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# Canadian Research Efforts for Shrimp (*Pandalus borealis*) in Division 0A and Subarea 1 in 1979

by

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## Introduction

The M.V. ZAGREB, a 46-metre stern trawler, was chartered by the Department of Fisheries and Oceans, to conduct research on various fish and invertebrate stocks in territorial and adjacent waters during 1979. A survey for salmon and shrimp was completed during August and September in the Davis Strait area. The latter part of that cruise (September 8-25) was primarily concerned with shrimp in the offshore grounds between 66°N and 68°30'N and 55°W and 59°30'W.

In addition, biological observers on board vessels fishing the Canadian quota in the 0 + 1 area supplied some information on catch per unit effort, composition of the catch, discarding practices and by-catch.

This presentation analyses and interprets the results of the research cruise relating to shrimp biomass and characteristics of its components. A preliminary and somewhat cursory examination is made of the information collected by observers from this area. Approximately 55% of the Canadian allocation has been taken to date and, it is hoped that additional observers will be dispatched during the balance of the season.

## Methods and Materials

### General

The original survey plans included an area extending to 69°N. However, extremely irregular bottom topography dictated this more northerly portion be excluded. For the remaining area, survey lines were fished at preselected locations and depths (Fig. 1). These lines were chosen on the basis of the distribution of commercial effort in the area from 1975 to 1978 (unpublished).

Fishing gear used throughout the survey was the Sputnik 1600 shrimp trawl with a 43 m headline and 51 m footrope. Mesh size in the cod end was 42 mm and the last 6 m were lined with 13 mm netting. Standard survey sets were 30-minutes duration with an average towing speed of 3.0 knots.

Recent information (Carrothers, unpublished) collected with acoustic instrumentation indicate that the horizontal opening of the Sputnik 1600 trawl is approximately 22 m. This estimate was averaged from sampled data collected at towing speeds of 2-3.5 knots, with and against current flow. This is appreciably less than the 30 m suggested by Hoydal (1978) for the Sputnik 1800 with a groundrope of similar length. The vertical lift of the trawl used in this survey was estimated around 7 m.

Shrimp were sampled from each set in which they occurred. Carapace length was recorded to the nearest 0.5 mm and shrimp were separated into ovigerous and non-ovigerous categories. Total catch of major by-catch fish species was determined or estimated. Length frequencies were obtained for these species as well.

The survey was run on a 24-hour fishing basis resulting in a total of 47 successful sets in the area. Fifteen of these were made over a 24-hour period in a locale selected for detailed study of diel variability in shrimp catches (see below).

An Expendable Bathythermograph cast was made with each survey set along with observations on sea surface temperature and atmospheric conditions.

Stratification

Stratification of the area surveyed (Fig. 1, Table 1) was based on existing information (Horsted, Kanneworff, Fréchette; personal communication). Because of discrepancies between the calculation of strata areas this exercise was repeated for the present study. All areas were calculated using an average of three readings from an A. OTT planimeter. All strata except for the shallowest (150-200 m) were 100 m intervals. Depths sampled were from 150-500 m although in the zones deeper than 400 m on the northern edge of the Bank (e.g. northern part of stratum 12) the sea floor was unfishable.

Biomass for each stratum was calculated by multiplying the average catch by the number of trawl hauls possible in that stratum without overlap. All strata estimates were summed to arrive at a total for the surveyed area (Table 1).

Diel variability

A well-documented characteristic of this fishery is the pronounced diel variability in catch rates (Berenboim *et al.*, 1976; Horsted, 1978; Carlsson *et al.*, 1978; Smidt, 1978;

Jones and Parsons, 1978). For this study fifteen stations were made over a 24-hour period in an area of optimum shrimp abundance (Fig. 1). Moving averages of three for catch per standard tow were plotted against time (Fig. 2). A curve was fitted by eye and hourly conversion factors were estimated where the curve intersected the midpoint of the interval with some degree of symmetry. These conversion factors and those for September by Carlsson et al. (1978) were used to adjust the catches made during the survey to optimum levels. Conversions for sets which overlap a time interval were adjusted by the proportion of time spent in each. The differences are compared to non-treated data (Table 1).

Observer Program

Biological observers were placed on three vessels licensed under developmental charter to fish the Canadian allocation of shrimp in the Davis Strait. Information has been made available from two of these trips supplying data during the months of August and October. These observers were trained in methods of shrimp sampling by staff from the Research and Resource Services Directorate of the Department of Fisheries and Oceans in St. John's, Newfoundland. Apart from regular observance of the catch data and shrimp sampling, their duties included collection of information on by-catch and, especially the discarding of small shrimp. As previously stated, the information is incomplete for 1979.

## Results and Discussions

### Diel Variability

Comparison of the conversion factors from this paper and Carlsson et al. (1978) is made in Table 2. The maximum conversion for the former is 8.61 and the latter 5.30. The optimum catch period for Carlsson et al. is centered more around midday than the results from this study. From the data presented here the optimum catches occur between 1300 and 1900 hours (Table 2, Fig. 2). Although somewhat 'off centre' compared to the earlier work the pattern is not unlike that observed by Smidt (1978) for the same month and even more similar to the pattern shown for August.

The utilization of conversion factors based on only one day's experimentation is doubtlessly limited in application or at least should be applied with due caution. We must consider the distinct possibility of considerable variation on a day-to-day basis. These estimates do, however, receive some support from previous work and moving averages of three have been employed to emphasize trend. Very few surveys provide sufficient time to conduct detailed study of this phenomenon. The sources of variation may include area, season, depth, intensity of illumination from day to day and fishing pressure, indicating that estimates of the diel variability are probably as variable as the catches themselves.

The method of Jones (Jones and Parsons, 1978) for calculating diel conversion factors using the percent ovigerous females present in the catch was attempted with the data from this survey. The method was abandoned for two reasons: 1) a distinct lack of relationship between catch per standard tow and percent ovigerous (Fig. 3) and 2) although the peak for optimum daily catches coincided reasonably well with the lower incidence of ovigerous animals, the period of lowest catches was considerably earlier than indicated by the high percent ovigerous period (Fig. 4). Using the ovigerous data, lowest levels of catch would be expected around 0330 hours. The catch information from this study shows the period lasting from about 2300 to 0200 hours. Carlsson's et al. highest conversion factor is applied at 2300 hours, a full 4.5 hours earlier than indicated by Jones' method.

Biomass

Details of biomass calculation are given in Table 1. Biomass for the survey area is estimated at 40,076 m tons using data untreated for diel variability, 52,802 using Carlsson's et al. (1978) conversion factors and 57,616 using the adjustments derived from this study. Despite the observed difference in conversion factors the latter two estimates are reasonably similar for total biomass but there is considerable difference on the basis of individual strata.

Additional information is given for an estimated horizontal net opening of approximately 27 m used by Veitch et al. (1978). However, in the light of new information provided by Carrothers, this inclusion is intended for comparison only.

Over 50% of the calculated biomass occurs in the large central area on the western side of the Store Hellefiske Bank between 200 and 400 m. Adjusted and unadjusted mean catch for each stratum (Table 3) show high densities in Stratum 5, especcially. It should be cautioned that the extrapolation is based on two sets only. South of 67°N catch rates and biomass are generally lower. Stratum 11 approaches more favorable densities and a relatively large biomass is suggested for so small an area. Stratum 1 is also a major contributor to the total biomass figure. The three sets used for this area were made in fishable grounds in the western portion only (Fig. 1). Since very little commercial activity is evident from areas to the northeast and fishable bottom is difficult to find, assumptions of homogeneity may be spurious in this case and the biomass inflated.

Horsted (1968) estimated biomass at 55,000 m tons for an area approximately 34,000 $km^2$. This survey indicates a similar biomass for a considerably smaller area (23,000 $km^2$). The difference may be explained in any or all of three ways: 1) difference in abundance between the two years (1976 vs 1979), 2) the present survey employed a small mesh liner, intended to reduce the selectivity problem and 3) the horizontal opening of the trawl used in 1976 was 30 m and should this be an overestimate, a lower biomass would result.

Length Composition

Length frequencies for all strata sampled are shown in Fig. 5. The sample for each set was adjusted to the total, unadjusted catch before converting to number per thousand. No adjustment has been made to the length frequencies to account for any differential size distribution associated with the diel vertical migration. The method of data accumulation gives weight to the more productive sets and comparison with individual length frequencies taken at times of optimum concentrations (i.e. conversion factor near 1.00) indicate good representation for each stratum. In order to consider these figures in some terms of relative abundance reference is made to catch rates given in Table 3.

Strata 5 and 6, which exhibit relatively high catch rates, produced a wide range of sizes with indistinct modes. Twenty-three sets made in stratum 6 over periods of varying abundance may account, in part, for the extremely wide range of sizes evident in that area. However, the pattern is also similar in samples obtained at the observed and predicted optimum catch periods.

Shrimp larger than 18 mm carapace length comprise the greater proportion of the catches in the deep water strata. There are indications that the incidence of smaller animals occurs more frequently in areas south of stratum 5, especially in depths less than 300 m. The smaller and younger animals evident in stratum 7, possibly representing the 0 and I age groups, provide the only evidence of potential recruitment. The impact of the mode between 15 and 17 mm shown in stratum 9 will probably be negligible in view of the low catch rate and small biomass. No data were collected from relatively shallow areas north of 68°30'N. Stratum 4 (<300 m) in the northwest of the survey area produced larger animals similar in size to those from deeper areas.

The proportions of ovigerous animals present in the catches were low even in areas where only very large animals were encountered (e.g. stratum 2). These low percentages may have contributed to the lack of relationship between the proportion of ovigerous animals and size of catch described in an earlier section.

Hydrographic Data

Two lines of stations were selected to present hydrographic profiles of the surveyed area (Fig. 6). Bottom readings were generally between 3 and 4°C in areas of highest shrimp concentrations (200-400 m). Habitat temperatures in this range are not unfavorable to the existance of Pandalus borealis. The 3°C isotherm was evident at approximately 200 m and the cold water layer (<1°C) occurred between 50 and 100 m.

The Commercial Fishery

Length frequencies obtained on board vessels fishing the Canadian shrimp allocation in 0 + 1 for August and October indicate a range of commercial sizes betwen 20 and 28 mm carapace length (Fig. 7). The figure for October shows a much higher proportion of ovigerous animals present in the catch than that evident from the survey data. It appears that a considerable amount of spawning occurred during the intervening fortnight. Catch rates for the observed periods were 321 kg per hour (5970 kg/day) for August and 165 kg per hour for sets sampled on October 3.

The major by-catch species was redfish comprising a reported 12% of the total catch in the earlier month and 21% for the day observed in October. Redfish sampled from three sets showed a range of sizes between 10 and 20 cm. One report stated that when the by-catch of redfish is high the net is split open and the fish floated off before the net is taken aboard. The reported by catch, therefore, may be in error if this amount is not recorded. Individual sets may produce very high catches of small redfish. Surveillance officers, boarding one of the shrimp vessels fishing the area, recorded a total catch of 7 m tons, 6 of which were small redfish.

Discards of shrimp of small size and unsuitable quality have been observed from the area but the relative proportions seem low. Of the two vessels which carried observers one had no appreciable discards while the other discarded at a rate of approximately 10%. A boarding by surveillance officers noticed one incidence of discarding in the order of 2%. Recollection of the length frequency diagram (Fig. 5) for the survey area would indicate little discarding in areas where commercial activity occurs with the possible exception of stratum 6.

## References

Berenboim, B.I., M. L. Zaferman, A. I. Klimenkov, A. Y. Lysy and A. K. Umakhanov. 1976. State of the stocks of deepwater shrimps in the West Greenland Area. ICNAF Res. Doc., No. 113, Serial No. 3936.

Carlsson, D. M., Horsted, Sv. Aa. and P. Kanneworff. 1978. Danish trawl surveys on the offshore west Greenland shrimp grounds in 1977 and previous years. ICNAF Sel. Pap., 4, p. 67-24.

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Smidt, E. 1978. Diurnal variation in shrimp catches on the offshore grounds in ICNAF Divisions 1B and 1C. ICNAF Sel. Pap. 4, p. 45.46.

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Table 1. Details of stratification, catch and biomass.

| Set No. | Date Sept. | Midpoint of set GMT-3hrs | Depth (m) | Catch per Standard tow | Conversion factor Carlsson et al 1978 | Adj. Catch | Conv. factor this paper | Adj. Catch | Stratum No. | Depth Interval (m) | Stratum area (km²) | BIOMASS (m. tons) 22 m SPREAD Unadj. | 22 m SPREAD Carlsson et al 1978 | 22 m SPREAD This paper | 27.4 m SPREAD Unadj. | 27.4 m SPREAD Carlsson et al 1978 | 27.4 m SPREAD This paper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 12 | 0803 | 326-322 | 82.55 | 1.21 | 99.89 | 1.98 | 163.28 | 1 | 300-400 | 3,359 | 7,156 | 8,262 | 9,306 | 5,725 | 6,609 | 7,445 |
| 15 | 12 | 1007 | 335-329 | 60.78 | 1.06 | 64.22 | 1.52 | 92.26 | | | | | | | | | |
| 19 | 13 | 1732 | 313-307 | 246.59 | 1.16 | 286.04 | 1.02 | 251.52 | | | | | | | | | |
| 16 | 12 | 1704 | 518-507 | 16.36 | 1.16 | 18.98 | 1.01 | 16.57 | 2 | > 500 | 337 | 82 | 108 | 94 | 66 | 87 | 75 |
| 17 | 12 | 1910 | 542-534 | 13.41 | 1.51 | 20.25 | 1.30 | 17.43 | | | | | | | | | |
| 20 | 13 | 2016 | 404-401 | 38.55 | 2.52 | 97.15 | 1.82 | 70.16 | 3 | 400-500 | 2,300 | 1,121 | 3,918 | 3,323 | 897 | 3,135 | 2,658 |
| 21 | 14 | 2227 | 419-417 | 20.87 | 5.30 | 110.61 | 5.08 | 106.02 | | | | | | | | | |
| 13 | 11 | 2249 | 275-273 | 48.90 | 5.30 | 259.17 | 5.44 | 265.82 | 4 | < 300 | 642 | 958 | 2,072 | 2,114 | 767 | 1,658 | 1,691 |
| 18 | 13 | 1522 | 276-275 | 133.15 | 1.01 | 134.48 | 1.02 | 135.81 | | | | | | | | | |
| 11 | 11 | 1628 | 359-357 | 627.10 | 1.16 | 727.44 | 1.00 | 627.10 | 5 | 300-400 | 2,784 | 17,936 | 22,078 | 18,299 | 14,348 | 17,663 | 14,639 |
| 12 | 11 | 1840 | 317-307 | 159.52 | 1.51 | 240.88 | 1.10 | 175.47 | | | | | | | | | |
| 1 | 9 | 0813 | 216-220 | 121.34 | 1.14 | 138.33 | 1.89 | 229.33 | 6 | 200-300 | 5,132 | 8,178 | 11,034 | 17,204* | 6,543 | 8,828 | 13,764* |
| 4 | 9 | 1649 | 216-212 | 112.95 | 1.16 | 131.02 | 1.00 | 112.95 | | | | | | | | | |
| 5 | 9 | 1921 | 271-285 | 117.03 | 1.51 | 176.72 | 1.34 | 156.82 | | | | | | | | | |
| 6 | 10 | 2037 | 282-275 | 65.36 | 2.52 | 164.71 | 1.82 | 118.96 | | | | | | | | | |
| 9 | 11 | 1108 | 264-260 | 224.53 | 1.03 | 231.27 | 1.36 | 304.24 | | | | | | | | | |
| 22 | 14 | 0412 | 231 | 48.47 | 1.83 | 88.70 | 3.65 | 176.92 | | | | | | | | | |
| 23 | 14 | 0834 | 273 | 253.38 | 1.13 | 286.32 | 1.87 | 473.82 | | | | | | | | | |
| 24 | 14 | 1032 | 256-262 | 115.21 | 1.03 | 118.67 | | | | | | | | | | | |
| 25 | 14 | 1206 | 254-265 | 162.39 | 1.01 | 163.85 | | | | | | | | | | | |
| 26 | 14 | 1326 | 256-264 | 114.31 | 1.00 | 114.31 | | | | | | | | | | | |
| 27 | 14 | 1530 | 258-267 | 122.44 | 1.01 | 123.66 | | | | | | | | | | | |
| 28 | 14 | 1726 | 256-253 | 198.66 | 1.16 | 230.45 | 1.00 | 198.66 | | | | | | | | | |
| 29 | 14 | 1915 | 258-262 | 173.89 | 1.51 | 262.57 | | | | | | | | | | | |
| 30 | 14 | 2059 | 258-262 | 11.79 | 2.52 | 29.71 | | | | | | | | | | | |
| 31 | 15 | 2247 | 258-262 | 11.79 | 5.30 | 62.49 | | | | | | | | | | | |
| 32 | 15 | 0020 | 258-264 | 15.54 | 4.08 | 63.40 | | | | | | | | | | | |
| 33 | 15 | 0147 | 258-264 | 32.02 | 3.98 | 127.59 | | | | | | | | | | | |
| 34 | 15 | 0325 | 258-260 | 14.29 | 2.65 | 37.87 | | | | | | | | | | | |
| 35 | 15 | 0508 | 256-260 | 69.74 | 1.74 | 121.35 | | | | | | | | | | | |
| 36 | 15 | 0637 | 258-260 | 116.86 | 1.33 | 155.42 | | | | | | | | | | | |
| 37 | 15 | 0758 | 258-260 | 57.27 | 1.24 | 71.21 | | | | | | | | | | | |
| 38 | 15 | 0916 | 258-264 | 29.94 | 1.13 | 33.83 | | | | | | | | | | | |
| 40 | 15 | 1953 | 232-223 | 47.17 | 1.78 | 83.93 | 1.47 | 69.25 | | | | | | | | | |
| 2 | 9 | 1047 | 179-185 | 141.07 | 1.03 | 145.30 | 1.46 | 205.96 | 7 | 150-200 | 2,298 | 2,657 | 2,736 | 3,879 | 2,125 | 2,189 | 3,103 |
| 42 | 16 | 0027 | 174-181 | 0 | - | - | - | - | | | | | | | | | |
| 46 | 16 | 1808 | 165-161 | 0 | - | - | - | - | 8 | 150-200 | 4,000 | 173 | 261 | 190 | 138 | 209 | 152 |
| 51 | 17 | 1831 | 190-181 | 5.28 | 1.51 | 7.97 | 1.10 | 5.81 | | | | | | | | | |
| 49 | 17 | 1412 | 227-231 | 35.61 | 1.01 | 35.93 | 1.07 | 37.96 | 9 | 200-300 | 819 | 366 | 389 | 382 | 293 | 311 | 306 |
| 50 | 17 | 1635 | 223-221 | 19.05 | 1.16 | 22.10 | 1.00 | 19.05 | | | | | | | | | |
| 7 | 11 | 2308 | 331-300 | 28.22 | 5.30 | 149.57 | 7.13 | 201.12 | 11 | 300-400 | 782 | 1,016 | 1,446 | 2,189 | 813 | 1,157 | 1,751 |
| 8 | 11 | 0114 | 362-377 | 0 | - | - | - | - | | | | | | | | | |
| 43 | 16 | 0824 | 331-335 | 246.52 | 1.13 | 278.57 | 1.87 | 460.99 | | | | | | | | | |
| 44 | 16 | 1006 | 382-379 | 116.31 | 1.06 | 123.29 | 1.52 | 177.26 | | | | | | | | | |
| 47 | 17 | 2131 | 377-379 | 4.76 | 2.52 | 12.00 | 2.82 | 13.42 | | | | | | | | | |
| 45 | 16 | 1200 | 419-425 | 101.28 | 1.02 | 102.80 | 1.27 | 128.12 | 12 | 400-500 | 504 | 433 | 498 | 636 | 346 | 398 | 509 |
| 48 | 17 | 2329 | 414-419 | 3.29 | 5.30 | 17.44 | 7.75 | 25.50 | | | | | | | | | |
| | | | | | | | | | | | 22,957 | 40,076 | 52,802 | 57,616 | 32,061 | 42,244 | 46,093 |

* Sets 24-27 and 29-38 not used for this estimate.

Table 2. Hourly Correction Factors for diel variation.

| Local Time (GMT-300) | This Paper | Carlsson *et al* 1978 |
|---|---|---|
| 0000-0100 | 8.61 | 4.08 |
| 0100-0200 | 7.56 | 4.08 |
| 0200-0300 | 5.74 | 2.65 |
| 0300-0400 | 4.49 | 2.65 |
| 0400-0500 | 3.56 | 1.74 |
| 0500-0600 | 2.95 | 1.74 |
| 0600-0700 | 2.48 | 1.33 |
| 0700-0800 | 2.14 | 1.33 |
| 0800-0900 | 1.87 | 1.13 |
| 0900-1000 | 1.65 | 1.13 |
| 1000-1100 | 1.47 | 1.03 |
| 1100-1200 | 1.32 | 1.03 |
| 1200-1300 | 1.21 | 1.00 |
| 1300-1400 | 1.12 | 1.00 |
| 1400-1500 | 1.06 | 1.01 |
| 1500-1600 | 1.02 | 1.01 |
| 1600-1700 | 1.00 | 1.16 |
| 1700-1800 | 1.02 | 1.16 |
| 1800-1900 | 1.10 | 1.51 |
| 1900-2000 | 1.34 | 1.51 |
| 2000-2100 | 1.82 | 2.52 |
| 2100-2200 | 2.82 | 2.52 |
| 2200-2300 | 5.08 | 5.30 |
| 2300-2400 | 7.75 | 5.30 |

Table 3. Mean Catch for each Stratum.

| Stratum No. | Catch/Standard Tow | | |
|---|---|---|---|
| | Unadjusted | Carlsson et al 1978 | This Paper |
| 1 | 130.0 | 150.1 | 169.0 |
| 2 | 14.9 | 19.6 | 17.0 |
| 3 | 29.7 | 103.9 | 88.1 |
| 4 | 91.0 | 196.8 | 200.8 |
| 5 | 393.3 | 484.2 | 401.3 |
| 6 | 97.2 | 131.2 | 204.6* |
| 7 | 70.5 | 72.7 | 103.0 |
| 8 | 2.6 | 4.0 | 2.9 |
| 9 | 27.3 | 29.0 | 28.5 |
| 11 | 79.2 | 112.7 | 170.6 |
| 12 | 52.3 | 60.1 | 76.8 |

* Sets 24-27 and 29-38 not used.

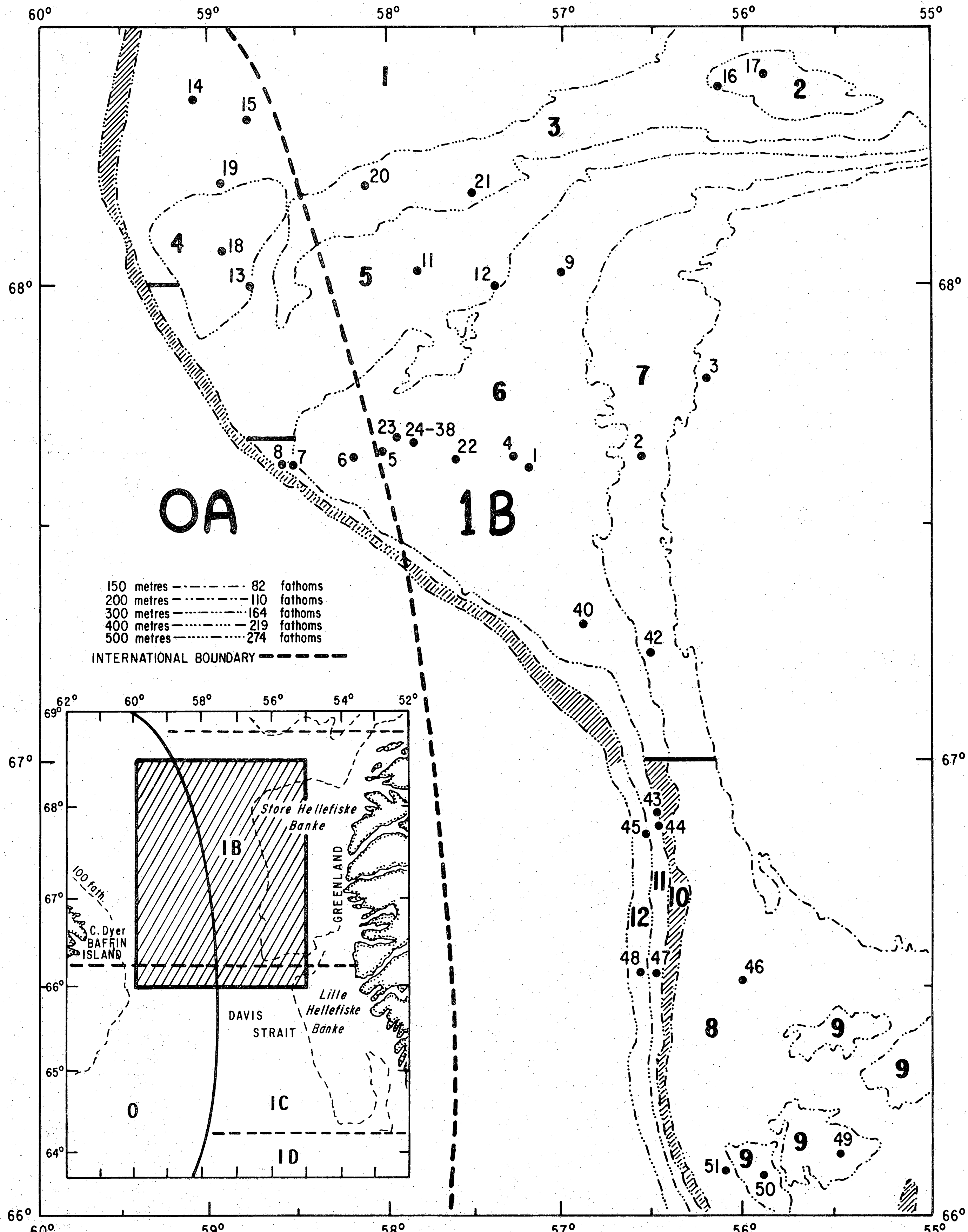


Fig. 1. Stratification and set positions for the survey area (shaded areas not included).

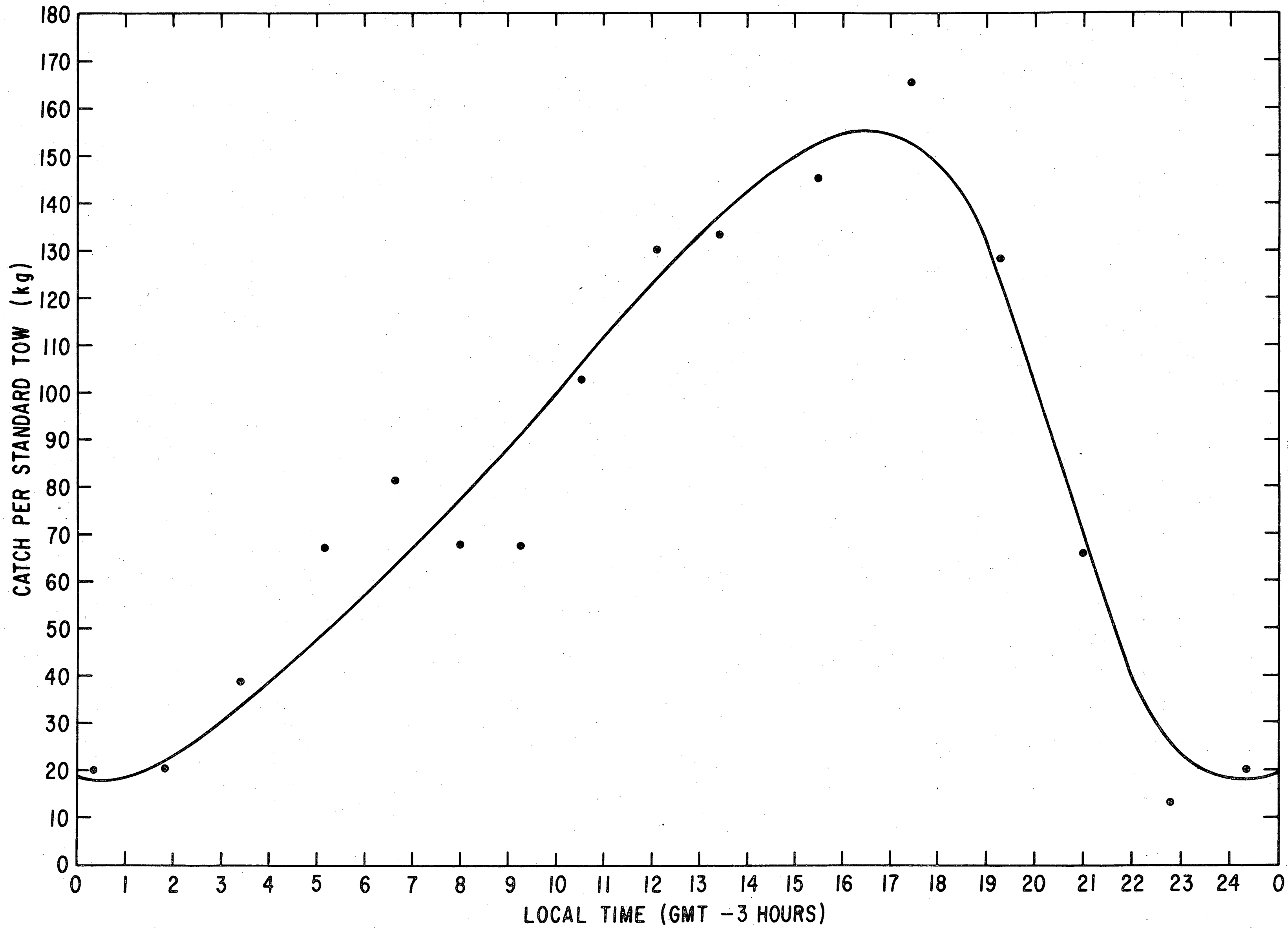


Fig. 2. Curve of diel variability - utilizes moving average of three on catch.

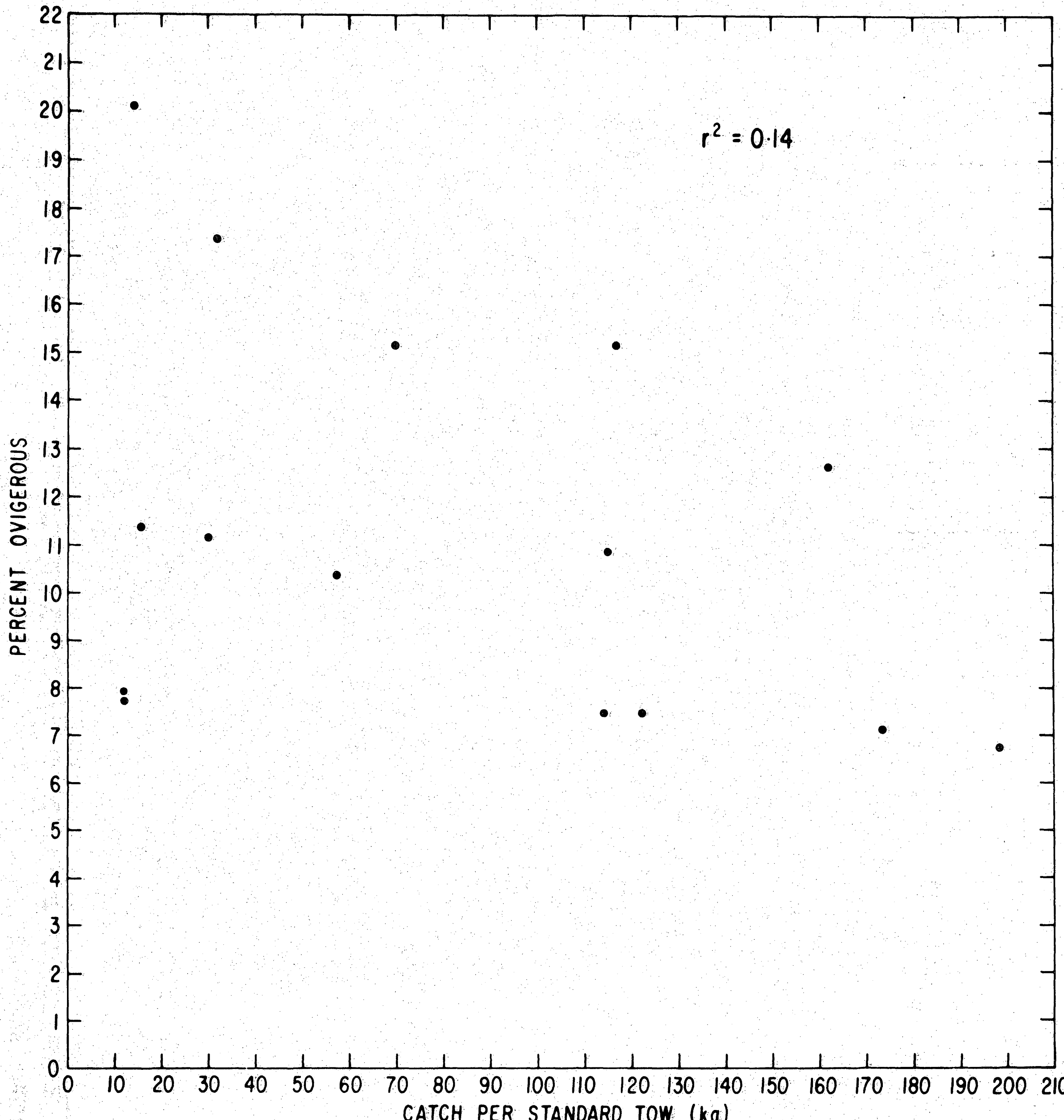


Fig. 3. Relationship between % ovigerous and catch.

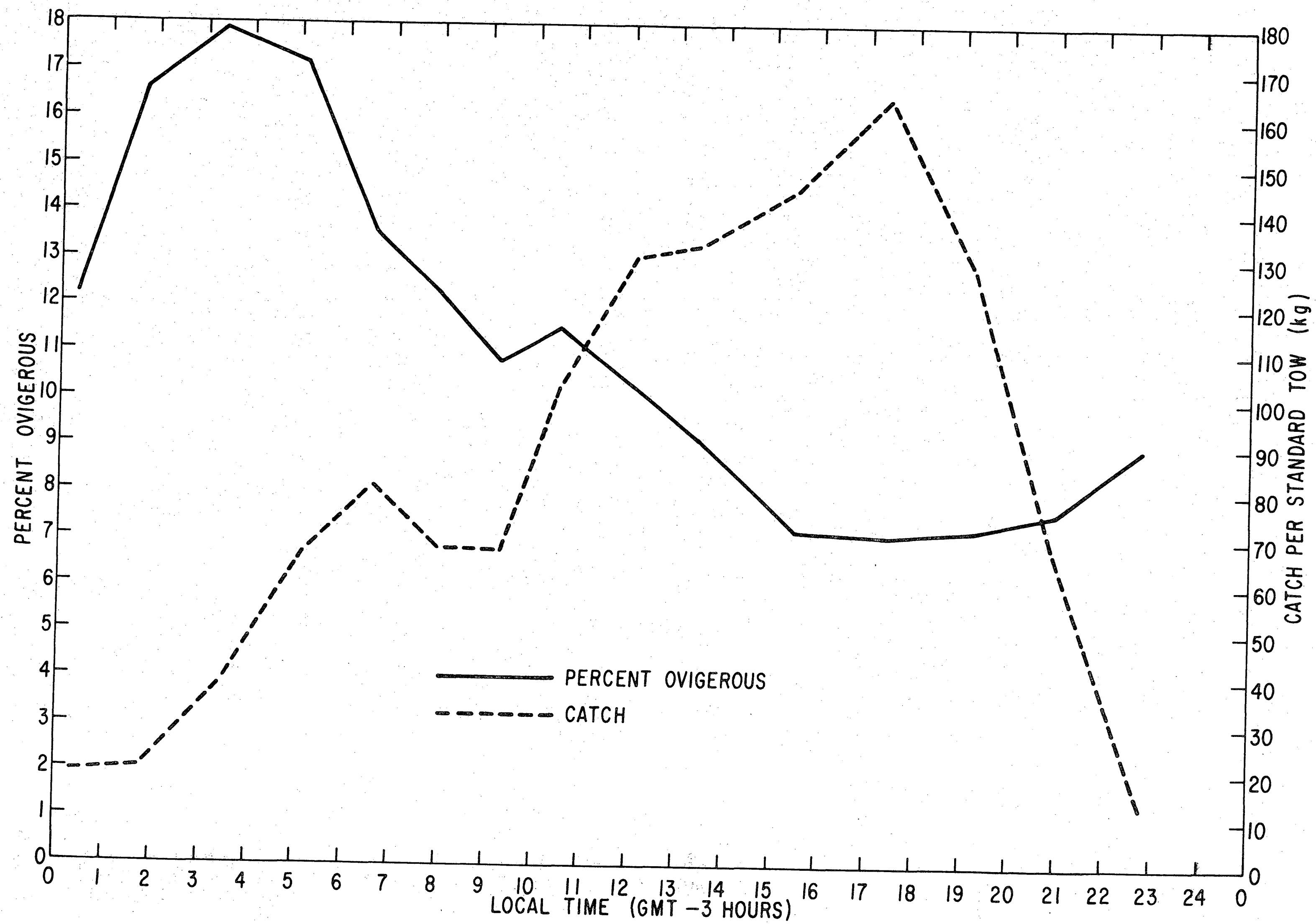


Fig. 4. % ovigerous vis-à-vis diel variability in catches (moving average of three for both).

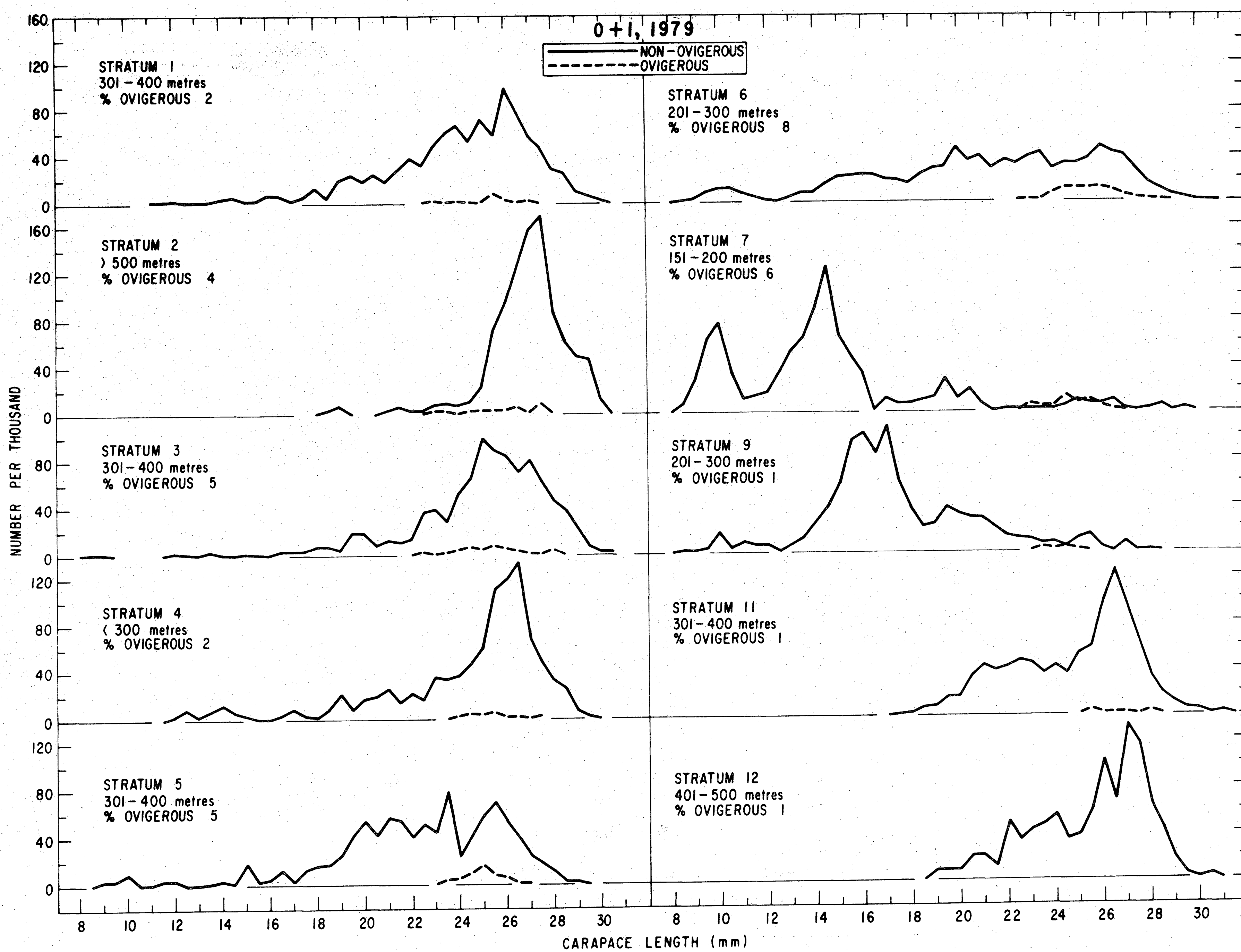


Fig. 5. Length distributions of shrimp in the surveyed area.

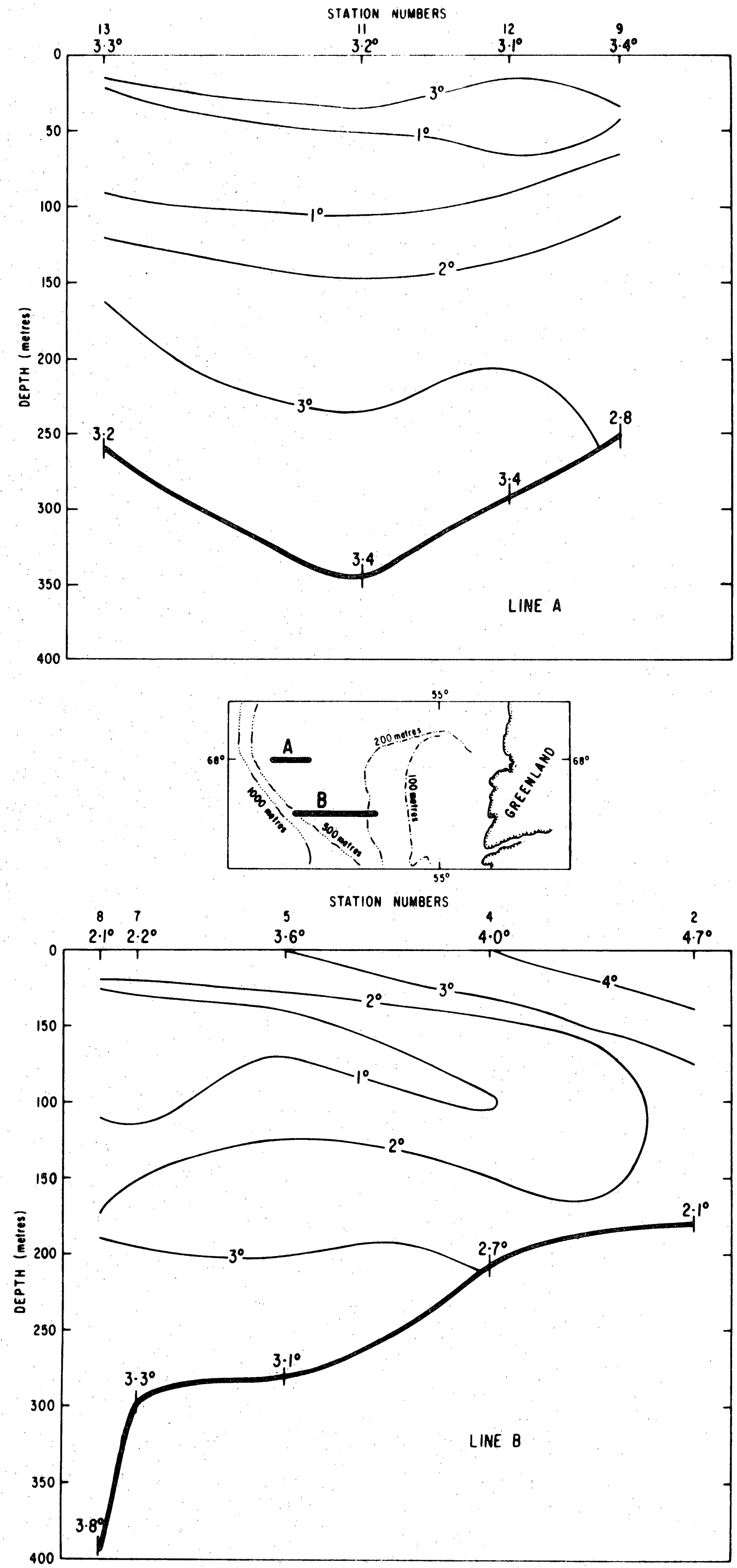


Fig. 6. Hydrographic profiles

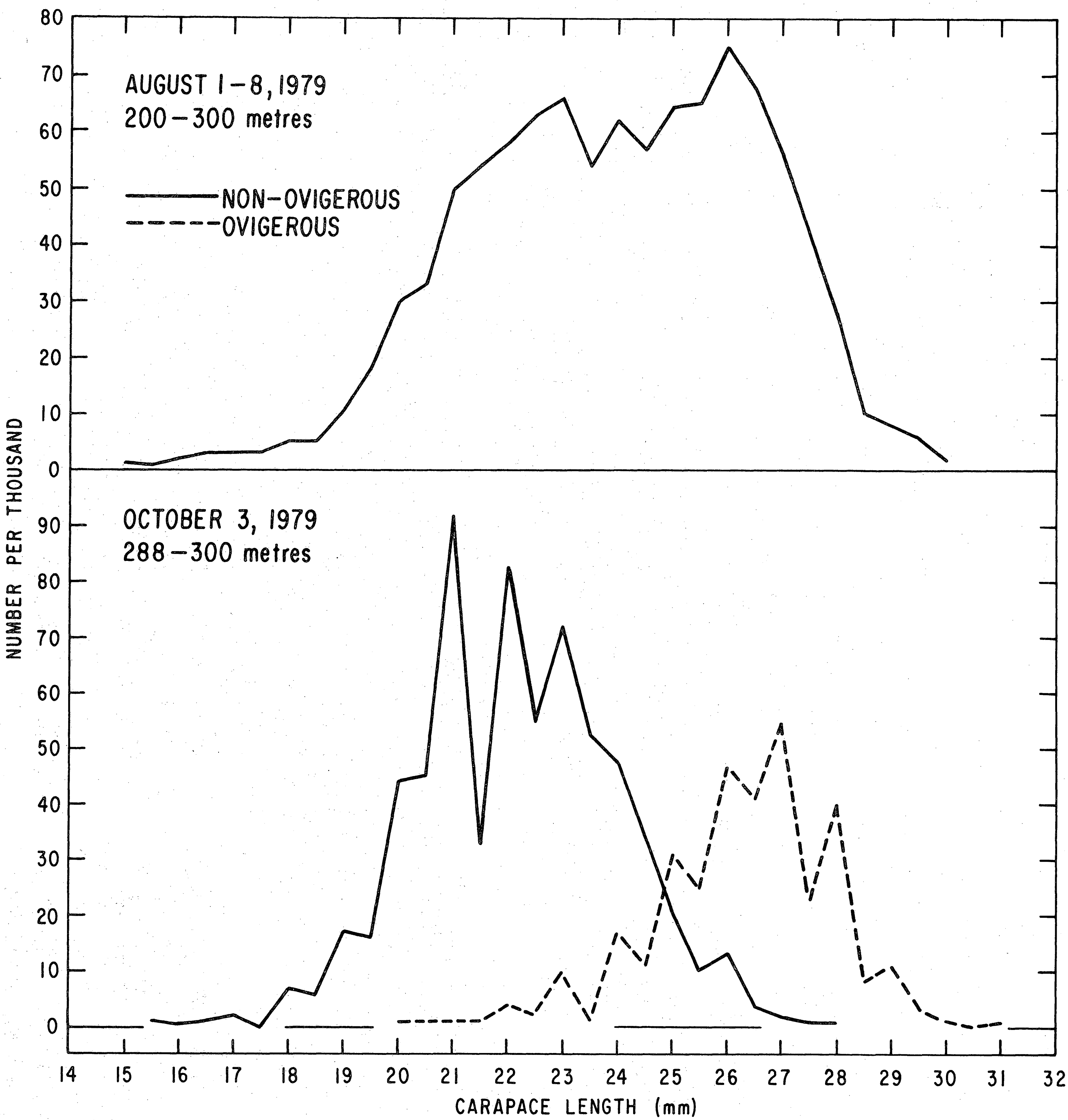


Fig. 7. Length distributions - commercial data.