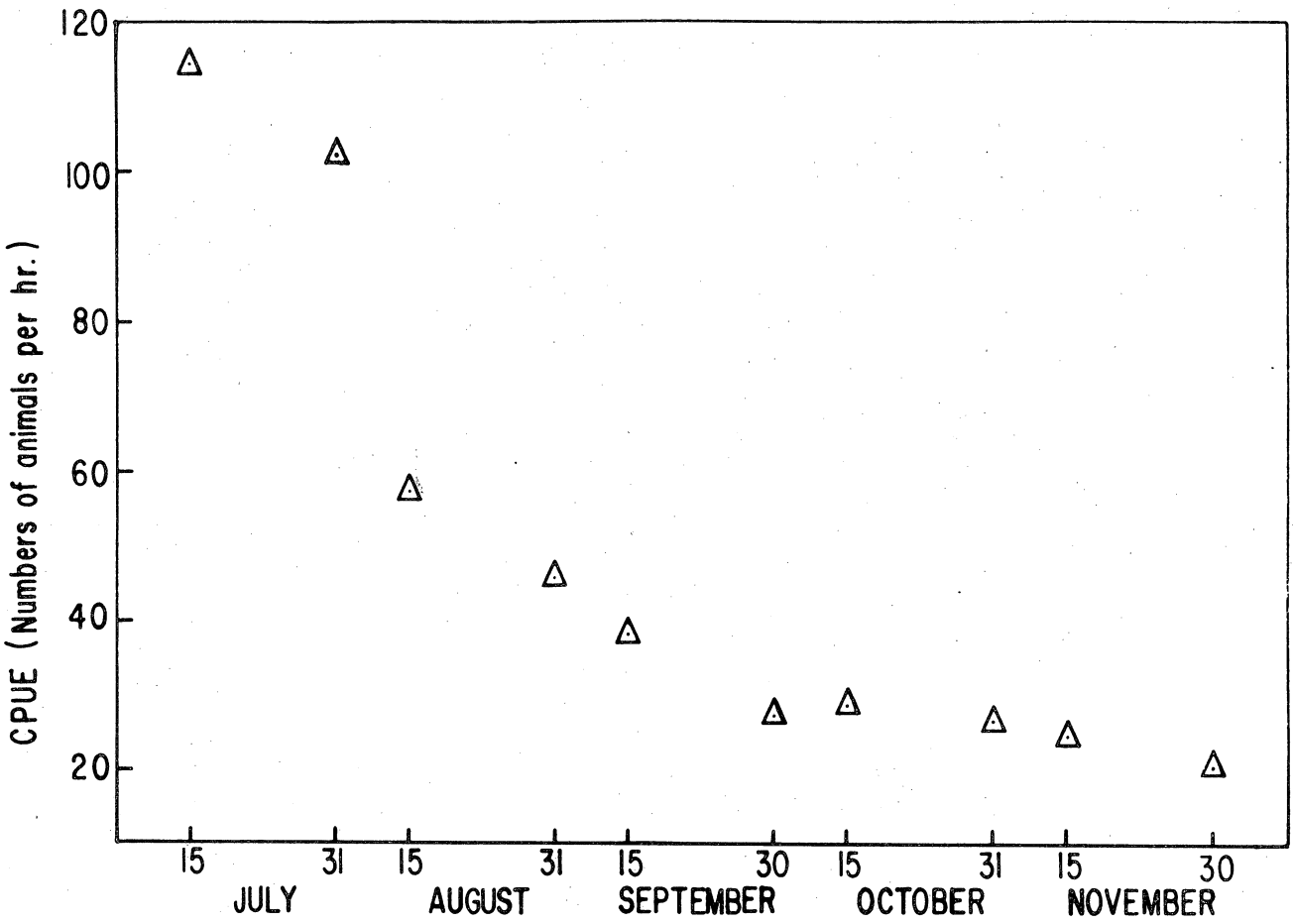

Fig. 2. C.P.U.E. (Numbers per Fisherman-hour) from Holyrood in 1979.

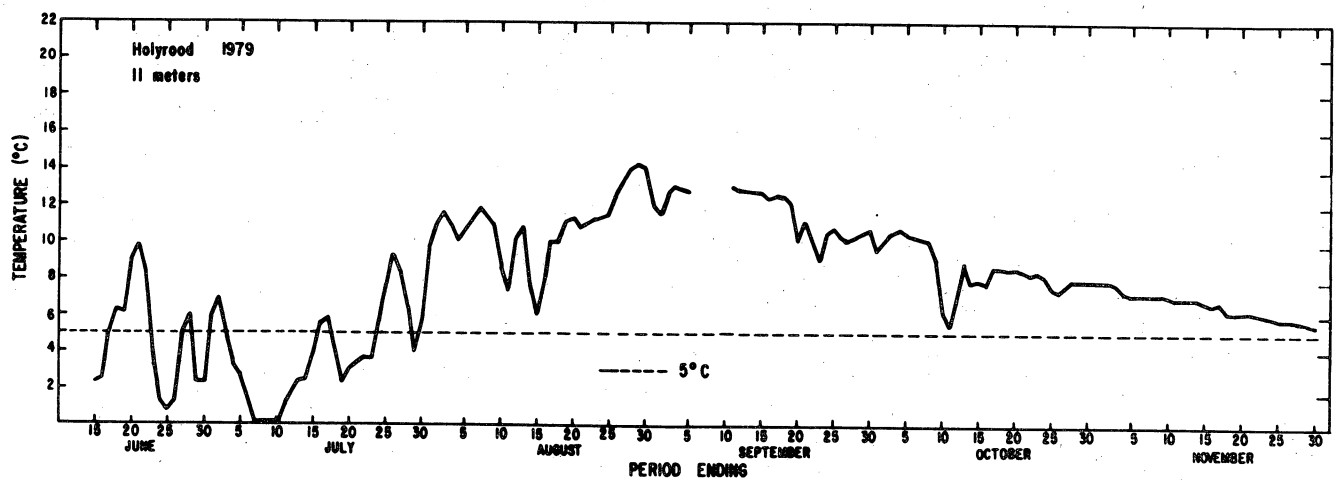

Fig. 3. Mean daily water temperatures over the fishing season at Holyrood in 1979.

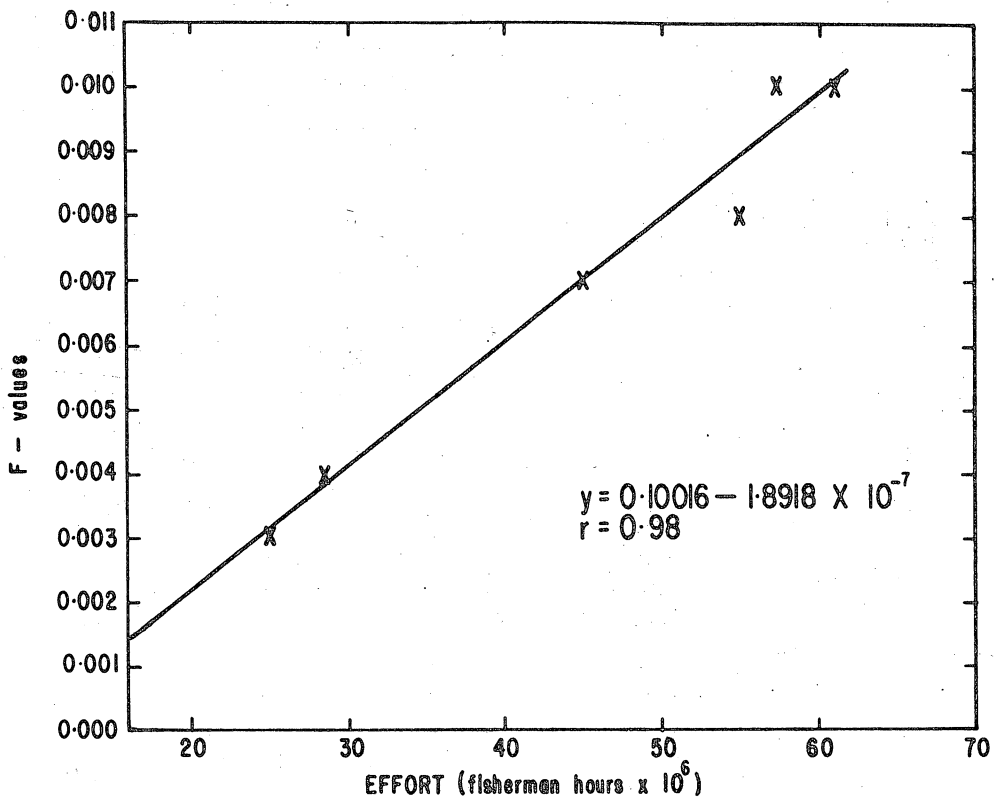

Fig. 4. The catch curve of C.P.U.E. at Holyrood for 1979.

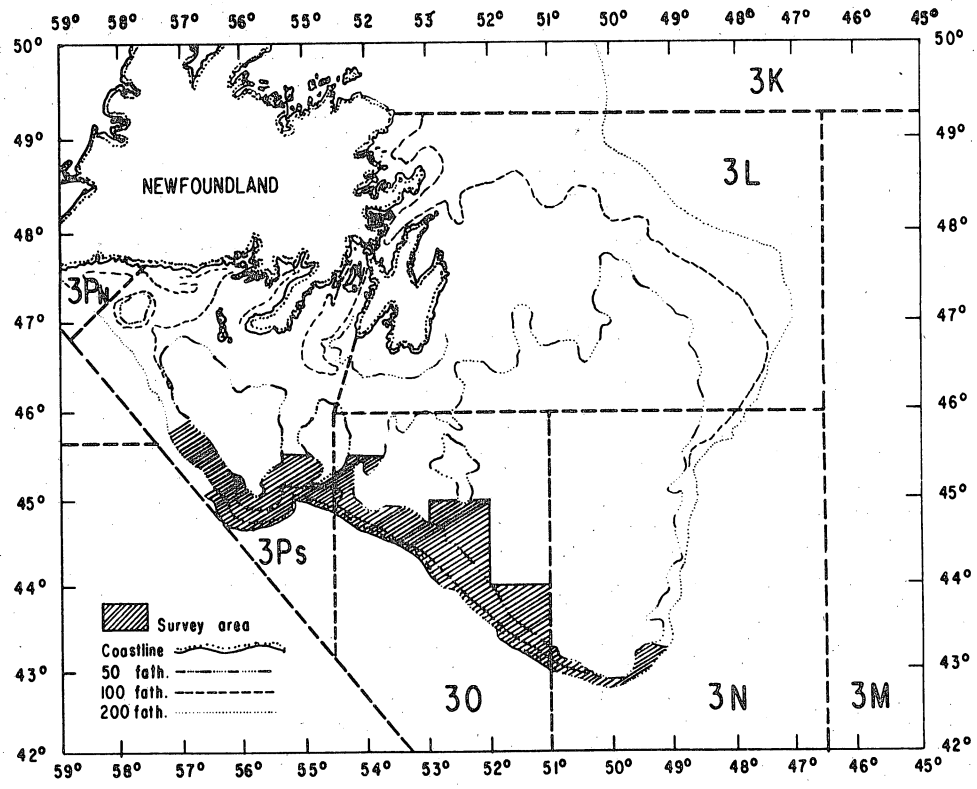

Fig. 5. Map of the Grand Banks showing area covered by spring random stratified survey.

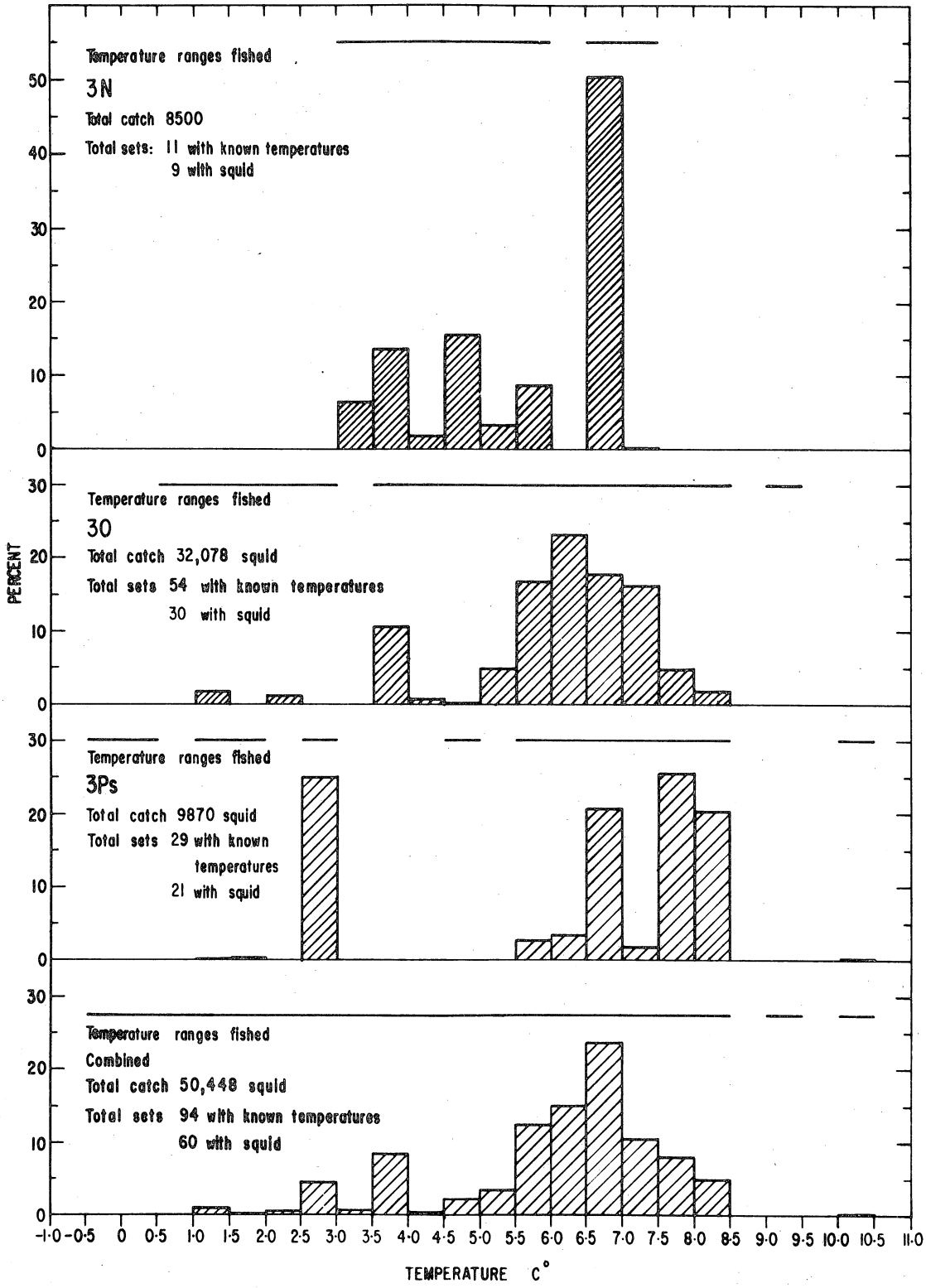

Fig. 6. Percent catch versus temperature (^{o}C) during spring random-stratified survey for ICNAF Divisions 3N, O, P.