INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

RESTRICTED

Serial No.2528
(B.g.20)

ICNAF Res.Doc.71/38

ANNUAL MEETING - JUNE 1971

Accuracy of abundance indices for cod from St. Pierre Bank (ICNAF Division 3Ps) based on Canada (Nfld.) research vessel surveys in terms of comparisons with commercial abundance indices

by

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Introduction

One of the chief objectives of research vessel surveys is to estimate the absolute or relative abundance of year-classes of fish several years prior to their recruitment to the commercial fishery. The surveys conducted by the St. John's Biological Station Laboratory have been no exception and the survival of year-classes of cod and haddock has been followed for many years, although no actual quantitative predictions have been made. The purpose of the present paper is to evaluate the survey data from St. Pierre Bank (ICNAF Division 3Ps) and to correlate abundance estimates of year-classes of cod at the pre-recruit stage with abundance estimates of these same year-classes after recruitment to the commercial fishery.

Materials and methods

The sampling design traditionally used on groundfish cruises has been a standard line system. Lines and stations selected under this system are described by Pinhorn (1971) in a document presented to this meeting. Fig. 1 shows the lines and stations fished on St. Pierre Bank during 1957-70, the period considered in the present paper.

Temperature conditions in this area vary with season and even from year to year within the same season (Templeman and Hodder, 1965). Also, primarily as a response to these changing temperature conditions, cod are known to migrate between depth zones from season to season (Templeman and May, 1965) and even to migrate to the Newfoundland coast in this area in the May-June period (Templeman, 1962). In view of these facts and since the survey cruises in 1957-65 were conducted during May-June but in 1967-70 were conducted during March-May (Fig. 2), the length compositions of the catches from each cruise were combined by depth zones of 0-50 fath, 51-100 fath and 101-150 fath. These were then converted to number per hour fished for each depth zone and the results are shown in Fig. 2. It became obvious that very few cod were caught deeper than 100 fath and this depth zone is omitted from Fig. 2. In fact, movements of cod occurred within depths less than 100 fath. It is further obvious that, except for occasional years of peculiar hydrographic conditions (e.g. 1958), the young cod of 2-3 years of age

(< 37 cm) remained for the most part in the 51-100 fath depth zone during the entire period from March to June, whereas the older cod were found in the 51-100 fath depth zone during the early part of this period, but moved onto the top of the bank in depths less than 50 fath during the later part of this March-June period (Fig. 2).

To evaluate the similarity of abundance indices calculated from research vessel surveys in successive years, indices of abundance of 2- and 3-year-old cod of each year-class were compared with indices of abundance of 4- and 5-year-old cod of the same year-class in later cruises. In view of the facts outlined above, three separate methods of computing these indices were used as follows:

1. Numbers of cod caught per hour fished for each year-class at each age were computed by applying an age-length key to numbers per hour length compositions as shown in Fig. 2 from sets made in 51-100 fath only for each cruise.

2. Numbers of cod caught per hour fished for each year-class at each age were computed for 2- and 3-year-old cod by applying an age-length key to number per hour length compositions from sets made in 51-100 fath only and for 4- and 5-year-old cod from sets made in 0-50 fath for the 1957-65 late spring to early summer cruises and from sets made in 51-100 fath for 1967-70 late winter to early spring cruises.

3. Numbers of cod caught per hour fished for each year-class at each age were computed by weighting the number per hour length compositions in each depth zone by the area of the depth zone as shown in Fig. 1. These areas are as follows:

0-50	fath	-	5749	square miles
51-100	"	-	2776	" "
101-150	"	-	869	" "

In the above computations, in years where no survey data were available (1961 and 1966) and for year-classes at the beginning and end of the period, numbers caught per hour for the missing ages were calcu-calculated by applying the average survival rates of the remaining year-classes between successive ages to the known number per hour at the age immediately before or after the missing ages.

In comparing indices of abundance of 2- and 3-year-old cod from the research cruises with indices of abundance of 4- and 5-year-old cod from the commercial fishery, the indices for 2- and 3-year-old cod calculated by Methods 1-3 above were used. The indices of abundance for 4- and 5-year-old cod from the commercial fishery were calculated in the following manner: Nominal catches and hours fished by Canada (Nfld.) side trawlers of 151-500 tons were tabulated for the spring fishery for the 1959-68 period. Average weight caught per hour fished was then calculated for each year and average number caught per hour fished calculated from this figure by using average weight values as determined from the Sampling Yearbooks for the respective years. Per mille length frequencies of catches of Canada (Nfld.) side trawlers of 151-500 tons, as well as length frequencies of other countries which appeared similar to Canada (Nfld.) frequencies, where the latter were lacking or few in number, were averaged and the resulting per mille length frequency adjusted to number per hour caught by these Canada (Nfld.) side trawlers in each year. Research age-length keys were applied to these length frequencies for each year and indices of abundance calculated for 4- and 5-year-old cod of each year class. For 1961 and 1966, in which no age-length keys were available, keys from the adjacent years were averaged and applied to the length frequency in the particular year. Numbers of measurements used for each country are given below:

Year	Country	No. of measurements
1959	Canada (Nfld.)	2047
1960	" "	520
	U.K.	2013
1961	Canada (Nfld.)	834
	Port.	500
1962	U.K.	1890
1963	-	-
1964	Canada (Nfld.)	267
1965	" "	999
1966	" "	2428
1967	" "	600
1968	" "	945

Results

Logarithmic transformations best described the relationships between abundance indices of 2- to 3-year-old cod and 4- to 5-year-old cod in successive research surveys. Correlation coefficients (r) were generally larger than with the arithmetic straight line fits and were significantly different from zero in all cases except ages 2-3 versus age 5 calculated by Method 3 (Table 1 and Fig. 3). Only two r-values were significant using arithmetic straight lines, between ages 2-3 and age 5 and ages 2-3 and ages 4-5 as calculated by Method 1.

On the other hand, arithmetic straight line fits best described the relationships between ages 2-3 in the research surveys and ages 4-5 in the commercial catches. Correlation coefficients were generally larger than with the logarithmic transformation and were significant in all cases except between ages 2-3 and age 5 calculated by Method 1 (Table 2 and Fig. 4). However, all r-values except two were still significant with the logarithmic transformation.

Except for the 1958 year-class, survival of the 1954-65 year-classes as determined from research vessel surveys fluctuated only moderately with the weakest year-classes being about 75% less than the long-term average and the strongest year-classes being about equal to the average (Fig. 5A). The 1958 year-class was represented in the 1960 research vessel catches in significant numbers but was only caught in small numbers in later research vessel cruises and in commercial catches. The catch of this year-class as 2-year-olds was not considered representative of its abundance and consequently this year-class is omitted from the above correlations. The 1966 and 1968 year-classes appear to be considerably stronger than average, while the 1967 year-class was slightly below average.

Discussion

It appears from the results presented in this paper that indices of abundance as determined from survey cruises to St. Pierre Bank are accurate enough, or at least consistent enough from year to year, to allow for prediction of relative levels of recruitment to the commercial fishery even with the present standard line system as used by the St. John's Biological Station. However, attempts at estimating absolute abundance levels of individual year-classes would be more difficult with this system since it does not allow for random coverage of the entire habitat of the species and hence any attempt at stratifying the area and using the stations fished on each line as random sets in the various strata would result in some strata having no sets at all and others with very few.

In considering the problem of stratifying the area according to the system of sampling described by Grosslein (1968), if only the pre-recruits of age groups 0-3 are being considered, then it appears that the problem may be simplified since in most years these age-groups are confined largely to the depth zone 51-100 fath and a stratification system within this zone may be sufficient. However, if older age-groups are considered, then the fact that these age-groups migrate to the top of the bank and more important to the Newfoundland coast must be considered. Any survey then undertaken would have to be in winter or early spring before this migration takes place.

Comparison of year-class strengths with those given by Bulatova (1970) indicates some differences (Fig. 5C). Deviations from the long-term mean of the 1960-66 year-classes were similar in both sets of data for the 1960-63 year-classes, ranging from 25-75% below this mean. Also, the deviations for the 1965 year-class was reasonably similar in both cases, being equal to the mean for Canada (Nfld.) and 25% above for Bulatova (1970). However, the strength of the 1964 year-class, while being 10% below the mean from Canada (Nfld.) data, was 125% above the mean from Bulatova (1970). Also, the 1966 year-class, while being 200% above the mean from Canada (Nfld.) data was only 60% above from Bulatova (1970) data. Bulatova (1970) also states that the 1967 year-class is probably not better than average, while the 1968 year-class was especially strong. This agrees favourably with the Canada (Nfld.) data (Fig. 5A), from which the 1967 year-class was judged to be about 25% less than the long-term 1954-68 mean and the 1968 year-class about 150% greater than the mean.

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Table 1. Correlation coefficients and tests of significance between indices of abundance of 2- and 3-year-old cod and 4- and 5-year-old cod from Canada (Nfld.) research surveys of St. Pierre Bank (ICNAF Division 3Ps), 1957-70. Indices of abundance are computed by three different methods which are described in text.

Method	Ages compared	Arithmetic straight line			Log-log straight line		
		r	df	t	r	df	t
1	2-3 vs 4	0.52	10	1.91	0.64	10	2.64*
	2-3 vs 5	0.83	10	4.73**	0.74	10	3.45**
	2-3 vs 4-5	0.72	10	3.20**	0.72	10	3.26**
2	2-3 vs 4	0.51	10	1.89	0.76	10	3.66**
	2-3 vs 5	0.56	10	2.13	0.59	10	2.31*
	2-3 vs 4-5	0.57	10	2.21	0.85	10	5.07**
3	2-3 vs 4	0.40	10	1.40	0.59	10	2.32*
	2-3 vs 5	0.42	10	1.45	0.50	10	1.84
	2-3 vs 4-5	0.45	10	1.60	0.59	10	2.31*

* significant at the 5% level
** significant at the 1% level

Table 2. Correlation coefficients and tests of significance between indices of abundance of 2- and 3-year-old cod from Canada (Nfld.) survey catches and 4- and 5-year-old cod from Canada (Nfld.) commercial catches of 151-500 tons side trawlers, St. Pierre Bank (ICNAF Division 3Ps), 1959-68.

Method	Ages compared	Arithmetic straight line			Log-log straight line		
		r	df	t	r	df	t
1	2-3 vs 4	0.83	8	4.15**	0.79	8	3.59**
	2-3 vs 5	0.54	8	1.79	0.32	8	0.94
	2-3 vs 4-5	0.88	8	5.29**	0.67	8	2.57*
3	2-3 vs 4	0.82	8	3.99**	0.82	8	4.04**
	2-3 vs 5	0.63	8	2.29*	0.50	8	1.62
	2-3 vs 4-5	0.88	8	5.33**	0.76	8	3.29*

* significant at the 5% level
** significant at the 1% level

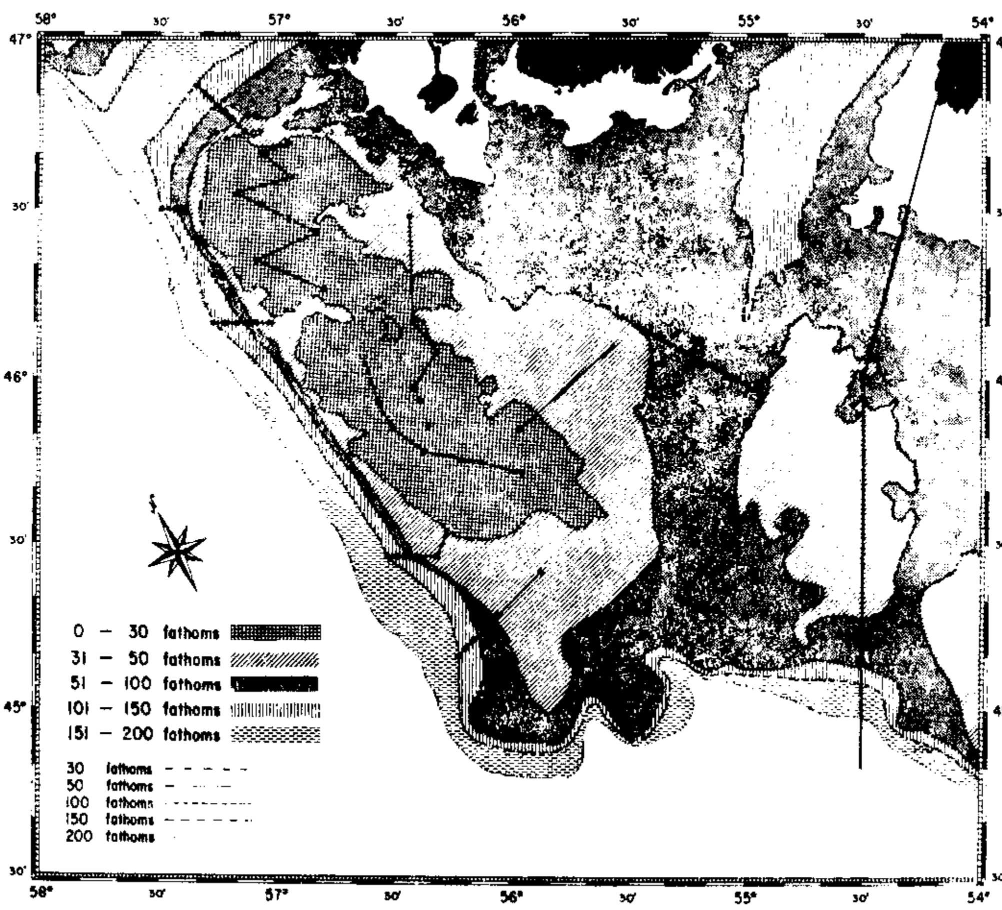

Fig. 1. Chart of St. Pierre Bank showing depth zones used in calculation of indices of abundance of cod and lines and stations fished during the period considered. Solid lines marked A, B and C delineate sections used for determination of depth zone areas.

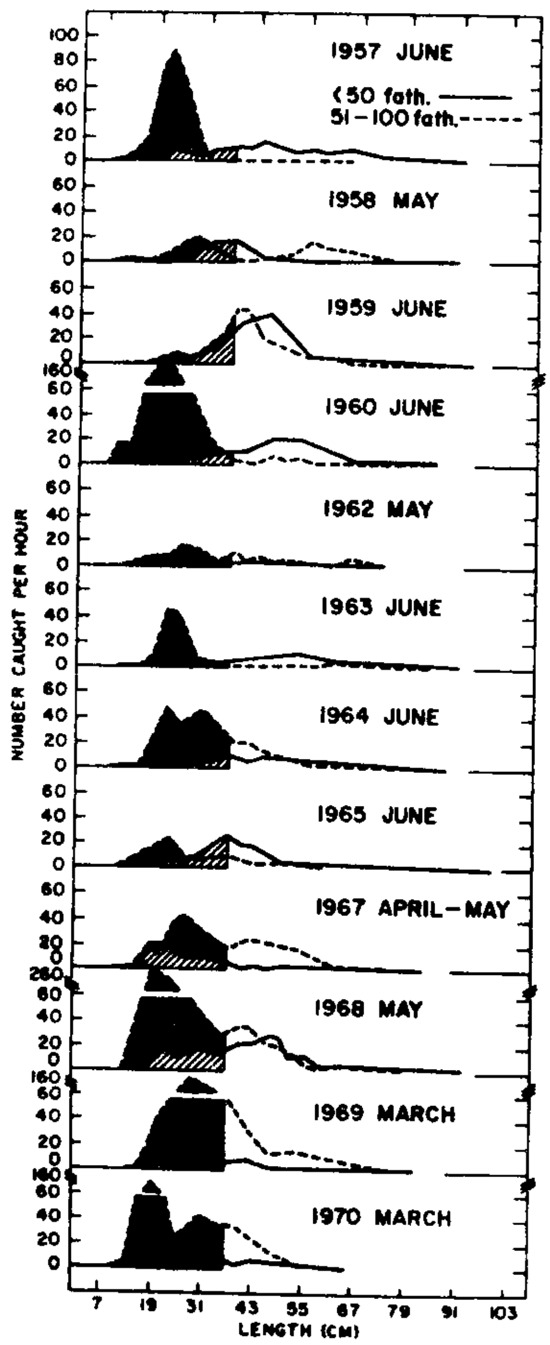

Fig. 2. Number caught per 1-hour trawling in each 3-cm length group in the two major depth zones from Canada (Nfld.) research vessel surveys, St. Pierre Bank (ICNAF Division 3Ps). Areas shaded and hatched to the left of vertical lines indicate cod less than 4 years old.

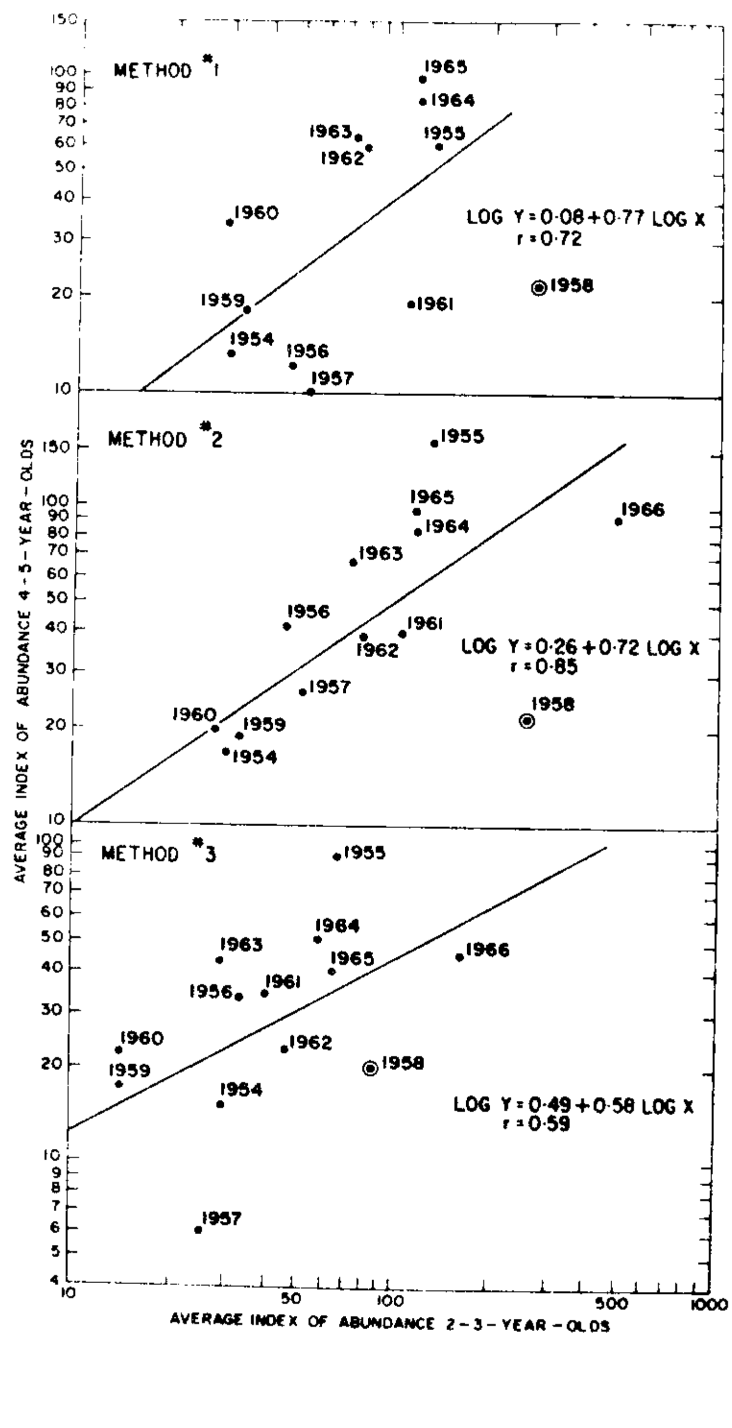

Fig. 3. Relationship between average indices of abundance of 2- to 3-year-old cod and 4- to 5-year-old cod of each year-class in successive research vessel surveys. See text for explanation of Methods 1-3 of calculating indices.

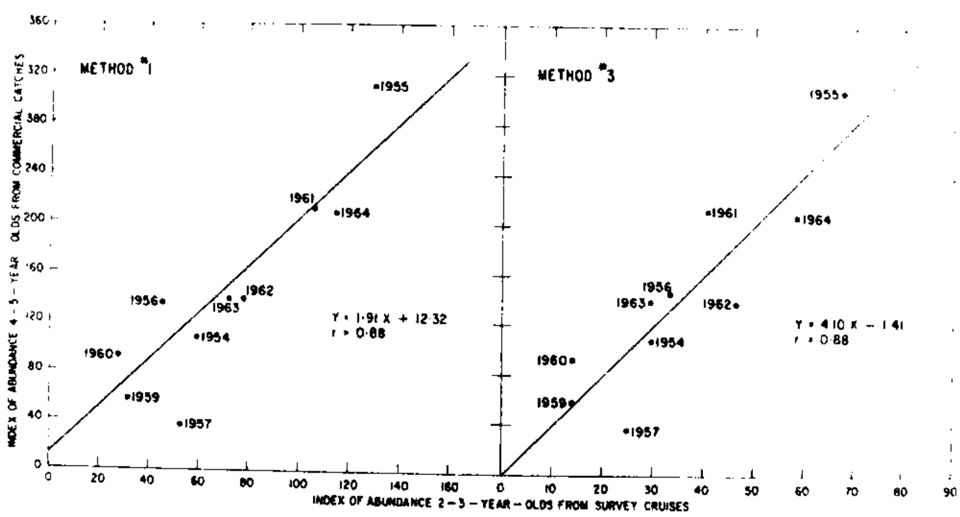

Fig. 4. Relationship between average indices of abundance of 2- to 3-year-old cod from research vessel surveys and 4- to 5-year-old cod from the commercial fishery by Canada (Nfld.) side trawlers of 151-500 tons for each year-class.

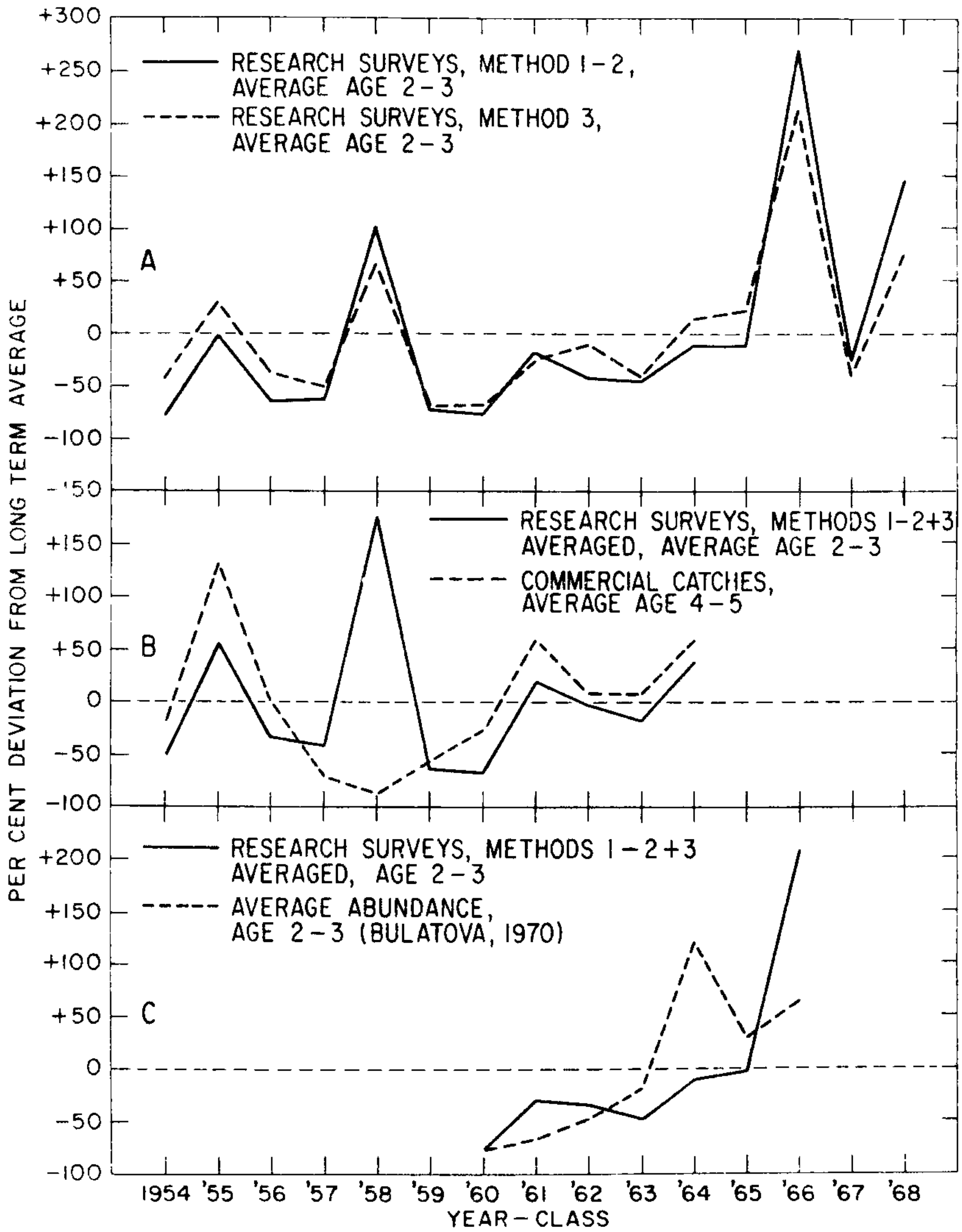

Fig. 5. Percent deviations by year-class of abundance indices of cod from long-term average of (A) 1954-68 year-classes from research data alone; (B) 1954-64 year-classes from research data and commercial data; (C) 1960-66 year-classes from Canada (Nfld.) research data and data of Bulatova (1970).