Northwest Atlantic Fisheries Organization

Serial No. N524

NAFO SCR Doc. 82/VI/35

SCIENTIFIC COUNCIL MEETING - JUNE 1982

Distribution and abundance of juvenile redfish (Sebastes spp.) on Flemish Cap in winter 1982: Evidence of strong recruitment

by

G.R. Lilly and C.A. Gavaris
Research and Resource Services
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland A1C 5X1

ABSTRACT

The distribution and abundance of juvenile redfish (Sebastes spp.) on Flemish Cap in January-February 1982 were determined from the catch of a research bottom-trawl survey and from the recovery of redfish from stomachs of cod taken in the same survey. Two modes in the juvenile redfish length-frequency, at 7-8 cm and 11-12 cm, were assumed to represent 1 and 2-yr-olds respectively. Both year-classes were found primarily between 200 and 300 m, with a major concentration in the south of the bank and a lesser one in the north.

The 1978 year-class, which in 1979 appeared strong in cod stomachs and moderately strong in trawl catches, was very weak in 1980 and has remained so, indicating that juvenile mortality, probably caused largely by cod predation, can be high. The 1980 and 1981 year-classes, which appear stronger than the 1978 year-class, have been noted as strong in other areas and may provide the first successful recruitment since the early 1970's.

INTRODUCTION

In a study of factors affecting recruitment, a measure of the strength of year-classes at the early juvenile stage is necessary for determining how successful cohorts have been in passing through the larval stage and for determining whether significant and variable mortality occurs between completion of the larval stage and recruitment to the fishery. No device specifically intended to sample early juveniles quantitatively has been used to date during the study of redfish (Sebastes spp.) recruitment on Flemish Cap (NAFO Div. 3M). However, some measure of relative year-class strength in winter 1978-81 has been provided from catches of juveniles during bottom trawl surveys (Gavaris and Legge, MS 1981) and from recoveries of juveniles from stomachs of Atlantic cod, Gadus morhua (Lilly, MS 1979, MS 1980, MS 1981). The number of juvenile redfish (approximately 7-8 cm total length) was low in 1978, high in 1979, low in 1980, and high in 1981. The year-class found abundantly in 1979 was relatively rare in 1980 and 1981, suggesting that mortality of juveniles can be high.

This paper describes the length-frequency, relative abundance and distribution of early juvenile redfish caught by the trawl and recovered from cod stomachs during a bottom-trawl survey of Flemish Cap in winter 1982.

METHODS

Cod and redfish were captured during a stratified random bottom trawl survey of Flemish Cap by the chartered Canadian research trawler Gadus Atlantica during 28 January-14 February, 1982. An Engel high-rise otter trawl with 29 mm liner in the codend was trawled at 3.5 knots (108 m/min) for 30 minutes at each fishing station. Fishing was conducted on a 24 hour basis.

Most cod stomachs were excised at sea and preserved in 10% formalin. In some cases the cod were frozen whole and thawed in the laboratory before removal and preservation of the stomachs.

Examination in the laboratory involved separating food items into taxonomic categories. Fish prey were counted and measured to the nearest mm. Many small redfish had frayed or missing tail

fins but intact vertebral columns. The total length of these specimens was estimated from the following relationship which was calculated from paired measurements of vertebral length (VL) and total length (TL) in specimens with intact tails (96 specimens from the 1982 collection and 32 from the 1981 collection):

$$TL = 1.270\ VL^{0.986} \quad (r^2 = 0.99;\ n=128)$$

When it was realized during the stomach examinations that 2 size-classes were represented in the juvenile redfish length-frequency, a somewhat arbitrary division between size-classes was made at 90 mm, and all unmeasurable juveniles which appeared to be <125 mm TL were assigned to one of the 2 size-classes on the basis of apparent size. Thus, the rate of recovery (average number of redfish recovered from cod greater than 29 cm (Lilly, MS 1981)) could be calculated for each redfish size-class separately for most but not all fishing sets.

RESULTS

Length-Frequency

The length-frequencies of juvenile redfish caught by the trawl and recovered from cod stomachs revealed two distinct modes (Fig. 1, 2), which are assumed to represent successive year-classes. Redfish caught by the trawl were measured fresh to the nearest centimetre fork length, whereas those recovered from cod stomachs were measured to the nearest millimetre total length and subsequently grouped into 5 mm length groups. The modal lengths were not exactly the same, those of redfish from the trawl being at 7-8 cm and 11-12 cm (Fig. 1) and those from cod stomachs being at about 7.2 cm and 10.5-10.9 cm (Fig. 2). Redfish from cod stomachs were smaller than those from the trawl in 1981 as well (Lilly, MS 1981). Part of the difference is due to shrinkage of redfish in cod stomachs during preservation in formalin (Lilly, MS 1981), but there may also be selection toward large redfish by the trawl or selection toward small redfish by the cod, particularly the small cod (<40 cm). A further possibility in 1982 is the relative absence of cod, and hence of redfish from cod stomachs, in the region of highest abundance of small redfish in the south between 200 and 300 m. In 1981 redfish in this area tended to be larger than those obtained from shallower depths (Lilly, MS 1981), so most recoveries from cod stomachs in 1982 may have been from areas where juvenile redfish were relatively small.

Distribution

The smaller year-class was most abundant in trawl catches in the southwestern, southeastern, and northern parts of Flemish Cap in depths of 200-300 m, with some good catches as shoal as 166 m in the southwest (Fig. 3). Sets on the shallowest part of the bank did not catch any 7-8 cm redfish. In contrast, the recoveries of this year-class from cod stomachs revealed a broader distribution which included the shallowest part of the bank but lacked areas of strong concentration (Fig. 4).

The larger year-class was most abundant in trawl catches in depths of 200-300 m in a broad arc in the south and a smaller area in the north (Fig. 5). Recoveries from cod stomachs revealed a broad distribution with no areas of concentration (Fig. 6).

Abundance

Juvenile redfish were 7-8 cm in length when they were first caught in January-February bottom trawl surveys (Table 1). The catch of juveniles of this length was 2-3 times greater in 1982 than in 1981, and in both years the catch was much greater than in 1979. The year-class which appeared in 1979 was not abundant in later years, but the year-class which appeared in 1981 survived to be very strong in 1982 at a length of 10-12 cm.

The pattern of weak and strong year-classes in recoveries from cod stomachs is identical to that in trawl catches, with the strong year-classes appearing in 1979, 1981, and 1982 (Table 2). However, the order of relative strength was 1981>1979>1982. The year-class which appeared in 1979 was not found later, and the year-class which appeared in 1981 was found in 1982, but at an abundance less than in 1981 and less than the new year-class in 1982.

DISCUSSION

Length Frequency and Age Interpretation

The length frequency of juvenile redfish on Flemish Cap in winter 1982 revealed two distinct modes at 7-8 cm and 11-12 cm F.L. The ages of these fish are uncertain. Redfish of 7-8 cm, caught in 1979 and 1981, were determined by interpretation of otolith annuli to be 2 year-olds (Gavaris and

Legge, MS 1981). However, redfish intermediate in size between those taken in larval sampling gear in summer and those captured by bottom trawl in January-February have not been taken in plankton gear, in lined otter trawls, or from cod stomachs (Lilly, MS 1981). That is, if 7-8 cm redfish are 2 year-olds, they are not captured as 1 year-olds by any collecting device currently used on Flemish Cap. If, however, the 7-8 cm redfish are 1 year-olds, their growth is consistent with the interpretation of events in the Gulf of Maine, where young redfish are thought to settle to the bottom at an age of 4-5 months and an average length of 4-5 cm (Kelly and Barker, 1961). A more recent isolated dominant year-class, assumed to be the 1971 year-class, was first recorded in a bottom trawl survey in the Gulf of Maine in autumn 1971 at a modal length of 6 cm (Mayo et al., 1981).

For ease of discussion the redfish at 7-8 cm and 11-12 cm will be referred to as 1 and 2 year-olds respectively in the remainder of this paper, but the actual age of each mode may be one year greater. Resolution of this ageing problem is essential for determining how successful each year-class has been in passing through the larval phase to the demersal early juvenile phase, that is, in determining the correspondence between larvae collected in spring-summer larval surveys and juveniles collected in January-February trawl surveys.

Distribution

The recoveries of juvenile redfish from cod stomachs yielded less reliable information on juvenile distribution and abundance in 1982 than in earlier years. In 1981 the trawl catches of 1 year-old redfish and the recovery of these juveniles from cod stomachs revealed somewhat different but complementary information on juvenile distribution. Juveniles were caught in only a few trawl sets but with a distinct concentration in the southwest between 200 and 300 m (Gavaris and Legge, MS 1981). Recoveries from cod stomachs also showed a concentration in the southwest but revealed the presence of juveniles in far more sets (Lilly, MS 1981). In 1982 the trawl catches were larger than in 1981 and showed a major concentration in the south and a minor one in the north. In contrast, the cod stomach examinations in 1982 yielded lower recovery rates in individual sets than in 1981 and failed to reveal areas of juvenile concentration.

Part of the reason for lower recovery rates in individual sets in 1982 is the presence of two juvenile age groups. Where both age groups occur in cod from a given set, the recovery rate of each age group must be lower than the total recovery rate. Recovery rate is also dependent on cod size (Lilly, MS 1981), and the 1982 sample contained a higher proportion of small cod than earlier samples. (For example, the size range 30-35 cm contributed 24.4% of the total sample in 1982 compared to just 3.5% in 1981). A further reason is a possible reduction in the degree of spatial overlap between cod and juvenile redfish. In 1982, catches of cod were nil or very small in areas of highest catches of juvenile redfish.

Both year-classes on Flemish Cap in winter 1982 were most abundant in the 200-300 m depth range, with largest catches in the south of the bank and a second area of lesser concentration in the north. Recoveries from cod stomachs showed 1 year-olds to be more abundant than 2 year-olds in depths less than 200 m, but neither year-class was abundant at this depth in trawl catches. The 2 year-olds were more abundant than 1 year-olds in depths greater than 300 m. Thus, the two age-classes overlapped considerably in distribution, with both groups sometimes occurring abundantly in the catch and in cod stomachs in the same set, but the 2 year-olds tended to be more deeply distributed.

Abundance and Year-Class Strength

The relative strength of the year-classes cannot be determined with confidence from either catches in the bottom trawl or recoveries from cod stomachs. Catches tend to be strongly skewed. For example, the difference between catch rates in 1979 and 1981 (Table 1) was due primarily to one very large catch in 1981 (Gavaris and Legge, MS 1981). The recovery rate from cod stomachs is influenced by many factors, including the size of cod examined, an upper limit to the ingestive capacity of cod, the degree of spatial overlap between cod and juvenile redfish, and the presence of alternate prey, including other year-classes of juvenile redfish.

Even with these limitations it is clear that the 1977 and 1979 year-classes were weak as 1 year-olds. The 1978 year-class appeared strong in cod stomachs but only moderate in the catches. It declined to a low level by 1980. The 1980 year-class was strong in both catches and cod stomachs, and was even more abundant as 2 year-olds in the catch in 1982. The 1981 year-class appeared strong as 1 year-olds.

This variable year-class success might be attributable in part to predation on juveniles. The 1977 and 1979 year-classes presumably did not pass successfully through the larval stage. The 1978 year-class was sufficiently successful in the larval stage to be abundant as early juveniles. However, it was found in large numbers in cod stomachs in three surveys in 1979 (January-February, March, April-May) (Lilly, MS 1980), and by January 1980 its abundance was very low. The demise of

this year-class is likely due to predation by cod and possibly other predators, including adult redfish (Kashinstev, 1962; Gavaris & Legge, MS 1981), but other factors such as inadequate food supply or physical environmental effects (Akenhead, MS 1978; Anon, MS 1980) may have contributed.

The 1980 year-class was abundant as 1 year-olds but, unlike the 1978 year-class, it survived in large numbers as 2 year-olds. This success may be due to (1) greater numbers surviving the larval stage and then swamping the ingestive capacity of predators or (2) decreased predation on juveniles resulting from either a decrease in predator abundance or the appearance of a strong succeeding year-class as alternate prey. The 1981 year-class is initially strong in the catches, and again this could be due to high success in the larval stage or moderate success in the larval stage coupled with reduced predation in the early juvenile stage. It is unlikely that these various possibilities can be distinguished without population estimates at the early demersal stage (perhaps October or November of first year) and seasonal information on mortality from predation.

Synchrony of Strong Year-Classes

Although predation on juveniles appears to be important in reducing abundance of a year-class, it would seem that such predation is not the major factor affecting redfish recruitment, for strong year-classes appear synchronously over wide geographic areas. The two strong modes at 7-8 cm and 11-12 cm found on Flemish Cap in winter 1982 were also abundant in the catch of a research survey on the Scotian Shelf in March-April 1982 (T. Kenchington, Bedford Institute of Oceanography, Dartmouth, N.S., pers. comm.). A strong mode at 7-8 cm was also caught in research surveys in winter 1981 in the Gulf of St. Lawrence and on St. Pierre Bank (unpubl. data). These juveniles would represent the 1980 year-class. In October-November 1981 small redfish (67-70 mm TL) were very abundant in stomachs of cod taken by line-trawl off Placentia Bay and Cape St. Mary's, southern Newfoundland. Fishermen reported that whales and large numbers of seabirds were feeding on these juveniles, and that these fish had not been seen previously in this area. These juveniles may represent the 1981 year-class. In all these areas these recent year-classes represent what may become the first successful redfish recruitment since the early 1970's.

A series of successful year-classes centered on 1971 or 1972 appears in the age compositions of commercial or research vessel catches from Flemish Cap (Gavaris, MS 1981), St. Pierre Bank (Atkinson, et al., MS 1981) and Gulf of St. Lawrence (McKone, et al., MS 1981). In the Gulf of Maine a dominant year-class appeared in research vessel catches in 1971, and length-frequencies from research vessel catches before and since 1971 have shown this to be an isolated successful year-class (Mayo, 1980). It is possible that the apparent series of successful year-classes in other areas is an artifact of errors in ageing, and that there was in these areas, as in the Gulf of Maine, a single dominant year-class in 1971. Research vessel catches in the early 1970's should be examined to confirm or negate this possibility.

It is possible to go back even further in comparing recruitment on Flemish Cap with that in the Gulf of Maine. Templeman (1976) examined length frequencies from research surveys and commercial sampling on Flemish Cap from 1958 to 1974 and concluded that there had been 3 moderately successful year-classes, in 1952, 1953, and 1957, a very successful year-class in 1959 (or a pair of successful year-classes in 1959-60), and another pair of highly successful year-classes in 1963-64. Mayo (1980) examined research vessel length frequencies from 1963 to 1978 and age-length keys from surveys in 1975-77 and concluded that in the Gulf of Maine there had been strong year-classes in 1953 and 1963 and some moderately strong year-classes in the late 1950's. In both areas there was no further strong recruitment until 1971 (or at least the early 1970's). Considering the possibility that the slow growth of redfish may result in some error in assignment of nominal year-class to the modes, the similarity between Flemish Cap and Gulf of Maine is most striking.

The appearance of strong redfish year-classes synchronously over wide geographic areas supports the hypothesis that some broad scale physical factor operating at the larval stage is the major mechanism promoting the production of large year-classes.

ACKNOWLEDGEMENTS

We wish to thank C. Mullins, who examined the cod stomachs, summarized the data therefrom, and helped prepare the illustrations. We also thank R. Wells (Scientist-in-charge), and technicians aboard the Gadus Atlantica during the 1982 survey.

REFERENCES

Akenhead, S.A. MS 1978. Report of the Canadian planning group of the Flemish Cap International Experiment meeting, St. John's, Newfoundland, 12-14 September 1977. ICNAF Res. Doc., No. 80, Ser. No. 5267, 51 p.

Anon, MS 1980. Report of ad hoc working group on the Flemish Cap Project, January 1980. NAFO SCS Doc., No. 9, Ser. No. N109, 6 p.

Atkinson, D.B., W.E. Legge, and P. Stead. MS 1981. The redfish stock in NAFO Division 3P. CAFSAC Res. Doc. 81/59, 21 p.

Gavaris, C.A. MS 1981. An assessment of redfish on the Flemish Cap. NAFO SCR Doc., No. 53, Serial No. N337, 7 p.

Gavaris, C.A., and W.E. Legge. MS 1981. Distribution and abundance of small redfish on the Flemish Cap. NAFO SCR Doc., No. 119, Serial No. N425, 12 p.

Kashintsev, M.L. 1962. Some notes on rosefish feeding in the Newfoundland area, In: Soviet Fisheries Investigations in the Northwest Atlantic, VINRO-PINRO, Moscow. (Israel Program to Scientific Translation, 1963).

Kelly, G.F., and A.M. Barker. 1961. Vertical distribution of young redfish in the Gulf of Maine. ICNAF Spec. Publ. 3: 220-233.

Lilly, G.R. MS 1979. Observations on the food of cod (Gadus morhua L.) on the Flemish Cap in winter. ICNAF Res. Doc., No. 70, Ser. No. 5412, 10 p.

MS 1980. Distribution and relative abundance of juvenile redfish (Sebastes sp.) on the Flemish Cap in 1978-80 based on information from cod stomachs. NAFO SCR Doc., No. 143, Ser. No. N217, 14 p.

MS 1981. Distribution and relative abundance of juvenile redfish on the Flemish Cap in 1978-81 based on recoveries from cod stomachs. NAFO SCR Doc., No. 118, Serial No. N424, 15 p.

Mayo, R.K. 1980. Exploitation of redfish, Sebastes marinus (L), in the Gulf of Maine-Georges Bank region, with particular reference to the 1971 year-class. J. Northw. Atl. Fish. Sci. 1: 21-37.

Mayo, R.K., V.M. Gifford, and A. Jearld Jr. 1981. Age validation of redfish, Sebastes marinus (L), from the Gulf of Maine-Georges Bank region. J. Northw. Atl. Fish. Sci. 2: 13-19.

McKone, W.D., C. Gavaris, and W.E. Legge. MS 1981. Redfish assessment for Divisions 4RST. CAFSAC Res. Doc. 81/58, 18 p.

Templeman, W. 1976. Biological and oceanographic background of Flemish Cap as an area for research on the reasons for year-class success and failure in cod redfish. ICNAF Res. Bull. 12: 91-117.

Table 1. Stratified mean catch per tow at length in numbers for small redfish (<16 cm) in research bottom-trawl surveys on Flemish Cap, January-February, 1978-82.

Length (cm)	1978	1979	1980	1981	1982
5					
6		0.14	0.01	0.04	1.14
7		1.67	0.04	36.10	66.84
8		1.39	0.20	34.51	100.43
9	0.01	0.18	0.16	0.06	14.53
10	0.02	0.35	0.22	0.04	101.27
11	0.08	1.34	0.08	0.11	250.83
12	0.32	0.67	0.10	0.18	182.92
13	0.80	0.22	0.36	0.16	40.15
14	1.33	0.49	0.29	0.13	1.69
15	1.39	0.87	0.24	0.09	0.56

Table 2. Mean number of redfish in two size-classes[1] recovered from cod (>29 cm) caught during research bottom-trawl surveys on Flemish Cap, January-February, 1978-82.

Length (mm)	1978	1979	1980	1981	1982
45-89	0.12	2.85	0.04	3.51	1.35
90-124	0.0	0.28[1]	0.0	0.02	1.08
Total	0.12	3.13	0.04	3.53	2.43

[1] When the size-classes of some specimens in a set were not known, these specimens were assigned to the two size-classes in the same ratio as specimens whose correct size-class categorization was known. This will result in some error. The value for the larger size-class in 1979 is almost certainly too high.

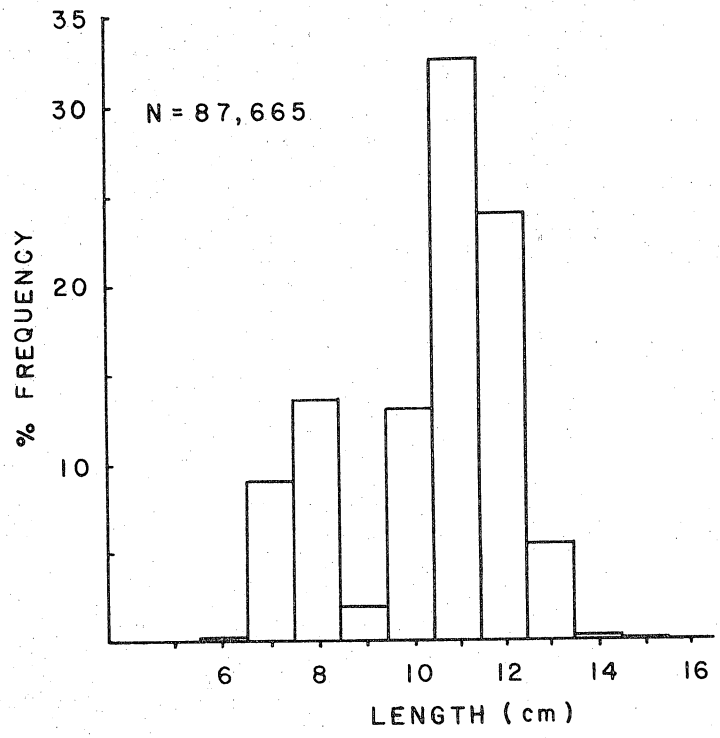

Fig. 1. Length frequency of juvenile redfish caught by the trawl in January-February, 1982.

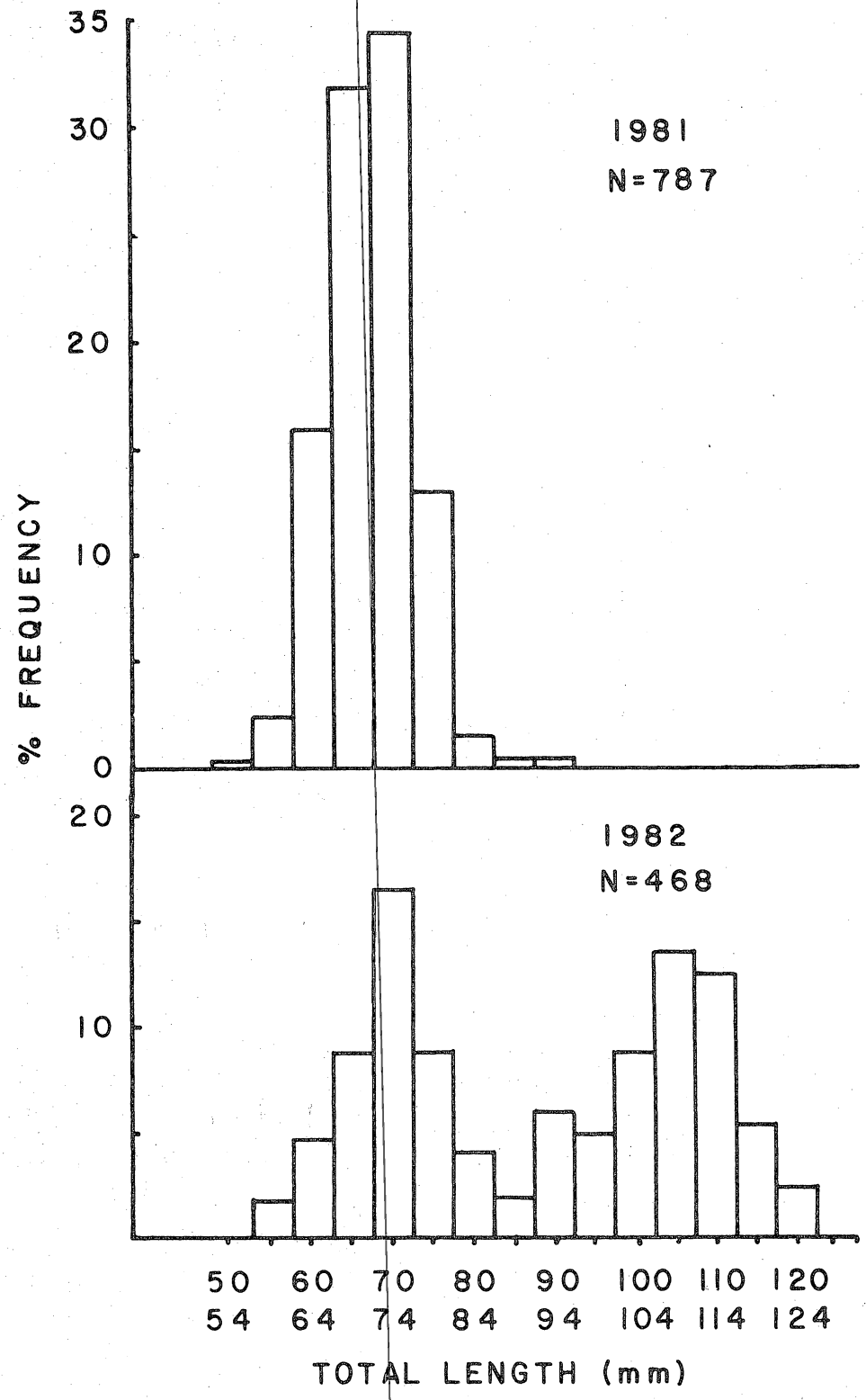

Fig. 2. Length frequencies of juvenile redfish recovered from stomachs of cod caught in January-February, 1981-82.

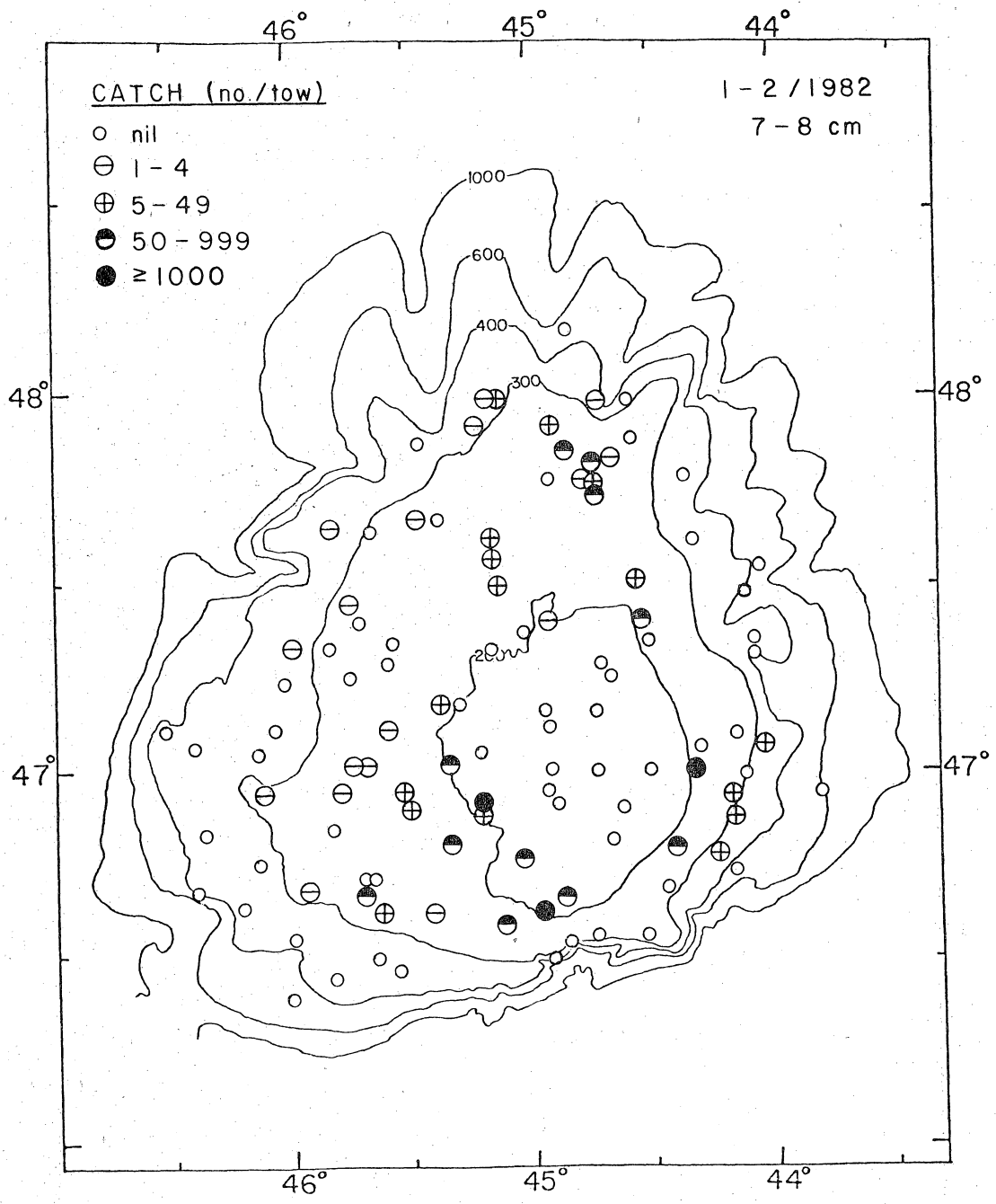

Fig. 3. Distribution of 7-8 cm (FL) redfish (representing presumed 1 year-olds) as determined from trawl catches in January-February, 1982.

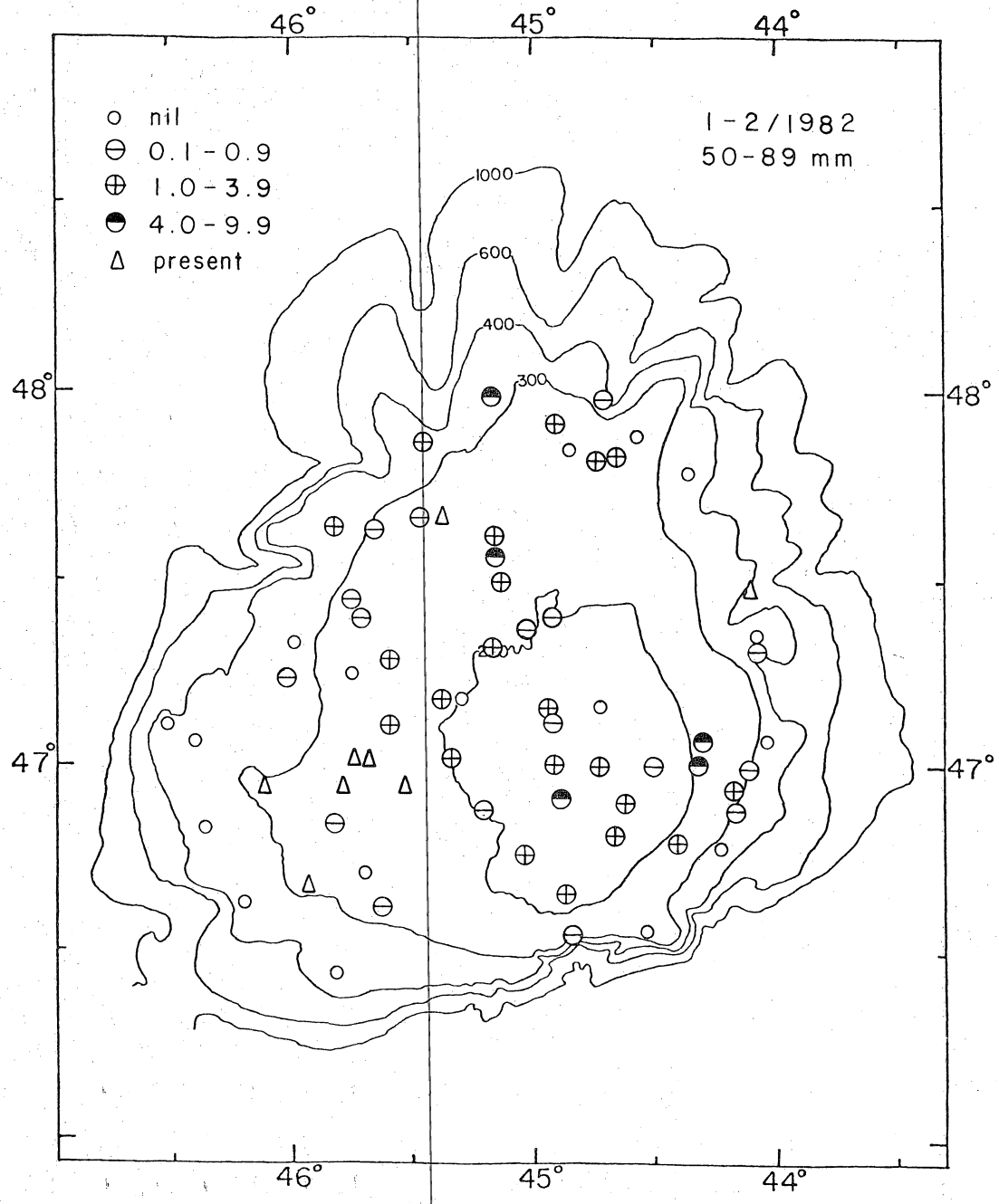

Fig. 4. Distribution of 50-89 mm (TL) redfish as determined from the recovery rate from cod stomachs in January-February, 1982. (Triangles indicate positions where the size-class was recorded but numbers were not counted.)

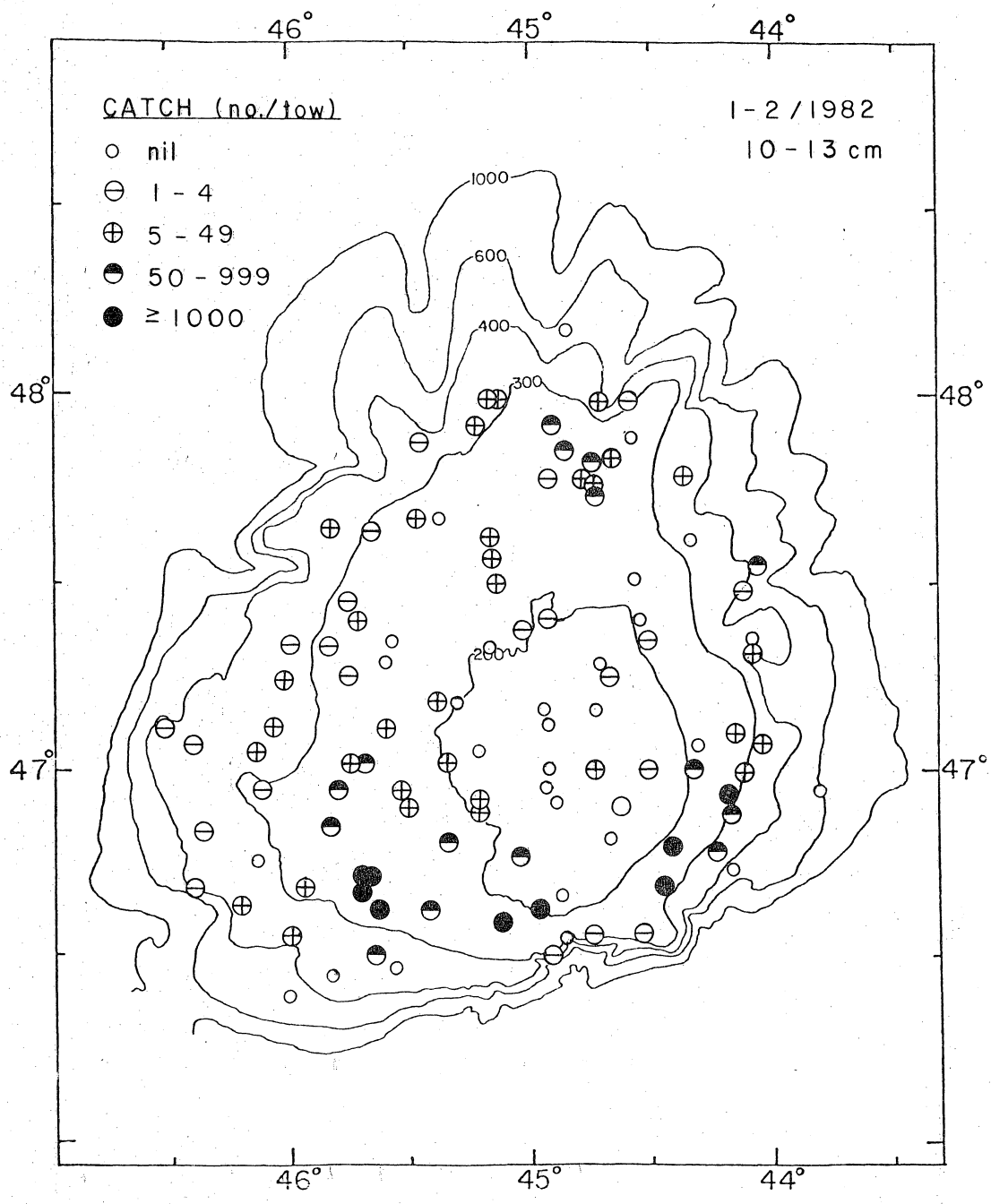

Fig. 5. Distribution of 10-13 cm (FL) redfish (representing presumed 2 year-olds) as determined from trawl catches in January-February, 1982.

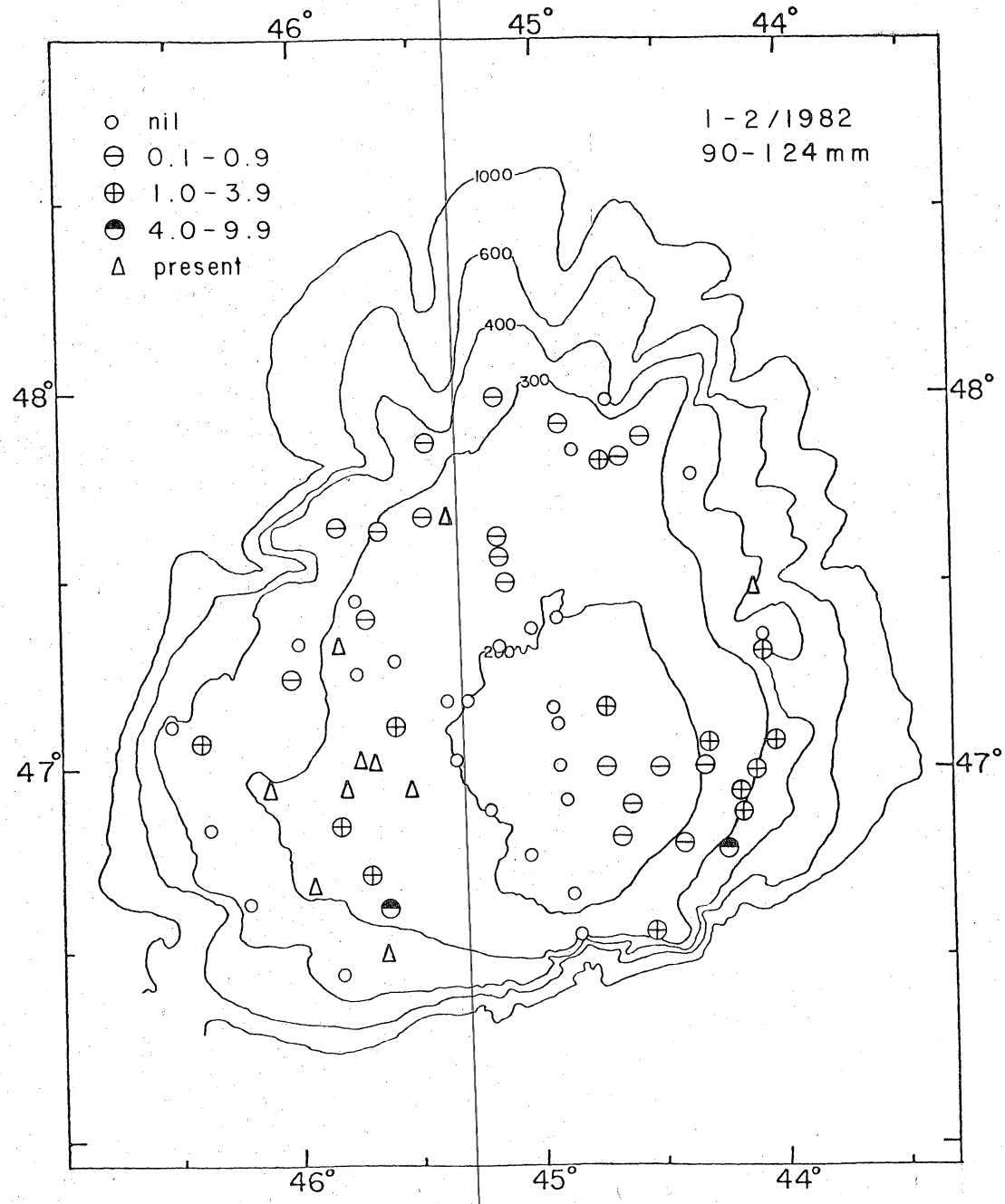

Fig. 6. Distribution of 90-124 mm (TL) redfish as determined from the recovery rate from cod stomachs in January-February, 1982.