INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No.1536
(D. c. 9)

Research Document No.68

ANNUAL MEETING - JUNE 1965

Trends in the haddock fishery of Subarea 3

by V. M. Hodder
Fisheries Research Board of Canada
Biological Station, St. John's
Newfoundland, Canada

Introduction

Although haddock were known to be abundant on the southern part of the Grand Bank (ICNAF Divisions 3N and 3O) in the 1930's (Thompson, 1939), exploitation of the stock did not begin on a large scale until 1946, after which landings increased rapidly to 80 thousand tons in 1949 (Fig. 1). As is usual after the initial exploitation of a virgin stock, the decline in numbers of large fish in the catches and some relaxation in fishing effort resulted in a decline in haddock landings to 43 thousand tons in 1953. Up to that time most of the haddock landed were taken on the Grand Bank portion of Subarea 3. However, the recruitment to the fishery of a very abundant year-class resulted in haddock being abundant not only on the Grand Bank (3N and 3O) but also on St. Pierre Bank (3P). A great increase in fishing intensity subsequently occurred and by 1955 landings had reached a peak of 105 thousand tons. This was again followed by a decline to 35 thousand tons in 1959. In 1960 and 1961 landings rose to 66 thousand and 80 thousand tons respectively but dropped to 35 thousand tons in 1962 and 14 thousand tons in 1963.

Except for very insignificant quantities taken inshore along the south coast of Newfoundland, the haddock fishery is strictly an offshore

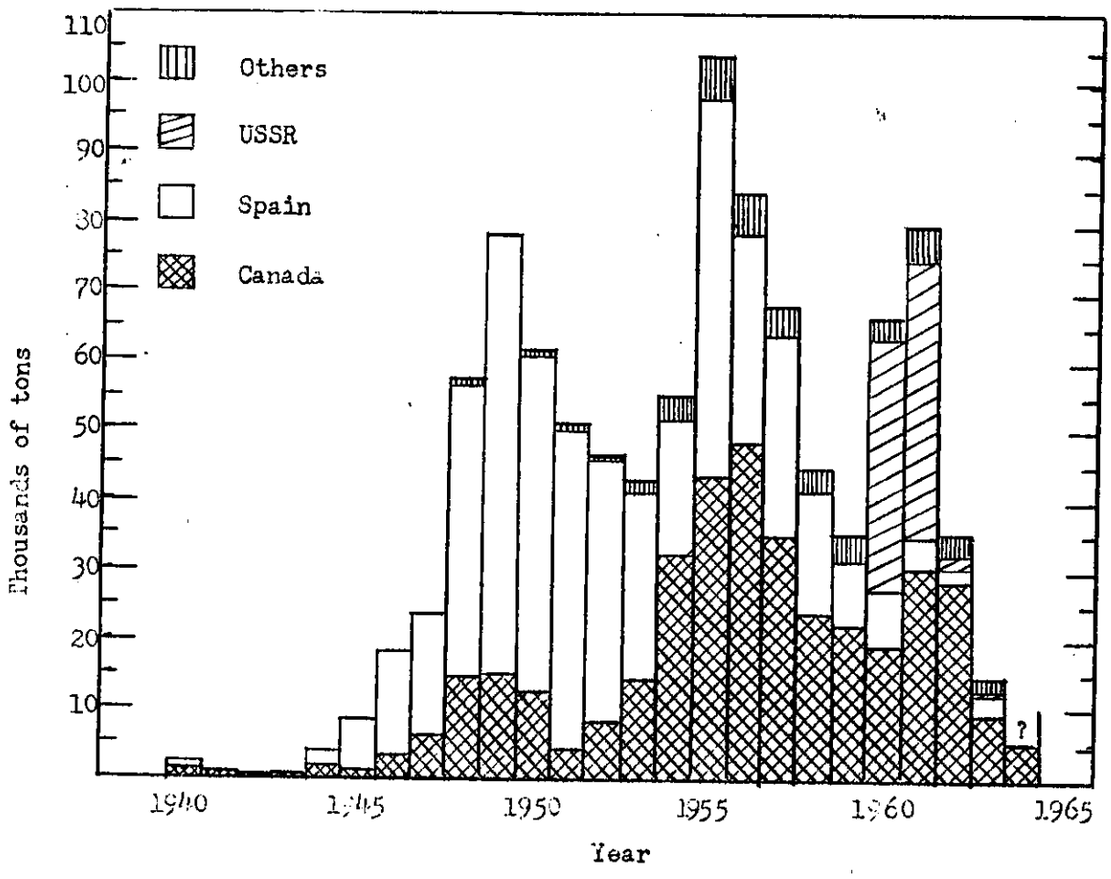

Fig. 1. Landings of haddock from the Newfoundland offshore banks (Subarea 3) during 1940-1963 (Nfld. landings only for 1964).

trawl fishery, which up to 1959 was carried on almost exclusively by Canadian and Spanish trawlers. In 1960 and 1961 USSR trawlers entered the haddock fishery and landings increased substantially in these years, but since then they have decreased to the lowest level since the start of the fishery.

Early in the exploitation of the Subarea 3 haddock stocks biologists of the St. John's Biological Station initiated length and age sampling of the commercial landings. Also by means of log books placed on board of most of the trawlers landing in Canadian (Nfld.) ports, statistics of landings and effort for the major commercial species, including haddock, have been available since about 1954, and these are the only effort statistics pertinent to the Subarea 3 haddock fishery, since Spanish and USSR data pertain to mixed fisheries with no separation of the effort devoted mainly to haddock fishing. This is unfortunate as we shall see later since the Canadian fishery takes place mainly during the winter and spring in Division 3O while the Spanish and USSR fisheries for haddock usually take place during summer and autumn in 3N.

This paper presents the results of a preliminary analysis of the available length and age data and an assessment of the stocks in so far as it is possible from the information available. While some data for the St. Pierre Bank stock are presented, emphasis has been placed on the Grand Bank stock which has been the mainstay of the haddock fishery during its short history.

Nature of the Subarea 3 haddock stocks

In Subarea 3, where the most northern of the haddock stocks of the Northwest Atlantic are located, the main haddock fishery normally occurs on the southern half of the Grand Bank in 3N and 3O (Fig. 2) but during the period 1954-56 there was a substantial fishery for haddock on St. Pierre Bank in Division 3P as well (Table 1), almost exclusively on the very abundant 1949 year-class. Only small quantities of haddock were landed from the latter bank before 1953 and no significant fishery for haddock has taken place there since 1957.

Growth and otolith studies indicate that the adult haddock on the Grand Bank and on St. Pierre Bank are relatively distinct groups. Some mixing may occur on the slope area in the deep water (south of Green Bank) between the Grand Bank and St. Pierre Bank, but the generally low temperature of the water (<0°C) in the channel between the 2 banks tends to limit the extent of mixing. Since haddock were not known to exist in abundance on St. Pierre Bank prior to 1950, it is the author's opinion that the water current pattern, immediately following the Grand Bank spawning in 1949, was such that haddock larvae in great numbers drifted in the general direction of St. Pierre Bank and the young settled on the bottom there in the autumn of 1949, the population subsequently developing its own distinctive growth characteristics. There has been no significant survival of year-classes on St. Pierre Bank since 1949 and no significant fishery since 1957, when the abundance of the 1949 year-class was reduced to a low level.

The Grand Bank (3N and 3O) stock, which has been the mainstay of the haddock fishery over the course of its short history, is usually located along the southwest slope (3O) during winter and spring, when the shallow areas of the bank are covered by cold water of unfavourable temperatures, generally less than 1°C (Templeman and Hodder, 1965); the haddock are thus concentrated in depths greater than 50 fathoms along a narrow band of the southwest slope, where most of the haddock landed by Canadian vessels are taken. Usually by June, sometimes earlier, when the shallow bank water has warmed sufficiently, the winter and spring concentrations disperse and most of the haddock move eastward across the Grand Bank coincident with the incursion of slope water (Templeman and Hodder, 1965). By midsummer and later haddock are usually concentrated again but now on the southeast shoal of the Grand Bank (3N) in shallow water of about 25 fathoms, where they feed largely on capelin and capelin eggs. Here they were exploited almost exclusively by Spanish trawlers up

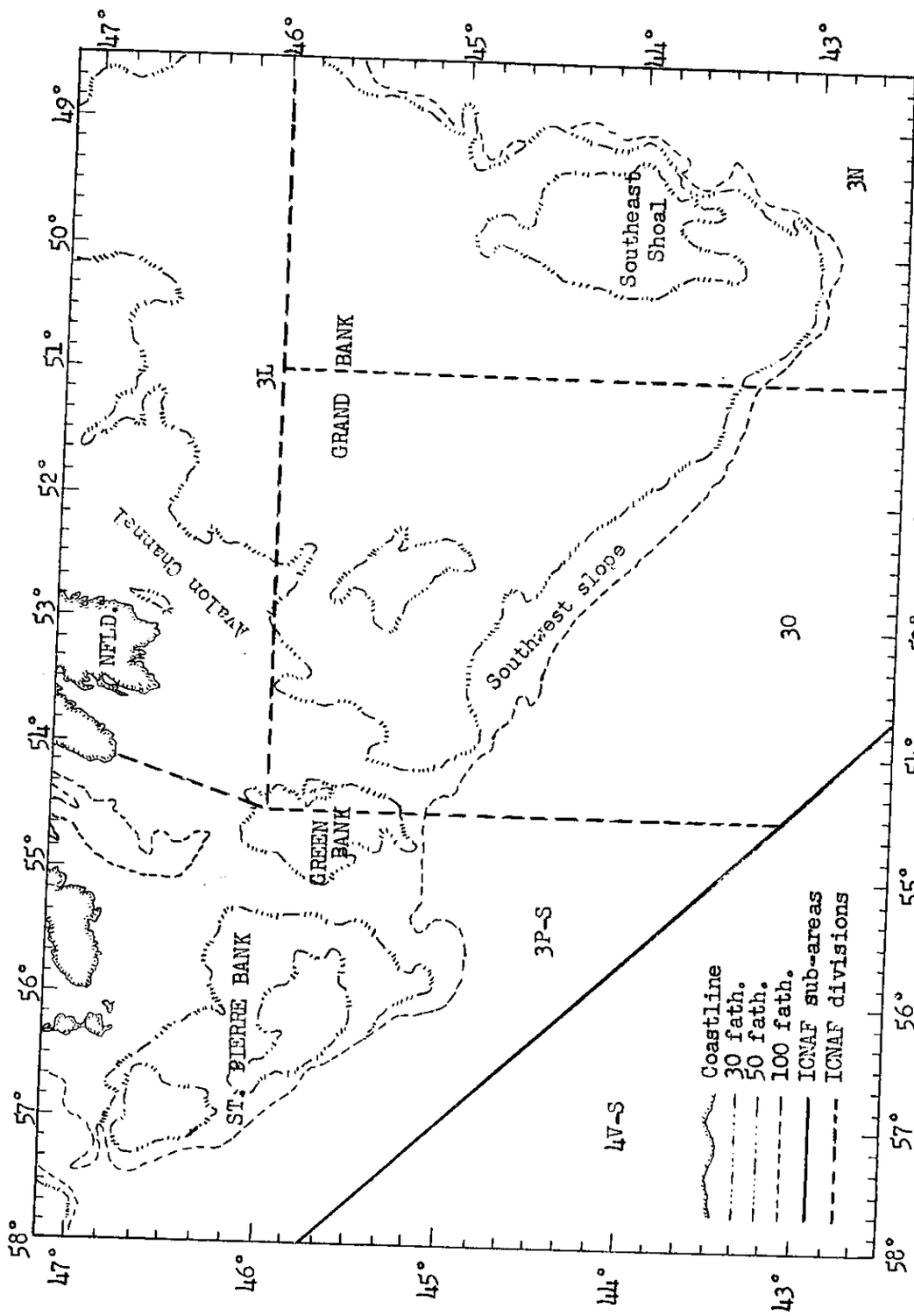

Fig. 2. Map of the southern part of Subarea 3 showing the location of places mentioned in the text.

to 1959 and by Russian trawlers in 1960 and 1961. As the autumn progresses and the shallow bank water becomes colder, the haddock are gradually forced to retreat to their winter-quarters in the deeper water along the southwest slope of the Bank. The above is generally the picture, but hydrographic conditions are variable and the haddock schools may in an unusually cold year remain concentrated along the slope for a longer than normal period, thus favouring the spring fishery for them; in an unusually warm year the haddock may disperse earlier in the spring and remain spread out over the bank for a longer than normal period, thus hampering the fishery.

Table 1. Subarea 3 haddock landings by country, 1954-64.

	Grand Bank (mainly 3N-O)					St. Pierre Bank (3P)					Division NK Others	Subarea 3 Total
	Canada	Spain	USSR	Others	Total	Canada	Spain	USSR	Others	Total		
1954	5,760	18,665	-	1,285	25,710	26,510	685	-	4	27,199	2,426*	55,335
1955	3,205	40,146	-	966	44,317	39,948	15,637	-	2,212	57,797	2,357*	104,471
1956	23,219	26,817	-	460	50,496	25,177	3,531	-	1,232	29,940	3,846*	84,282
1957	30,332	27,655	-	397	58,384	4,271	1,474	-	334	6,079	3,623*	68,086
1958	23,037	16,789	-	147	39,973	368	496	-	92	956	3,455*	44,384
1959	20,604	7,604	-	144	28,352	1,726	956	-	95	2,777	3,911*	35,040
1960	16,984	5,854	36,306	3,135	62,279	1,986	1,945	-	228	4,159	46	66,484
1961	29,366	2,953	39,913	4,559	76,791	1,048	1,530	-	280	2,858	5	79,654
1962	27,653	1,645	1,614	2,489	33,401	768	613	-	176	1,557	187	35,145
1963	8,563	2,207	369	1,187	12,326	712	1,003	3	300	2,018	87	14,431
1964+	5,784	1,255	1,945	810	9,794	1,083	650	—	625	2,358	—	12,152

* Mostly 151-500 OT of France (St. P. & M.)

+1964 landings provisional.

C 5

47

Index of relative abundance

As an index of relative abundance, the only landing-per-unit-effort data available are those for Canadian (Nfld.) trawlers since 1954. While the ICNAF Statistical Bulletins contain effort data for trawlers of other countries (mainly Spain and USSR) which have exploited the Subarea 3 haddock stocks, it has not been possible to utilize such data in this analysis because they pertain to mixed fishing with no separation of effort devoted mainly to haddock. Consequently the landings-per-unit-effort are based on statistics of effort and landings which represent less than 40% of the total haddock yield during 1954-63. Although a few trawlers of the 51-150 tonnage class participated in the Canadian fishery for haddock at various times, the effort and landing data are essentially those for trawlers of the 151-500 tonnage class into which most of the Newfoundland trawlers fall.

The landings, estimated effort in hours fished, and landings-per-unit-effort for the entire Canadian fleet during 1954-63 are shown (cross-hatched) in Fig. 3, together with the total annual haddock landings and estimated annual effort, the latter value having been obtained by dividing the total annual landings by the corresponding landings-per-hour-fished of Canadian (Nfld.) trawlers.

On St. Pierre Bank the landing-per-unit-effort was at a high level (approximately 2 tons per hour) during 1954-56, but it rapidly decreased to a low level after 1957 and the haddock fishery there has been negligible since then.

On the Grand Bank the best and most consistent fishing occurred during 1955-57 (averaging 1.7-2.2 tons per hour). In 1958 and 1960 the average landings-per-hour-fished were down to 1.1 and 0.9 tons respectively, but during 1959 and 1961 they were near the 1955-57 level. The low values in 1958 and 1960 were due largely to hydrographic conditions in the winter and spring (water temperatures being higher than usual and haddock being thus less concentrated in the fishing areas than normal). However, the rapid decline in landing-per-unit-effort after 1961 is most certainly due to decreased abundance of commercial-sized haddock.

Year-class survival

For purposes of studying the contribution of year-classes to the commercial haddock fishery, length and age sampling of commercial landings was begun in the early 1950's and continued to the present time. Except for the discarding of unmarketable fish at sea, haddock are landed without culling into market categories. During the unloading process a "grab" sample of 300-400 haddock is usually taken, from which length measurements are obtained together with otoliths and scales from a random sample of 1 in 10 of these for subsequent age determinations. All ages are based on otolith readings by the author, who in innumerable cases also read the scales to verify ages when there was the slightest doubt in otolith interpretations.

Since the current interest in haddock is focused on the state of the Grand Bank stock (the transitory fishery on St. Pierre Bank having been largely due to the abundance of one year-class), only the year-class survival of Grand Bank haddock is considered here. Table 2 gives the number of samples and numbers of haddock measured and aged for the January-June period of 1955-63, and in Fig. 4 are shown the corresponding length and age compositions in terms of the average landings-per-unit-effort. The age compositions were obtained by applying age-length keys to the corresponding length compositions. The January-June period was selected for comparison of abundance of year-classes in successive years, because it is the period of the most intensive fishery by Canadian trawlers and also because it is the period when growth is practically negligible.

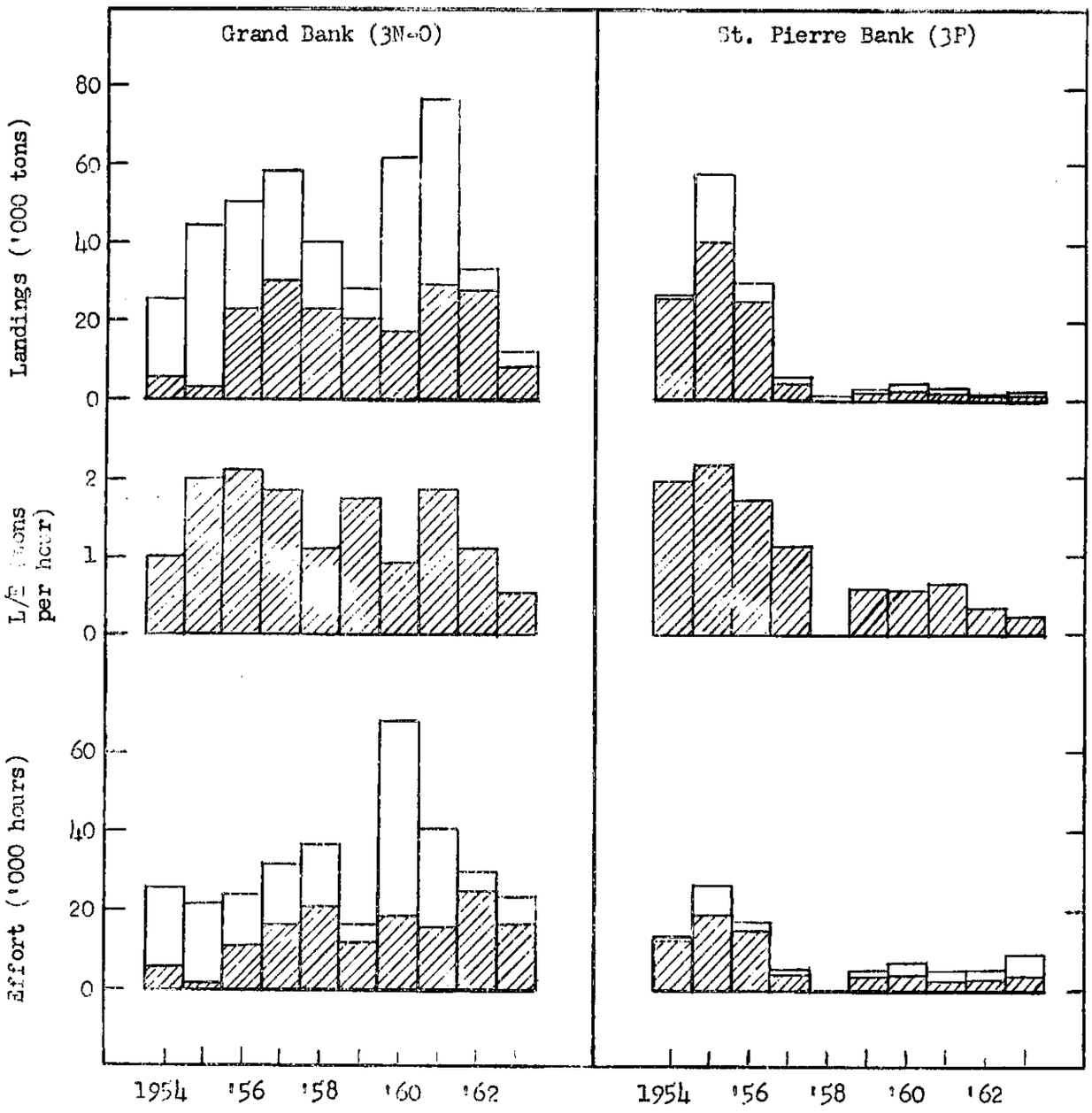

Fig. 3. Haddock landings, landings-per-unit-effort of Newfoundland trawlers, and estimated effort for the period 1954-63 in Subarea 3 (Canadian data cross-hatched).

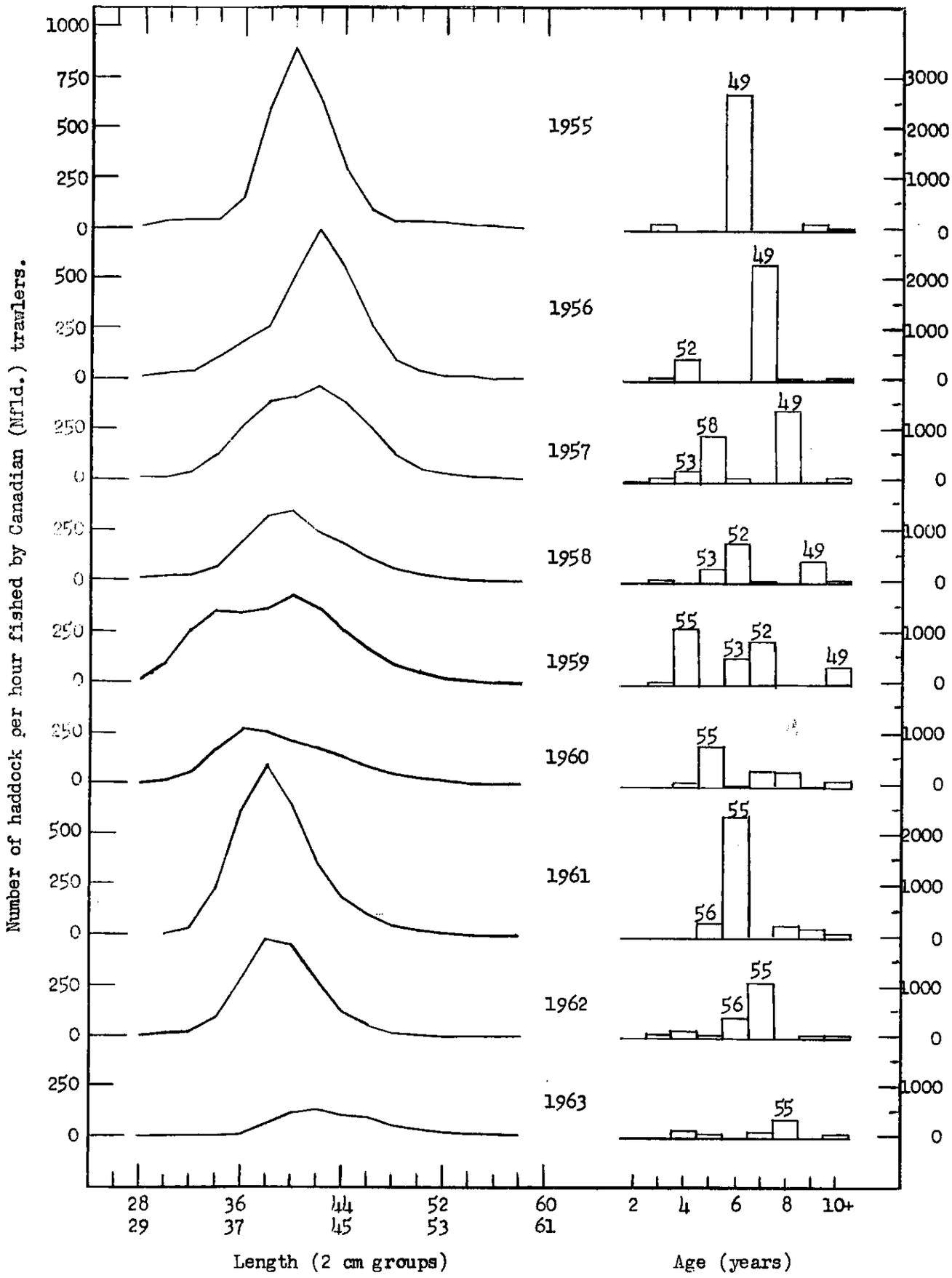

Fig. 4. Relative abundance of length and age groups of haddock in the landings of Canadian (Nfld.) trawlers from the Grand Bank during 1955-63.

Table 2. Numbers of haddock samples and numbers of fish measured and aged from the landings of Canadian (Nfld.) trawlers from the Grand Bank during January-June of 1955-63.

Year	No. of samples	No. of fish measured	No. of fish aged
1955	16	4,514	320
1956	57	15,486	698
1957	95	31,447	1,582
1958	53	22,028	938
1959	52	15,558	839
1960	64	25,400	1,349
1961	56	24,866	2,110
1962	54	22,114	2,286
1963	22	6,792	841

On the Grand Bank the most recent outstanding year-classes were those of 1946, 1949 and 1955 with moderate survival in 1952 and somewhat smaller year-classes in 1953 and 1956 (Fig. 4). Other year-classes between 1946 and 1963 were either complete failures or very small. During 1954-58, the 1949 year-class to a large degree and the 1952 and 1953 year-classes to a lesser extent were dominant in the landings. In 1959, while these older year-classes formed a significant part of the landings by weight, the 1955 year-class showed up in abundance in the commercial landings for the first time and this year-class continued to dominate in the samples up to 1963. While samples from commercial landings are not suitable for predicting the success or failure of the more recent year-classes, research vessel surveys, using codends lined with 25 mm nylon netting, have particularly since 1961 confirmed the rapid decrease in abundance of commercial-sized haddock as well as the poor survival of recent year-classes up to 1964.

Mortality estimates

The natural logarithms of the numbers per hour fished (Fig. 4) for the significant year-classes are plotted against age in Fig. 5. The peaks of the curves occur at age 6 and recruitment is considered to be essentially complete at this age although trawl selection may have been incomplete for the smaller sizes of fish in this age group and some discarding at sea may have occurred. Although there is some deviation from linearity in the relative abundance of successive age groups (ages 6-10) of the year-classes, the data show a rapid decrease in abundance with age. While a total mortality coefficient $(Z)_{\text{clupea}}$ of 0.75 is estimated from the decrease in abundance of the 1949 year-class between 1956 and 1959 (ages 7-10), values of between 0.9 and 1.0 are obtained for the more recent year-classes. Unfortunately the data are not adequate to provide a sufficiently reliable separation of Z into its natural and fishing components.

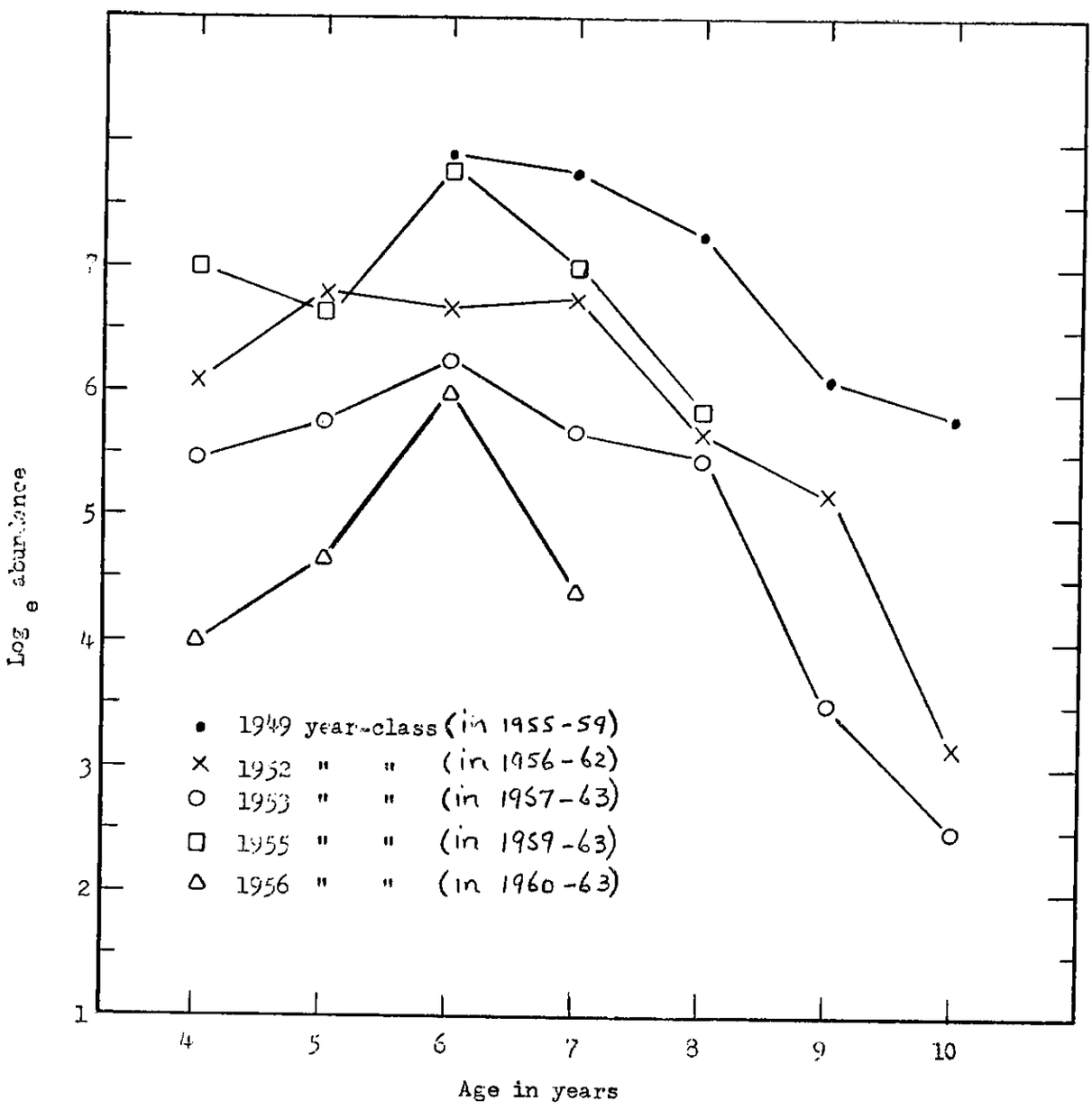

Fig. 5. Plots of relative abundance against age (up to age 10) for the significant year-classes of haddock in the landings of Canadian (Nfld.) trawlers from the Grand Bank between 1955 and 1963.

DISCUSSION

There is no doubt that the haddock fishery in Subarea 3 has entered a period when yields from the stocks must remain at a relatively low level for the next few years or until such a time as year-classes undergo a much higher degree of survival than has been the case since 1955. While annual landings have fluctuated greatly during the short 20-year history of the fishery, year-class survival has fluctuated much more severely. Considerable differences in year-class survival occur in all haddock stocks of the Northwest Atlantic (Walford, 1938; Hennemuth et al., 1964) but these variations seem to be much more extreme in the northern than in the southern parts of the range of haddock in the ICNAF Area.

The problems of determining the causes of fluctuations in year-class survival are extremely complex. The many factors that could conceivably affect brood production and survival make the formulation of theories about the causes of fluctuations extremely difficult. Although many workers in the field of fishery science have attempted to relate brood strength to such factors as water temperature, currents, wind drift, etc., during the early pelagic phase of development, it is not surprising that no real clear-cut relationships have evolved. Much of the difficulty lies in the absence of suitable data on the various causative factors concurrent with data on the time and duration of spawning, the distribution of eggs and larvae and the subsequent settling of young fish on the bank plateaus and slopes. It is obvious that the acquisition of such data would require for any one stock the use of much research vessel time and man-power resources spread over a long period of years; and, even if the actual basic causes were determined, it is unlikely that much, if anything, could be done to improve the situation. Lacking the necessary resources to conduct such widespread and long-term explorations, one must resort to speculation in the light of generally-known environmental conditions.

In the Georges Bank area Walford (1938) has demonstrated the importance of currents in the widespread dispersion of haddock eggs and larvae during the several months between spawning and the settling to the bottom of juvenile haddock. In the North Sea the importance of wind drift in the movement of the upper layers of water containing haddock eggs and larvae was shown by Carruthers et al. (1951). Templeman (1955) observes that all the haddock populations of the Northwest Atlantic live and spawn on the northern edge of the Gulf Stream. Large eddies are known to exist between the Gulf Stream and the slopes of the banks on which haddock spawn. In certain years these eddies may during the pelagic phase of haddock result in the relocation over oceanic depths of water masses containing the young fish. Inevitably, when several months after hatching these young haddock seek the bottom to take up a bottom-feeding existence, they must perish if they are not over bank or slope areas of less than perhaps 150 fathoms (270 m).

Haddock of the Grand Bank in Subarea 3 spend the winter and spawn on the southwest slope of the bank. It is only necessary for the water mass containing the eggs and larvae to shift a few miles to the southwest before oceanic depths are encountered. On the other hand, if the water currents are such that the water layers containing the young pelagic haddock drift northward and by settling time are located over the northern half of the Grand Bank, unfavourable temperatures may limit survival. May (In press) notes that fluctuations in year-class survival of haddock on the southern Grand Bank generally correspond with the fluctuations in year-class survival of cod (the 1949 and 1955 year-classes of both haddock and cod were the most successful of all year-class in recent years), but the variations in cod survival are much less extreme than for haddock, due probably to possible recruitment of young cod from northern areas. Since cod and haddock of the southern Grand Bank spawn in approximately the same areas and at about the same time (May-June), it is not unreasonable to assume that the same factors which affect the survival of haddock probably also affect survival of cod in the area.

It has been often asserted that the size of the spawning population is of little or no importance in the production of good or poor year-classes. This may be true for certain stocks to which recruitment is relatively stable from one spawning to the next. However, with the almost complete loss of frequent year-classes before settling, it may well be important that Grand Bank haddock should

...../11

spawn in as great a quantity as possible and especially over as wide an area as possible. In view of the lack of sufficient production of recruits to the haddock fishery of the southern Grand Bank since 1955-56, Templeman (Doc. 25, This Meeting) wonders whether it is not dangerous to reduce the mature population of a species beyond a certain size, especially at the northern and southern outposts of a species. While a large spawning stock of haddock does not guarantee the production of good year-classes regularly, it would seem obvious that the chances of obtaining some good year-classes are much better when the spawning population is large.

REFERENCES

Carruthers, J. N., A. L. Lawford, V. F. C. Veley and B. B. Parish. 1951. Variations in brood-strength in the North Sea haddock in the light of relevant wind conditions. Nature, 168(4269) : 317-319.

Hennemuth, R. C., M. D. Grosslein, and F. D. McCracken. 1964. Abundance, Age composition of landings, and total mortality of haddock caught off southern Nova Scotia, 1956-61. Int. Comm. NW Atlantic Fish., Res. Bull. No.1,pp.43-73.

May, A. W. (In press). Validity of otolith ages of southern Grand Bank cod. Int. Comm. NW Atlantic Fish., Res. Bull. No. 2.

Templeman, Wilfred. 1955. Groundfish stocks of the Western North Atlantic. Trans. 20th North American Wildlife Conf., March 14-16, 1955, pp. 454-476.

Thompson, H. 1939. The occurrence and biological features of haddock in the Newfoundland area. Nfld. Dept. Nat. Resources, Res. Bull. No. 6, 31 pp.

Templeman, W. and V. M. Hodder (In press). Distribution of haddock on the Grand Bank in relation to season, depth and temperature. Int. Comm. NW Atlantic Fisheries, Environmental Symposium, Rome, ICNAF Special Publication Series.