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The flatfish fisheries of the
Scotian Shelf

by

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SECTION I - THE FISHERIES

INTRODUCTION

There are six species of the family Pleuronectidae fished commercially on the Scotian Shelf (ICNAF Divisions 4Vn, 4Vs, 4W, 4X) - witch flounder [*Glyptocephalus cynoglossus* (L.)], American plaice [*Hippoglossoides platessoides* (Fabricius)], Atlantic halibut [*Hippoglossus hippoglossus* (L.)], yellowtail flounder [*Limanda ferruginea* (Storer)], winter flounder [*Pseudopleuronectes americanus* (Walbaum)], and Greenland halibut [*Reinhardtius hippoblossoides* (Walbaum)]. The Atlantic halibut and its fishery are not considered in this document. The nature of the halibut fishery in SA4, prosecuted mainly by longline, and the high value of the species set it apart from the other flounder species.

LANDINGS

Landings of flatfish (excluding halibut) from the Scotian Shelf increased from 10,000 metric tons in 1960 to 55,000 tons in 1968, and ranged from 20,000-37,000 tons in the 1969-71 period (Table 1). Canada has been the main exploiter although the USSR has made sporadic, large landings since 1965.

A breakdown of flatfish landings by species is available from 1960 for most countries but only for 1970 and 1971 for USSR landings, earlier USSR landings being reported

as "unspecified flounders". The average species composition in each Division in 1970-71 Soviet landings was used to prorate landings for earlier years. The breakdown used was:

<u>Division</u>	<u>Plaice</u>	<u>Winter flounder</u>	<u>Witch</u>	<u>Yellowtail</u>
4Vn	50%	-	50%	-
4Vs	49%	-	42%	9%
4W	32%	7%	47%	14%
4X	12%	11%	60%	17%

There were considerable differences between the Soviet catch compositions in 1970 and 1971, thus there is a high uncertainty associated with the breakdown by species for earlier years.

On the basis of this breakdown, landings of Greenland halibut from the Scotian Shelf have been negligible, the largest landing being 38 tons in 1969 (Table 2). Research vessel surveys confirm that Greenland halibut are scarce on the Scotian Shelf only occasional specimens being taken in the colder water on the eastern part of the shelf. This is the southern extremity of the range of this northern, cold-water, species, and it is unlikely that it will ever play a significant role in the flatfish fishery on the Scotian Shelf.

Winter flounder landings were also low, reaching a maximum of about 3,000 tons in 1971 (Table 3). Winter flounder is coastal species and is abundant inshore in bays along the coast of Nova Scotia and particularly in the Bay of Fundy. Offshore, the only sizeable population is found in the shallows of Sable Island Bank as shown by research vessel catches (Table 4). It is probably on Sable Island Bank where the bulk of the Soviet winter flounder catch is taken. However, it is likely that only the deeper fringe of the population is exploited as the bulk of the population resides in water shallower than that navigable by large fishing vessels and also lies within the Canadian 12-mile fishing zone. The Canadian catch is almost entirely coastal and made by small inshore vessels. Almost all is taken within Canadian territorial sea and thus outside the ICNAF Convention Area.

Thus, neither Greenland halibut or winter flounder is significant in a discussion of the international flatfish fishery on the Scotian Shelf and are not considered further here.

The landings from the remaining three species, plaice, witch, and yellowtail combined increased from about 10,000 tons in 1960 to 52,500 tons in 1968, fluctuating between 18,000 and 34,000 tons in 1969-71 (Table 5). Landings from Div. 4X have been small - always less than 2,000 tons annually. The bulk of the landings have come from Div. 4W and Div. 4Vs. Canadian landings have been highest from Div. 4Vs while Soviet landings have been predominantly from Div. 4W.

CATCH PER UNIT EFFORT

The catch per unit effort (cpe) of Canadian otter trawlers of 151-500 gross tons of plaice, witch, and yellowtail combined declined in Div. 4Vn and Div. 4Vs, but did not change greatly in Div. 4W and Div. 4X in the period 1965-72 (Table 6). For the Scotian Shelf as a whole cpe declined from 150.7 kg/hr in 1965 to 104.5 kg/hr in 1972, a drop of 30%. This is associated with landings which were substantially higher than the stocks supported in the pre-1965 period (Table 5). It is almost exclusively the yellowtail stocks which are responsible for this decline in cpe, falling from 72.9 kg/hr in 1965 to 14.8 kg/hr in 1972, a drop of 80%.

These cpe data were obtained by averaging the monthly values in each Division and combining these by weighting by the area of each Division (to the 200 fath contour).

SECTION II - SPECIES ASSESSMENTS

WITCH

DISTRIBUTION AND ABUNDANCE - RESEARCH VESSEL SURVEYS

Canadian research vessel survey catch per tow data averaged for 1970-72 (for stratification scheme and methodology see Halliday and Kohler, ICNAF Res. Doc. 71/35) indicate that witch are distributed widely on the Scotian Shelf (Fig. 1), but in low concentrations. Localized areas of high abundance occur along the edge of the Laurentian Channel, in "the Gully" between Sable Island and Banquereau banks, in the deep holes north of Banquereau and in the deeper holes at the mouth of the Bay of Fundy, i.e. predominantly in depths greater than 100 fath.

Survey abundance estimates do not indicate any substantial changes in the 1970-72 period (Table 7). Population number and biomass estimates, uncorrected for catchability, were about 20 million fish with a biomass of about 10,000 tons.

LENGTH AND AGE COMPOSITION OF SURVEY CATCHES

Witch less than 20 cm are virtually absent from survey catches and very few less than 30 cm are caught, except in Div. 4Vs, where moderate numbers of fish 20-30 cm are caught (Fig. 2). Fish over 60 cm are rare. Full recruitment to the survey gear apparently occurs at age 8 for both males and females (Fig. 3).

Very few fish as young as age 6 are taken. Only in Div. 4Vs are age groups 5 and 6 moderately represented in catches. Females older than age 12 are common but few males are in this age category.

NOMINAL CATCHES

Nominal catches fluctuated between 5,000 and 22,500 metric tons in 1960-71 (Table 8). The Canadian fishery has been fairly stable, ranging from 5,000-9,000 tons. However, nominal catches by the USSR have fluctuated greatly and may have been as high as 13,700 tons in 1968. Most Soviet landings were from Div. 4W but Div. 4Vn and Div. 4Vs are important to the Canadian fishery.

Although otter trawlers predominate in the fishery, significant quantities are taken by Canadian Danish and Scottish seine vessels. In 1969-71, seiners accounted for 35% of the Canadian landings (18% of total landings by all countries).

CATCH PER UNIT EFFORT

Between 1965 and 1972 catch rates of witch by Canadian otter trawlers declined in Div. 4Vn but increased slightly in Div. 4W and Div. 4X, resulting in no major trends in catch rates for the Scotian Shelf as a whole between 1965 and 1972 (Table 9).

LENGTH AND AGE COMPOSITION OF COMMERCIAL LANDINGS

There have been no biological sampling data for Soviet witch landings reported to ICNAF. Thus it has been necessary to assume that Soviet trawler landings have the same size and age composition as those of Canadian trawlers. Insufficient Canadian sampling data are available to treat years and Divisions separately. Thus the average 1970-72 length and age compositions were derived using the 12 otter trawl and 4 Danish seine samples available for these years (Fig. 4). The samples originated from Div. 4Vn, 4Vs, 4W.

Commercial landings are composed of fish 30-60 cm long and age 5 to over 15 years. Danish seiners take smaller and younger fish than otter trawlers. Females are larger and older than males in landings of both gears but particularly in otter trawl landings. Very few 5 year olds occur in commercial landings, full recruitment to the gear occurring

at age 7 in the Danish seine fishery and age 8 in the otter trawl fishery for males, and at age 8 in the Danish seine fishery and about age 11 in the otter trawl fishery for females. Few males over age 12, and few females over age 15, are caught.

MORTALITY

Catch curves from commercial and survey age compositions give estimates of instantaneous total mortality (Z) of 0.33–0.56 for males and 0.30–0.50 for females (Table 10). The lower estimates of Z in Div. 4X are understandable as landings are low in relation to estimated population size from surveys. Values of $Z = 0.55$ for males and $Z = 0.50$ for females are taken as best estimates of mortality in the fished population.

No estimates of natural mortality of witch are available. As this is a fairly long-lived species, and as females are more abundant than males at older ages and thus probably have a lower natural mortality than males, values of $M = 0.20$ for males, and $M = 0.15$ for females are assumed.

YIELD PER RECRUIT

The Beverton and Holt yield per recruit model was applied to males and females separately, using the following parameters:

	<u>Males</u>	<u>Females</u>
W_{∞} (asymptotic weight)	1.90 kg	5.1 kg
K (rate of completion of growth curve)	0.12	0.07
t_0 (growth correction factor)	-0.04	-0.42
t_p (age at entry to exploited area)	5 yrs	5 yrs
t_{p1} (mean age at entry to exploited phase)	6.5 yrs	8 yrs
t_{λ} (last age of significant contribution to fishery)	15 yrs	20 yrs

Growth parameters were obtained from Powles and Kennedy (1967, ICNAF Res. Bull., 4: 91-100). Values of t_{ρ} and t_{λ} were estimated from age compositions of commercial landings. Three values of M were used, 1.0, 1.5, 2.0 .

For males, the current value of fishing mortality (F) of 0.35, assuming $M = 0.20$, is close to optimum (F_{opt} as defined by Gulland) and gives about 93% of maximum yield per recruit (Fig. 5). For values of M less than 0.20, current F is close to that giving maximum yield per recruit.

For females, the current value of $F = 0.35$, assuming $M = 0.15$, is close to that giving maximum yield per recruit (Fig. 6). If M is less than 0.15 then F is above F_{max} . If $M = 0.20$, F is at the F_{opt} level, or 92% of F_{max} .

There is some doubt as to the t_{ρ} value particularly for females. With gradual recruitment, the 50% recruitment point is difficult to judge by eye. However, this is not critical to the conclusions over the most likely range of t_{ρ} for females of 7.5-8.5 years old (when $M = 0.15$) (Fig. 7).

CONCLUSIONS

Although landings since 1965 have been higher than prior to 1965, there are no indications from cpe data that overall abundance of witch on the Scotian Shelf has declined since 1965. However, fishing mortality rates for both sexes are close to that giving maximum yield per recruit. These mortality rates are average values for the 1965-72 period. This implies that removals should not be allowed to significantly exceed those of the 1965-71 period when they averaged about 13,000 metric tons.

Discards of witch at sea by Canadian vessels are negligible as pre-commercial size are not vulnerable even to small mesh trawl gear (see Fig. 2). However, this also precludes estimates of future recruitment from research vessel surveys.

PLAICE

DISTRIBUTION AND ABUNDANCE FROM RESEARCH VESSEL SURVEYS

Plaice are widely distributed on the Scotian Shelf, but major concentrations occur only in Div. 4V in depths less than 100 fath, particularly in the cold water area to the north of Banquereau (Fig. 8). Biomass estimates from research vessel surveys (uncorrected for catchability) in 1970-72 range from about 40,000-51,000 metric tons (Table 11). Declines are indicated in Div. 4W and Div. 4X but not in Div. 4V. Population numbers declined from 190 million in 1970 to 143 million in 1972, declines occurring in Div. 4V, Div. 4W and Div. 4X.

SIZE AND AGE COMPOSITION FROM RESEARCH VESSEL SURVEYS

Length range in survey catches was 10-70 cm with modes normally between 20 and 30 cm (Fig. 9). The length-frequencies are consistent in distribution within areas among years. Survey catches in 1972 contained fish from age 1 to over 12 years but age 1 fish were extremely rare and age 2 were poorly represented (Fig. 10). Plaice are not fully recruited to the small mesh survey trawl until about age 7.

COMMERCIAL LANDINGS

Landings increased from less than 3,000 tons in 1960 to 1963 to over 10,000 tons in 1966-71 (excluding 1970), and may have been as high as 20,700 tons in 1968 (Table 12). The Canadian fishery has been predominantly in Div. 4V, while the Soviet fishery was mainly in Div. 4W.

Over 90% of the landings are caught by otter trawl. In 1969-71, 5-8% of Canadian landings were caught by Danish seine gear (3-5% of total landings) and 2-6% by long-line and hand-line (1-3% of total landings).

SIZE AND AGE COMPOSITION OF COMMERCIAL LANDINGS

There are no available biological sampling data for Soviet plaice landings. Thus, it has been necessary to assume that Soviet landings are identical to Canadian landings in size and age composition. There were insufficient Canadian sampling data to treat gears, areas and years separately thus, all samples for 1968-72 (14 otter trawl and 1 Danish seine) were combined to give average size and age composition of landings in this period. Twelve of the samples used were from Div. 4Vs and three from Div. 4Vn.

Landings of males ranged in length from 30-55 cm with a predominant mode at 38 cm (Fig. 11). Landings of females ranged in length from 30-70 cm with a predominant mode at 48 cm.

Occasional 5 yr-olds and a few 6 yr-olds occur in the landings of males which appear to be fully recruited to the gear at age 9. A few males older than 15 years are landed. Ages 5 and 6 are absent from female landings and 7 yr-olds are scarce. Full recruitment to the fishery appears to occur at age 11. About 29% of females landed are older than 15 years.

CATCH PER UNIT EFFORT

Catch rates of Canadian trawlers of 151-500 gross tons between 1965 and 1972 imply that plaice abundance on the Scotian Shelf increased between 1965 and 1969 then declined through 1972 (Table 13). The decline in catch rates between 1970 and 1972 of 24% agrees well with the decline in survey estimates of population numbers of 25%. However, survey biomass estimates increased in 1971 then dropped in 1972 to 13% below the 1970 level.

MORTALITY

Total mortality rates (Z) estimated from catch curves from commercial and survey age compositions (Table 14) ranged from 0.46 to 0.79 for males and 0.49 to 0.80 for females. Survey estimates for the Scotian Shelf as a whole, obtained by weighting Division estimates by survey population estimates were $Z = 0.65$ for males and $Z = 0.60$ for females. These are higher estimates than the $Z = 0.46$ for males and $Z = 0.54$ for females obtained from commercial data and which are applicable to Div. 4V. However, the catch curve method gives estimates which are historical, and commercial data reflect exploitation rates as far back as 1962, while survey data reflect exploitation rates during the 1966-72 period when landings were highest. Thus survey data may give a more accurate estimate of mortality during the most recent period of the fishery. Values of $Z = 0.65$ for males and $Z = 0.60$ for females are used here.

No estimates of natural mortality are available for Scotian Shelf plaice. Pitt (ICNAF Res. Doc. 72/15) obtained estimates of $M = 0.25$ for males and 0.20 for females in Subareas 2 and 3, while Powles (1969, J. Fish. Res. Bd. Canada 26: 1205-1235) obtained values of M varying between 0.11 and 0.16 for sexes combined in the southern Gulf of St. Lawrence (Div. 4T). Considering the longevity of the species, Pitt's estimates are likely to be maximal. However, his values are used here.

GROWTH

Survey mean lengths at age for each Division were weighted by estimated population numbers at age to give estimates representative of the Scotian Shelf as a whole (Table 15). These estimates are smaller than mean lengths at age from commercial landings which are representative of Div. 4V. Survey estimates were used to calculate parameters of the von Bertalanffy growth equation as younger ages were better represented in the data and because the data were average values for all of the Scotian Shelf.

The values obtained were:

	<u>Males</u>	<u>Females</u>
L_{∞}	44.6 cm	229.8 cm
K	0.114	0.013
t_0	-2.16	-3.70
Ages fitted	2-12	2-15

While the L_{∞} estimate for males is biologically realistic, that for females is not. However, the curves fit the data well over the range of ages fitted and should be adequate for use in the Beverton and Holt yield equation.

YIELD PER RECRUIT

The Beverton and Holt yield per recruit equation was calculated for males and females separately using the growth parameters cited above and other parameters as follows:

	<u>Males</u>	<u>Females</u>
W_{α} (derived from L_{α})	0.76 kg	236.9 kg
t_{ρ}	2.0 yrs	2.0 yrs
$t_{\rho 1}$	7.5 yrs	9.5 yrs
t_{λ}	20 yrs	25 yrs

Values of $t_{\rho 1}$ were estimated visually from age compositions of commercial landings.

Yield per recruit curves for males are flat topped when M is in the range 0.15-0.25 (Fig. 12). When $M = 0.25$, the current value of $F = 0.40$ is close to F_{opt} , and gives about 80% of the yield per recruit obtainable at very high values of F . If M is less than 0.25, then F is above F_{opt} and closer to the asymptotic value.

If $M = 0.20$ for females, the current F value of 0.40 is higher than F_{opt} and yield per recruit is over 90% of that obtainable with very high F values (Fig. 13). If M is less than 0.20, then F is above F_{max} .

CONCLUSIONS

Although landings increased in 1965, catch rates also increased until 1969, then dropped to about 1965 levels by 1972. However, fishing mortality rates representative of the 1966-72 period were close to F_{opt} and little gain in yield would accrue from further increase. Thus, any substantial increase in landings above the 1966-71 average of 13,600 metric tons is unlikely to be sustainable.

Moderate quantities of plaice are discarded by the Canadian fleet and these have not been taken into account in this analysis. Increase in regulation mesh size from 4 1/2 inches to 5 1/8 inches on 1 January 1974 should result in some increase in sustainable yield.

The occurrence of substantial quantities of fish in the 20-30 cm size range in research vessel catches indicate that it should be possible to predict recruitment to the fished population of 30 cm+ fish.

YELLOWTAIL

DISTRIBUTION AND ABUNDANCE FROM RESEARCH VESSEL SURVEYS

Yellowtail has a localized distribution on the tops of offshore banks in depths less than 50 fath (Fig. 14). Densest concentrations are located on Banquereau, particularly on the Eastern Shoal, Sable Island and Middle banks. Biomass estimates from research vessel surveys in 1970-72 (uncorrected for catchability) range from 18,000-24,000 metric tons (Table 16). Population numbers varied from 85-100 million.

SIZE AND AGE COMPOSITION FROM RESEARCH VESSEL SURVEYS

Survey catches were composed of fish with a length range of 10-50 cm but most fish lay within the size range 20-40 cm (Fig. 15). Modal lengths of Banquereau yellowtail lay between 30 and 35 cm, while those of Sable Island and Middle Bank fish lay between 25 and 30 cm. Catches in 1970 and 1971 contained fish aged 2-10 yrs but on Banquereau most were 5-7 years old in 1970 and 6-8 years old in 1971, while those in Div. 4W were predominantly 3-6 years old in both years (Fig. 16). Full recruitment to the survey gear appears to take place about age 6 for both sexes.

COMMERCIAL LANDINGS

Landings increased from less than 1,000 tons in 1960 to over 5,000 tons in 1964 and to over 9,000 tons in 1968, subsequently declining to about 1,800 tons in 1971 (Table 17). Soviet landings have originated mainly from Div. 4W and Canadian landings from Div. 4Vs. Virtually all landings are made by otter trawlers.

SIZE AND AGE COMPOSITION OF COMMERCIAL LANDINGS

There are no available biological sampling data for Soviet yellowtail landings. Thus, it has been necessary to assume that Soviet landings are identical to Canadian landings in size and age composition.

There was insufficient Canadian sampling data to treat areas and years separately thus all samples for 1962-69 (total of 20, 6 from Div. 4W, 14 from Div. 4Vs) were combined to give average size and age compositions of landings in this period.

Landings of males ranged in length from 25–50 cm with a mode at 36 cm (Fig. 17). Landings of females ranged in length from 30–55 cm with a mode at 38 cm.

A few 4 yr-olds and a few fish over 10 years old occur in the landings but most are 5–8 years old and there is little difference in the age composition of males and females (Fig. 17). There are slightly more females aged 7 and over and fewer 5 year old females than males in the landings. Both sizes appear to be fully recruited at age 6.

CATCH PER UNIT EFFORT

Catch rates of yellowtail by Canadian otter trawlers on the Scotian Shelf declined by 80% from 72.9 kg/hr in 1965 to 14.8 kg/hr in 1972 (Table 18). This decline occurred in both the Banquereau and Sable Island–Middle Bank concentrations to the same degree.

MORTALITY

Total mortality rate, Z , was calculated for males and females and for Banquereau and Sable Island Bank concentrations separately, from catch curves of 1960–69 commercial landings and 1970 and 1971 survey age compositions. Mortality was also calculated from the mean survival rates between 1970 and 1971 surveys (Table 19).

Mean estimates from surveys were $Z = 1.08$ for males and 0.74 for females on Banquereau, and 1.88 for males and 1.09 for females on Sable Island Bank. These were considerably higher than mortality rates from commercial age compositions of 0.66 for males and 0.74 for females. However, as commercial age compositions reflect mortality rates from about 1955 while survey data reflect those of the more recent period from 1965, survey data are likely to give the more accurate estimates of current mortality rates.

To obtain a single average value of Z representative of the whole Scotian Shelf, the values for males and females in each area were averaged, weighting by the sex ratio in commercial catches, to give $Z = 0.89$ for Banquereau and $Z = 1.43$ for Sable Island Bank. The values were then averaged, weighting by the population numbers in each region as determined in 1970–72 surveys, to give $Z = 1.23$ for the Scotian Shelf.

There are no estimates of natural mortality of Scotian Shelf yellowtail. Lux obtained a value of $M = 0.22$ for New England populations (Lux, 1969, ICNAF Res. Bull., 6: 47-52). Natural mortality could be expected to be somewhat higher than that in more long-lived species such as plaice and witch, and the values $M = 0.20-0.40$ are considered here. Age compositions imply that there is little difference in survival of males and females, thus natural mortality is assumed to be the same for both sexes.

GROWTH

Mean lengths at age from Canadian research vessel surveys are almost identical for males and females and between Banquereau and Sable Island Banks (Table 20). Therefore all survey data were combined to calculate von Bertalanffy growth equation parameters giving:

$$L_{\infty} = 77.9 \text{ cm} \quad (W_{\infty} = 3.8 \text{ kg})$$

$$K = 0.063$$

$$t_0 = -2.10 \text{ yrs}$$

YEAR PER RECRUIT

The Beverton and Holt yield per recruit equation was calculated using the growth parameters cited above and other parameters as follows:

$$t_{\rho} = 2.0 \text{ yrs}$$

$$t_{\rho 1} = 5.5 \text{ yrs}$$

$$t_{\lambda} = 12 \text{ yrs}$$

These values were obtained by inspection of commercial age composition.

Taking $Z = 1.20$ when $M = 0.30$, $F = 0.90$. This is above F_{opt} (0.50) and gives about 95% of the yield per recruit obtainable at very high values of F (Fig. 18). If $M = 0.20$, current F is above $F_{max} = 0.80$, and if $M = 0.40$ current F is still above F_{opt} and gives about 90% of the yield per recruit obtainable at very high F values.

CONCLUSIONS

In the 1965-69 period when landings averaged 6,250 tons after a period of lower landings, cpe fell from 72.9 kg per hour to 24.8 kg/hr - a decline of 66%. In 1970-72 cpe has remained at the low level of about 15 kg/hr, implying that current lower levels of landings are not resulting in further stock decline. During the 1965-72 period, F has been above F_{opt} and yield per recruit has been close to maximum. This implies that the sustained yield of yellowtail from the Scotian Shelf is lower than 6,000 tons per annum.

There are moderate quantities of yellowtail discarded by the Canadian fleet, and probably also by other fleets fishing regulated species. Thus, the increase in regulation mesh size from 4 1/2 inches to 5 1/8 inches on 1 January 1974 could result in some increase in long-term yield. Research vessel surveys indicate that 2-4 yr olds are in part vulnerable to small mesh trawls and thus prediction of the strength of incoming year classes may be possible.

SECTION III - GENERAL CONCLUSIONS

Individual species assessments indicate that witch landings should not greatly exceed 13,000 tons, plaice landings 13,600 tons and yellowtail landings should be less than 6,000 tons to obtain rational exploitation of the flatfish resources of the Scotian Shelf. Thus total landings should probably not exceed 30,000-35,000 tons. Combined landings of these three species exceeded 35,000 tons only in 1968.

As the separation of landings by species prior to 1970 is largely guesswork, the level of landings associated with the mortality rates calculated is only approximate. However, in total these errors should largely balance out.

Important aspect of these fisheries, particularly relevant to plaice and yellowtail, are the quantities discarded at sea, and the quantities taken incidentally in small mesh fisheries, and it has not been possible to consider these here. Some estimates of the effects of discards should be possible with available data although this is far from complete. An assessment of the effects of small-mesh fisheries, however, cannot be made until data on the quantities involved and their size and age compositions are collected. If the effects of these factors could be minimized, some increase in yield from Scotian Shelf flatfish stocks should accrue.

Table 1 : Flatfish landings (excluding halibut) from the Scotian Shelf by ICNAF Division and country (metric tons round).

Year	ICNAF Division				C O U N T R Y									
	4Vn	4Vs	4W	4X	Total	Canada	France(SP)	FRG	Japan	Poland	Romania	USSR	UK	USA
1960	4,090	782	3,982	1,160	10,014	9,771	8	-	-	-	-	-	-	235
1961	1,983	1,916	5,788	990	10,677	10,438	-	-	-	-	-	28	-	211
1962	2,836	1,918	6,874	896	12,524	11,537	-	-	-	-	-	671	-	316
1963	5,906	2,198	5,336	1,022	14,462	13,532	-	-	-	-	-	586	-	344
1964	5,112	6,953	4,351	2,200	18,616	17,813	231	2	-	-	-	113	9	448
1965	4,912	9,315	11,980	2,467	28,674	19,867	182	-	-	1	-	8,324	1	299
1966	6,004	11,011	15,558	2,373	34,946	20,927	39	-	-	-	-	13,817	11	152
1967	4,559	13,956	3,596	2,661	24,772	24,144	-	-	-	1	-	324	2	301
1968	4,263	20,797	27,177	3,029	55,266	25,115	177	-	-	-	-	29,842	-	132
1969	4,518	10,466	14,898	3,267	33,149	19,945	140	-	-	45	-	12,914	-	105
1970	4,388	4,835	7,175	3,251	19,649	13,667	39	-	9	6	84	5,705	-	139
1971	4,843	9,707	19,108	3,391	37,049	16,816	26	-	1	-	-	20,053	-	153

Table 2 : Greenland halibut landings from the Scotian Shelf by ICNAF Division and country (metric tons round).

Year	ICNAF Division				COUNTRY			
	<u>4Vn</u>	<u>4Vs</u>	<u>4W</u>	<u>4X</u>	<u>Total</u>	<u>Canada</u>	<u>F.R.G.</u>	<u>Poland</u>
1960	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-
1964	-	1	-	1	2	-	2	-
1965	-	-	-	-	-	-	-	-
1966	1	-	-	-	1	1	-	-
1967	2	-	-	-	2	2	-	-
1968	1	9	-	-	10	10	-	-
1969	16	20	-	2	38	18	-	20
1970	9	5	3	2	19	16	-	3
1971	15	4	2	3	24	24	-	-

Table 3 : Winter flounder landings from the Scotian Shelf by ICNAF Division and country (metric tons round).

Year	ICNAF Division				C O U N T R Y					
	<u>4Vn</u>	<u>4Vs</u>	<u>4W</u>	<u>4X</u>	Total	Canada	France(SP)	Japan	USSR	USA
1960	2	-	17	65	84	77	-	-	-	7
1961	70	-	79	702	851	846	-	-	2	3
1962	38	-	122	537	697	644	-	-	47	6
1963	11	6	104	551	682	613	-	-	42	27
1964	13	-	23	1,286	1,322	1,282	1	-	10	29
1965	27	5	637	1,183	1,852	1,237	-	-	610	5
1966	52	3	920	1,023	1,998	998	-	-	992	8
1967	35	1	28	902	966	925	-	-	23	18
1968	7	1	1,619	1,133	2,760	1,127	-	-	1,620	13
1969	3	-	842	1,398	2,243	1,393	-	-	843	7
1970	8	-	44	1,479	1,531	1,480	-	1	42	8
1971	8	229	1,364	1,484	3,085	1,430	-	1	1,647	7

Table 4 : Winter flounder -- A. estimated population biomass (metric tons) and kg./tow. B. estimated population numbers ($\times 10^{-6}$) and no./tow, from Canadian research vessel surveys, July 1970-72.

A

Strata	ICNAF Div.	1970		1971		1972	
		Biomass	kg/tow	Biomass	kg/tow	Biomass	kg/tow
40-42	4Vn	-	-	-	-	-	-
43-52	4Vs	-	-	-	-	-	-
40-52	4V	-	-	-	-	-	-
53-66	4W	520	0.30	790	0.46	3,120	1.82
70-95	4X	380	0.21	240	0.13	220	0.12
40-95	4VWX	900	0.18	1,030	0.21	3,340	0.67

B

Strata	ICNAF Div.	1970		1971		1972	
		Popn. no.	No./tow	Popn. no.	No./tow	Popn. no.	No./tow
40-42	4Vn	-	-	-	-	-	-
43-52	4Vs	-	-	-	-	-	-
40-52	4V	-	-	-	-	-	-
53-66	4W	1.8	1.03	2.2	1.30	5.4	3.12
70-95	4X	0.5	0.28	0.5	0.27	0.4	0.24
40-95	4VWX	2.3	0.46	2.7	0.55	5.8	1.17

Table 5 : Landings of plaice, yellowtail and witch from the Scotian Shelf by ICNAF Division and country (metric tons round).

Year	4Vn	4Vs	4W	4X	Total	Canada	France	Japan	Poland	Romania	USSR	UK	U.S.A.
1960	4,088	782	3,965	1,095	9,930	9,694	8	-	-	-	-	-	228
1961	1,913	1,916	5,709	288	9,826	9,592	-	-	-	-	26	-	208
1962	2,798	1,918	6,752	359	11,827	10,893	-	-	-	-	624	-	310
1963	5,895	2,192	5,232	461	13,780	12,919	-	-	-	-	544	-	317
1964	5,099	6,952	4,328	913	17,292	16,531	230	-	-	-	103	9	419
1965	4,885	9,310	11,343	1,284	26,822	18,630	182	-	1	-	7,714	1	294
1966	5,951	11,008	14,638	1,350	32,947	19,928	39	-	-	-	12,825	11	144
1967	4,522	13,955	3,568	1,759	23,804	23,217	-	-	1	-	301	2	283
1968	4,255	20,787	25,558	1,896	52,496	23,978	177	-	-	-	28,222	-	119
1969	4,499	10,446	14,056	1,867	30,868	18,534	140	-	25	-	12,071	-	98
1970	4,371	4,830	7,128	1,770	18,099	12,171	39	8	3	84	5,663	-	131
1971	4,820	9,474	17,742	1,904	33,940	15,362	26	-	-	-	18,406	-	146

Table 6 : Catch per unit effort (kg/hr trawling) of plaice, witch and yellowtail on the Scotian Shelf - Canadian otter trawlers of 151-500

<u>Year</u>	<u>Plaice</u>	<u>Witch</u>	<u>Yellowtail</u>		
1965	42.9	34.9	72.9		
1966	67.8	22.4	49.5		
1967	58.0	28.7	47.4		
1968	61.6	30.9	49.7		
1969	73.5	31.7	24.8		
1970	72.7	20.9	14.0		
1971	61.0	31.3	14.7		
1972	54.9	34.8	14.8		
	<u>Div. 4Vn</u>	<u>Div. 4Vs</u>	<u>Div. 4W</u>	<u>Div. 4X</u>	<u>All Divisions</u>
1965	195.9	487.4	86.3	5.8	150.7
1966	153.7	535.1	32.4	6.1	139.7
1967	225.7	435.5	62.3	8.2	134.1
1968	173.0	478.3	67.2	10.1	142.2
1969	152.3	454.4	50.1	10.9	130.0
1970	134.6	392.6	30.6	7.8	107.6
1971	135.7	338.8	61.2	9.0	107.0
1972	112.4	321.1	71.4	7.1	104.5

Table 7 : Witch flounder - A. estimated population biomass (metric tons and kg./tow. B. estimated population numbers ($\times 10^{-6}$) and no./tow, from Canadian research vessel surveys, July 1970-72.

A

Strata	ICNAF Div.	1970		1971		1972	
		Biomass	kg/tow	Biomass	kg/tow	Biomass	kg/tow
40-42	4Vn	1,190	3.56	3,440	10.31	880	2.64
43-52	4Vs	4,120	3.83	2,960	2.76	3,140	2.92
40-52	4V	5,310	3.77	6,400	4.55	4,020	2.85
53-66	4W	1,640	0.96	1,420	0.83	2,170	1.26
70-95	4X	2,750	1.50	980	0.48	4,150	2.25
40-95	4VWX	9,700	1.96	8,800	1.76	10,340	2.08

B

Strata	ICNAF Div.	1970		1971		1972	
		Popn. no.	No./tow	Popn. no.	No./tow	Popn. no.	No./tow
40-42	4Vn	2.2	6.64	10.6	31.68	2.4	7.06
43-52	4Vs	10.0	9.29	5.3	4.89	6.8	6.27
40-52	4V	12.2	8.66	15.9	11.23	9.2	6.46
53-66	4W	4.1	2.40	3.1	1.81	4.2	2.45
70-95	4X	4.7	2.55	1.6	0.87	5.9	3.21
40-95	4VWX	21.0	4.23	20.6	4.14	19.3	3.87

Table 8 : Witch landings from the Scotian Shelf by ICNAF Division and country (metric tons round).

Year	ICNAF Division				Total	C O U N T R Y							
	4Vn	4Vs	4W	4X		Canada	France(SP)	Japan	Poland	USSR	UK	USA	
1960	3,192	209	2,623	46	6,070	5,914	6	-	-	-	-	-	150
1961	1,494	475	3,175	69	5,213	5,074	-	-	-	13	-	-	126
1962	2,030	342	3,774	65	6,211	5,697	-	-	-	313	-	-	201
1963	4,648	322	2,363	144	7,477	7,028	-	-	-	279	-	-	170
1964	4,040	1,925	2,556	291	8,812	8,406	157	-	-	60	-	-	189
1965	3,163	1,969	6,219	521	11,872	7,710	63	-	1	4,003	1	94	22
1966	3,720	1,524	7,910	521	13,675	7,046	19	-	-	6,586	4	20	2
1967	2,491	3,252	1,619	383	7,745	7,498	-	-	1	152	2	92	29
1968	2,608	6,384	12,804	751	22,547	8,771	52	-	-	13,695	-	-	28
1969	2,090	2,418	7,470	797	12,775	6,672	40	-	8	6,027	-	-	55
1970	2,263	1,022	1,960	809	6,054	4,921	14	3	2	1,059	-	-	64
1971	2,332	3,309	11,083	1,141	17,865	6,817	6	-	-	10,978	-	-	

Table 9 : Catch per unit effort (kg/hr) of witch on the Scotian Shelf by Division - Canadian otter trawlers of 151-500 gross tons.

<u>Year</u>	<u>Div. 4Vn</u>	<u>Div. 4Vs</u>	<u>Div. 4W</u>	<u>Div. 4X</u>	<u>All Divisions</u>
1965	88.7	94.4	23.9	0.7	34.9
1966	72.3	59.5	12.3	1.0	22.4
1967	80.3	82.4	14.0	1.7	28.7
1968	86.3	80.0	19.9	2.4	30.9
1969	46.6	83.4	26.6	3.6	31.7
1970	50.5	61.3	10.0	2.2	20.9
1971	64.4	66.9	32.6	3.4	31.3
1972	56.4	79.6	37.7	1.9	34.8

Table 10 : Witch Div. 4VW - instantaneous total mortality - Z, from catch curves.

<u>Data base</u>	<u>Division</u>	<u>Z</u>		<u>Z</u>	
		<u>Males</u>	<u>Ages</u>	<u>Females</u>	<u>Ages</u>
Commercial age compositions 1970-72	4VW	0.56	8-12	0.50	11-14
1972 survey age compositions	4Vs	0.55	8-12	0.47	8-11
" " " "	4W	0.45	8-12	-	-
" " " "	4X	0.33	8-12	0.30	9-12

Table 11: American plaice - A. estimated population biomass (metric tons) and kg/tow. B. estimated population numbers ($\times 10^6$) and no./tow, from Canadian research vessel surveys, July 1970-72.

A

Strata	ICNAF Div.	1970		1971		1972	
		Biomass	kg/tow	Biomass	kg/tow	Biomass	kg/tow
40-42	4Vn	1,760	5.29	5,380	16.12	6,210	18.63
43-52	4Vs	27,070	25.16	32,630	30.33	23,770	22.10
40-52	4V	28,830	20.46	38,010	26.46	29,980	21.28
53-66	4W	10,050	5.86	9,810	5.72	6,610	3.86
70-95	4X	6,860	3.73	3,430	1.85	3,060	1.66
40-95	4VWX	45,470	9.21	51,250	10.31	39,650	7.99

B

Strata	ICNAF Div.	1970		1971		1972	
		Popn. no.	No./tow	Popn. no.	No./tow	Popn. no.	No./tow
40-42	4Vn	11.6	34.91	7.7	23.14	24.7	73.93
43-52	4Vs	102.4	95.16	103.8	96.48	74.4	69.19
40-52	4V	114.0	80.83	111.5	79.11	99.1	70.32
53-66	4W	52.3	30.51	37.0	21.55	33.1	19.28
70-95	4X	23.7	12.86	11.2	6.08	10.4	5.66
40-95	4VWX	190.0	38.27	159.7	32.15	142.6	28.72

Table 12: American plaice landings from the Scotian Shelf by ICNAF Division and country (metric tons round).

Year	ICNAF Division				C O U N T R Y								
	4Vn	4Vs	4W	4X	Total	Canada	France(SP)	Japan	Poland	Romania	USSR	UK	USA
1960	896	192	786	1,035	2,909	2,844	2	-	-	-	-	-	63
1961	417	164	853	210	1,644	1,562	-	-	-	-	9	-	73
1962	750	112	868	267	1,997	1,695	-	-	-	-	216	-	86
1963	1,237	140	778	259	2,414	2,115	-	-	-	-	182	-	117
1964	938	1,059	617	519	3,133	2,838	67	-	-	-	25	9	194
1965	1,692	3,042	3,090	542	8,366	5,543	119	-	-	-	2,525	-	179
1966	2,215	5,979	4,706	637	13,537	9,112	20	-	-	-	4,288	7	110
1967	1,984	6,895	801	1,106	10,786	10,520	-	-	-	-	104	-	162
1968	1,641	9,521	8,591	941	20,694	9,829	114	-	-	-	10,684	-	67
1969	2,365	5,714	4,756	868	13,703	9,300	60	-	12	-	4,280	-	51
1970	2,069	3,177	2,482	635	8,363	6,303	19	5	1	84	1,896	-	55
1971	2,470	5,295	5,991	545	14,301	7,513	18	-	-	-	6,700	-	70

Table 13 : Plaice : catch per unit effort (kg/hr) on the Scotian Shelf by Division - Canadian otter trawlers of 151-500 gross tons.

<u>Year</u>	<u>Div. 4Vn</u>	<u>Div. 4Vs</u>	<u>Div. 4W</u>	<u>Div. 4X</u>	<u>All Divisions</u>
1965	93.6	144.3	11.8	3.4	42.9
1966	81.0	260.4	12.8	4.2	64.8
1967	135.7	191.7	15.3	5.5	58.0
1968	86.7	206.5	24.6	6.8	61.6
1969	105.2	265.1	19.4	6.3	73.5
1970	84.1	276.1	16.0	4.5	72.7
1971	70.9	216.5	23.9	2.9	61.0
1972	56.0	193.2	22.0	4.5	54.9

Table 14 : Plaice Div. 4VWX - instantaneous total mortality -Z, from catch curves

<u>Data base</u>	<u>Division</u>	<u>Z</u> <u>Males</u>	<u>Ages</u>	<u>Z</u> <u>Females</u>	<u>Ages</u>
Commercial age compositions, 1968-72	4V	0.46	9-14	0.54	12-14
1972 survey age compositions	4Vn	0.73	7-12	0.80	8-12
" " " "	4Vs	0.58	7-12	0.55	7-12
" " " "	4W	0.79	7-12	0.61	7-12
" " " "	4X	0.55	7-12	0.49	8-12
1972 survey estimates weighted by population numbers	4VWX	0.65		0.60	

Table 15 : Plaice : mean length (cm) at age from 1972 survey catches and 1968-72 commercial landings.

<u>Age</u>	<u>Males</u>		<u>Females</u>	
	<u>Surveys</u>	<u>Commercial</u>	<u>Surveys</u>	<u>Commercial</u>
2	16.7	-	16.7	-
3	20.7	-	21.3	-
4	21.4	-	22.4	-
5	25.3	-	25.3	-
6	26.6	-	27.9	-
7	27.0	33.5	29.5	-
8	33.4	35.9	31.7	39.4
9	31.8	36.3	36.3	40.8
10	33.2	37.6	37.9	43.2
11	34.8	39.7	42.1	44.9
12	35.3	39.6	46.0	47.3
13	-	41.0	46.2	46.5
14	-	42.5	48.6	49.8
15	-	41.4	50.0	48.1

Table 16 : Yellowtail flounder - A. estimated population biomass (metric tons) and kg/tow. B. estimated population numbers ($\times 10^{-6}$) and no./tow, from Canadian research vessel surveys, July 1970-72.

A

Strata	ICNAF Div.	1970		1971		1972	
		Biomass	kg/tow	Biomass	kg/tow	Biomass	kg/tow
40-42	4Vn	-	-	-	-	140	0.42
43-52	4Vs	9,750	9.43	7,960	7.39	13,910	12.91
40-52	4V	9,750	7.20	7,960	5.64	14,050	9.95
53-66	4W	12,370	7.21	9,800	5.72	9,430	5.50
70-95	4X	270	0.14	280	0.15	580	0.31
40-95	4VWX	22,390	4.59	18,040	3.63	24,060	4.84

B

Strata	ICNAF Div.	1970		1971		1972	
		Popn. no.	No./tow	Popn. no.	No./tow	Popn. no.	No./tow
40-42	4Vn	-	-	-	-	0.3	1.04
43-52	4Vs	31.4	29.19	26.9	24.93	44.0	40.83
40-52	4V	31.4	22.28	26.9	19.02	44.3	31.41
53-66	4W	68.1	39.68	57.5	33.52	44.4	25.89
70-95	4X	0.7	0.37	1.0	0.53	3.0	1.64
40-95	4VWX	100.2	20.16	85.4	17.17	91.7	18.46

Table 17 : Yellowtail landings from the Scotian Shelf by ICNAF Division and country (metric tons round).

Year	ICNAF Division					C O U N T R Y					Total
	4Vn	4VS	4W	4X		Canada	France(SP)	Poland	USSR	USA	
1960	-	381	556	14		936	-	-	-	15	
1961	2	1,277	1,681	9		2,956	-	-	4	9	
1962	18	1,464	2,110	27		3,501	-	-	95	23	
1963	10	1,730	2,091	58		3,776	-	-	83	30	
1964	121	3,968	1,155	103		5,287	6	-	18	36	
1965	30	4,299	2,034	221		5,377	-	-	1,186	21	
1966	16	3,505	2,022	192		3,770	-	-	1,951	14	
1967	47	3,808	1,148	270		5,273	-	-	45	29	
1968	6	4,882	4,163	204		5,378	11	-	3,843	23	
1969	44	2,314	1,830	202		2,562	40	5	1,764	19	
1970	39	631	2,686	326		947	6	-	2,708	21	
1971	18	870	668	218		1,032	2	-	728	12	

Table 18. : Yellowtail : catch per unit effort
(kg/hr) on the Scotian Shelf by Division
- Canadian otter trawlers of 151-500 gross
tons.

<u>Year</u>	<u>Div. 4Vn</u>	<u>Div. 4Vs</u>	<u>Div. 4W</u>	<u>Div. 4X</u>	<u>All Divisions</u>
1965	13.6	248.7	50.6	1.7	72.9
1966	0.4	215.2	7.3	0.9	49.5
1967	9.7	161.4	33.0	1.0	47.4
1968	0	191.0	22.7	0.9	49.7
1969	0.5	105.9	4.1	1.0	24.8
1970	0	55.2	4.6	1.1	14.0
1971	0.4	55.4	4.7	2.7	14.7
1972	0	48.3	11.7	0.7	14.8

Table 19 : Yellowtail instantaneous mortality rates -Z.

Method	Banquereau (4Vs)		Sable Island Bank (4W)	
	Males	Females	Males	Females
Commercial landings 1960-69 Catch curves	0.66*	0.74*	*4Vs + 4W combined	
Survey 1970 Catch curves	1.38	0.57	1.28	1.23
Survey 1971 Catch curves	1.24	0.78	1.23	1.55
Survey 1970-71 combined Catch curves	1.39	0.69	1.81	1.53
Survey Mean survival 1970-71 for ages 6-10	1.06	0.95	2.53	0.74
Survey survival Σ 7-10 / Σ 6-9 for 1970-71	0.32	0.70	2.56	0.39
Mean of survey estimates	1.08	0.74	1.88	1.09

Table 20.: Yellowtail : mean length at age (cm) from 1970 and 1971 Canadian research vessel surveys combined.

<u>Age</u>	<u>Banquereau</u>		<u>Sable Island Bank</u>	
	<u>Males</u>	<u>Females</u>	<u>Males</u>	<u>Females</u>
2	-	15.8	17.5	17.0
3	21.1	22.0	21.0	21.3
4	25.8	25.3	25.6	24.7
5	27.5	27.5	27.2	28.4
6	31.7	31.7	29.7	31.5
7	35.1	35.6	32.7	34.4
8	34.4	37.9	35.8	38.3
9	41.3	41.2	-	41.6
10	43.0	43.8	-	44.1

WITCH

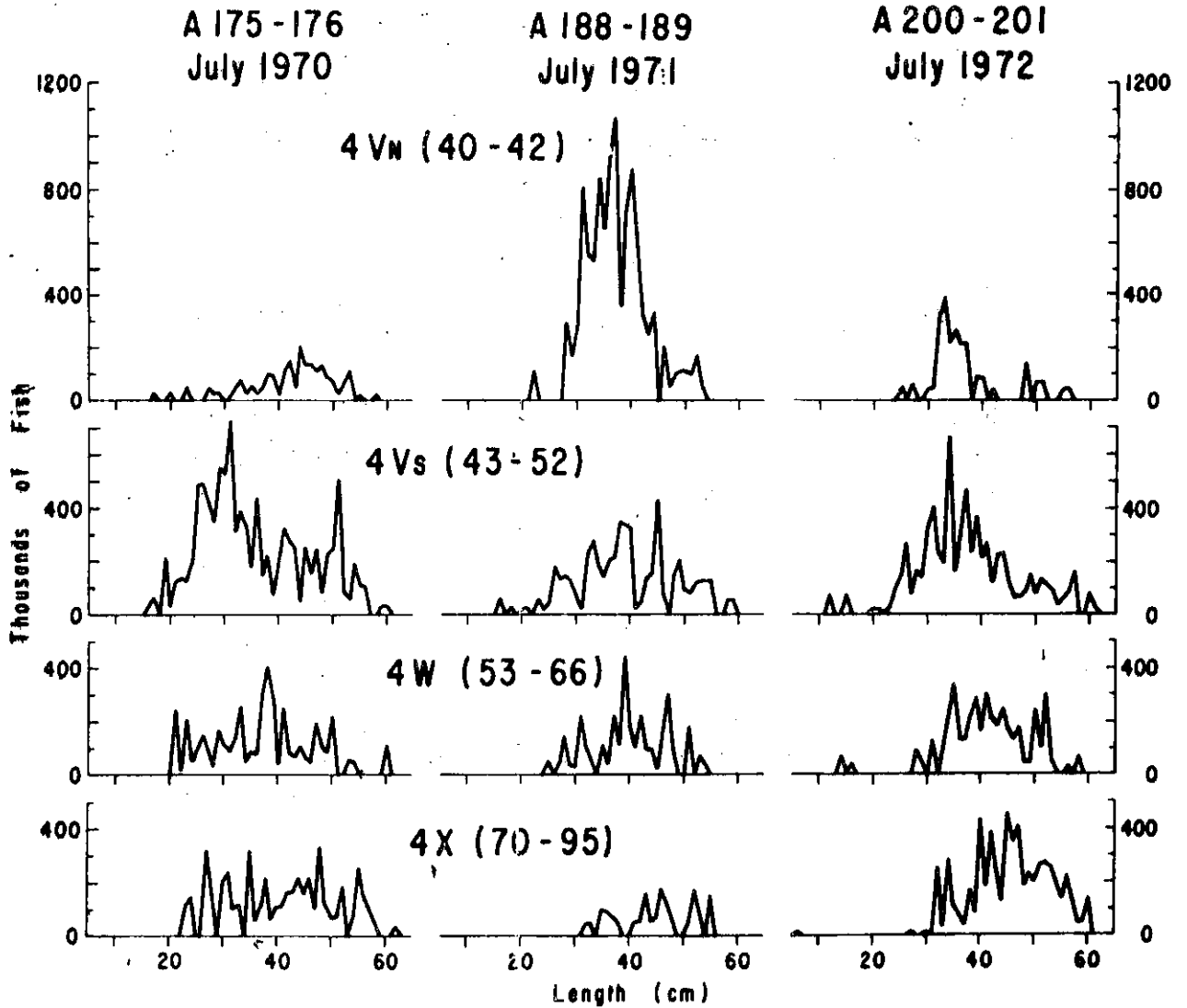


Fig. 2. Witch : length-frequency of the Scotian Shelf population by ICNAF Division estimated from Canadian research vessel surveys, 1970-72.

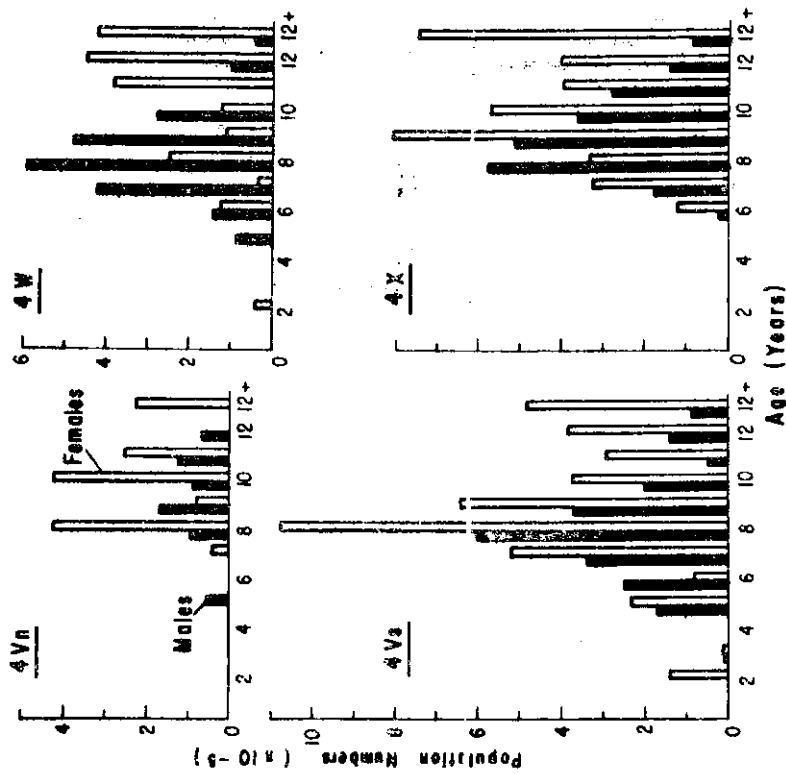


Fig. 3. Witch: age composition of the Scotian Shelf population by ICNAF Division estimated from Canadian research vessel surveys in 1972.

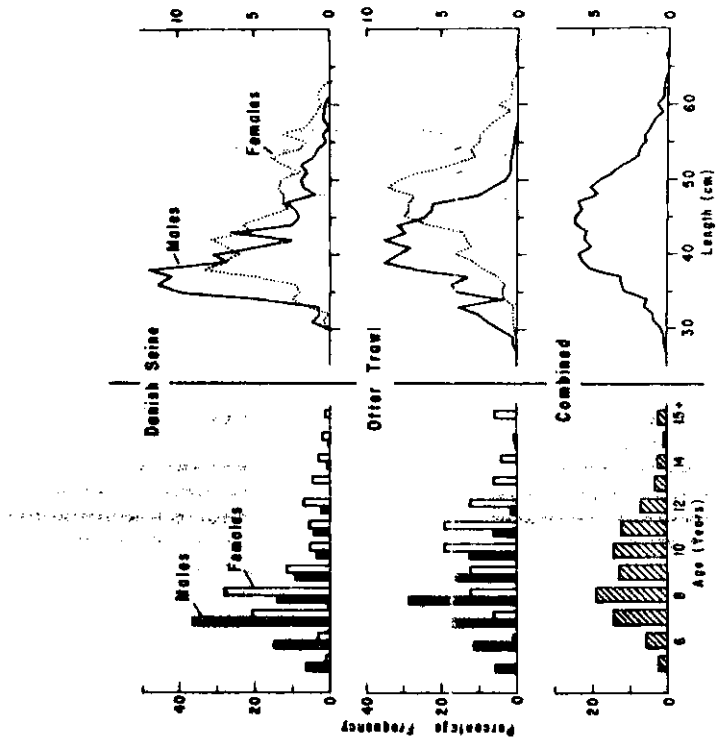


Fig. 4. Witch: length and age composition of commercial landings from Div. 4W, 1970-72.

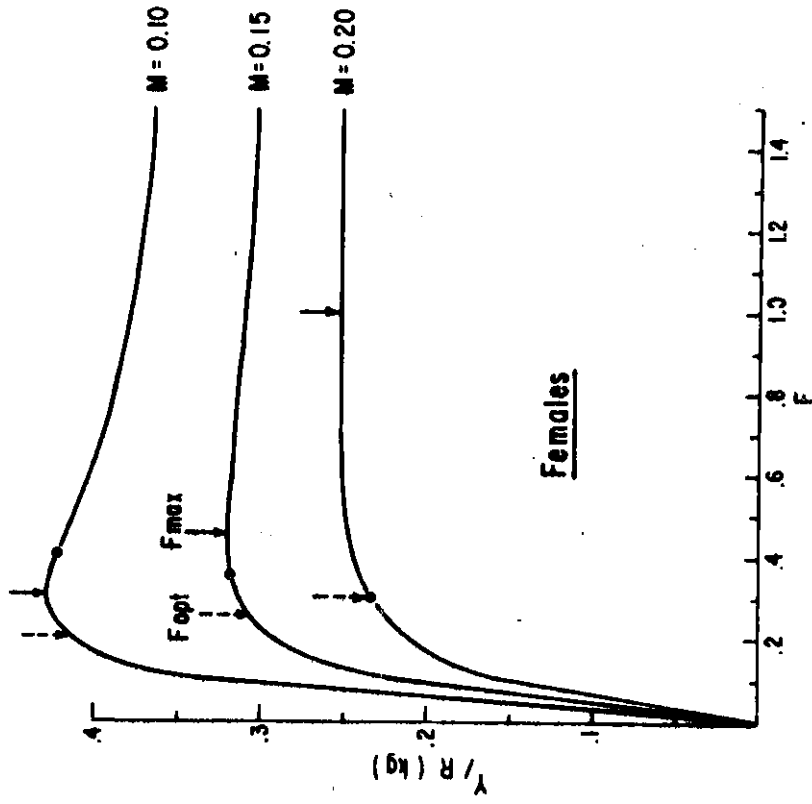


Fig. 6. Witch: yield per recruit of females. Dots indicate 1965-72 values of F .

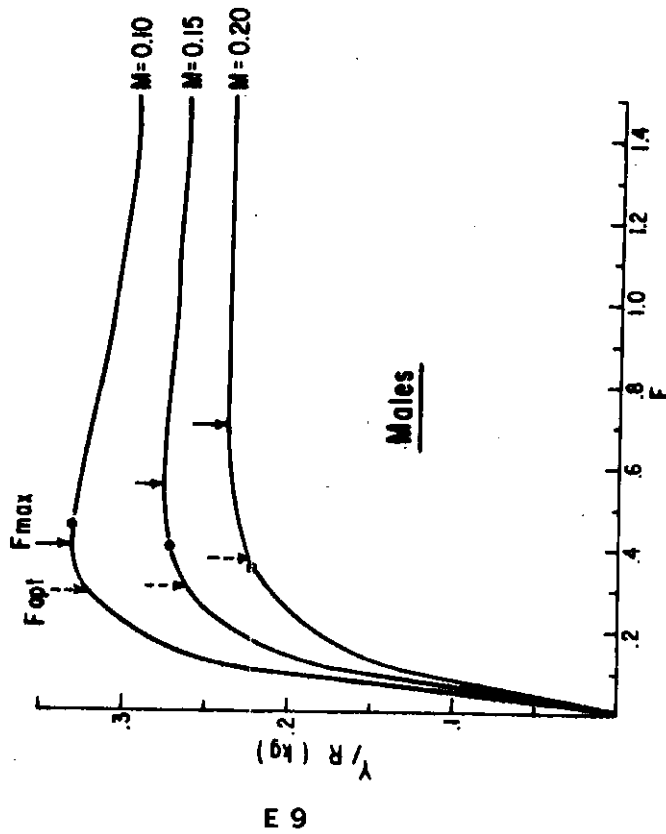


Fig. 5. Witch: yield per recruit of males. Dots indicate 1965-72 values of F .

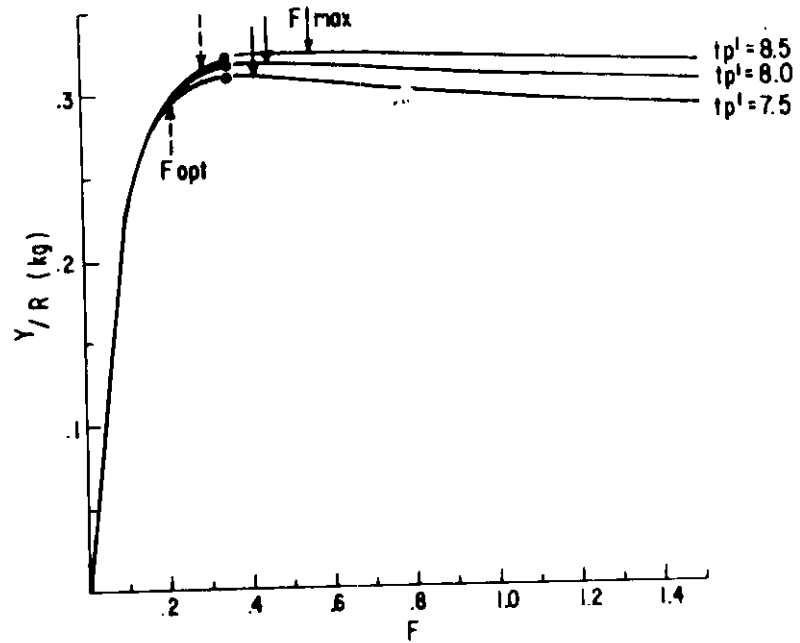


Fig. 7. Witch : yield per recruit of females for $M = 0.15$ and mean recruitment ages to the fishery of 7.5-8.5 yrs. Dots indicate 1965-72 values of F.

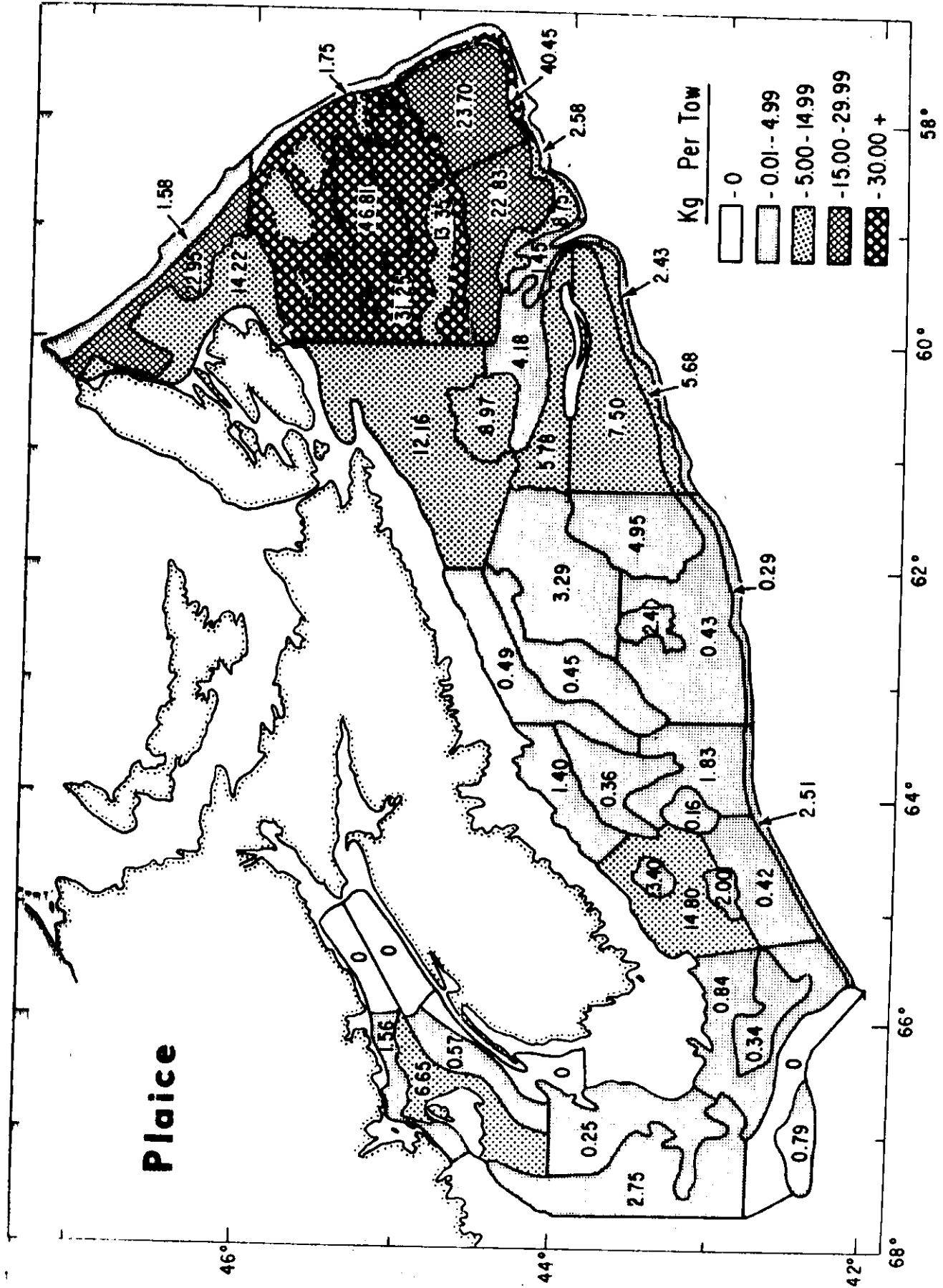


Fig. 8. Plaice : mean abundance (kg/tow) on the Scotian Shelf from Canadian research vessel surveys, 1970-72.

PLAICE

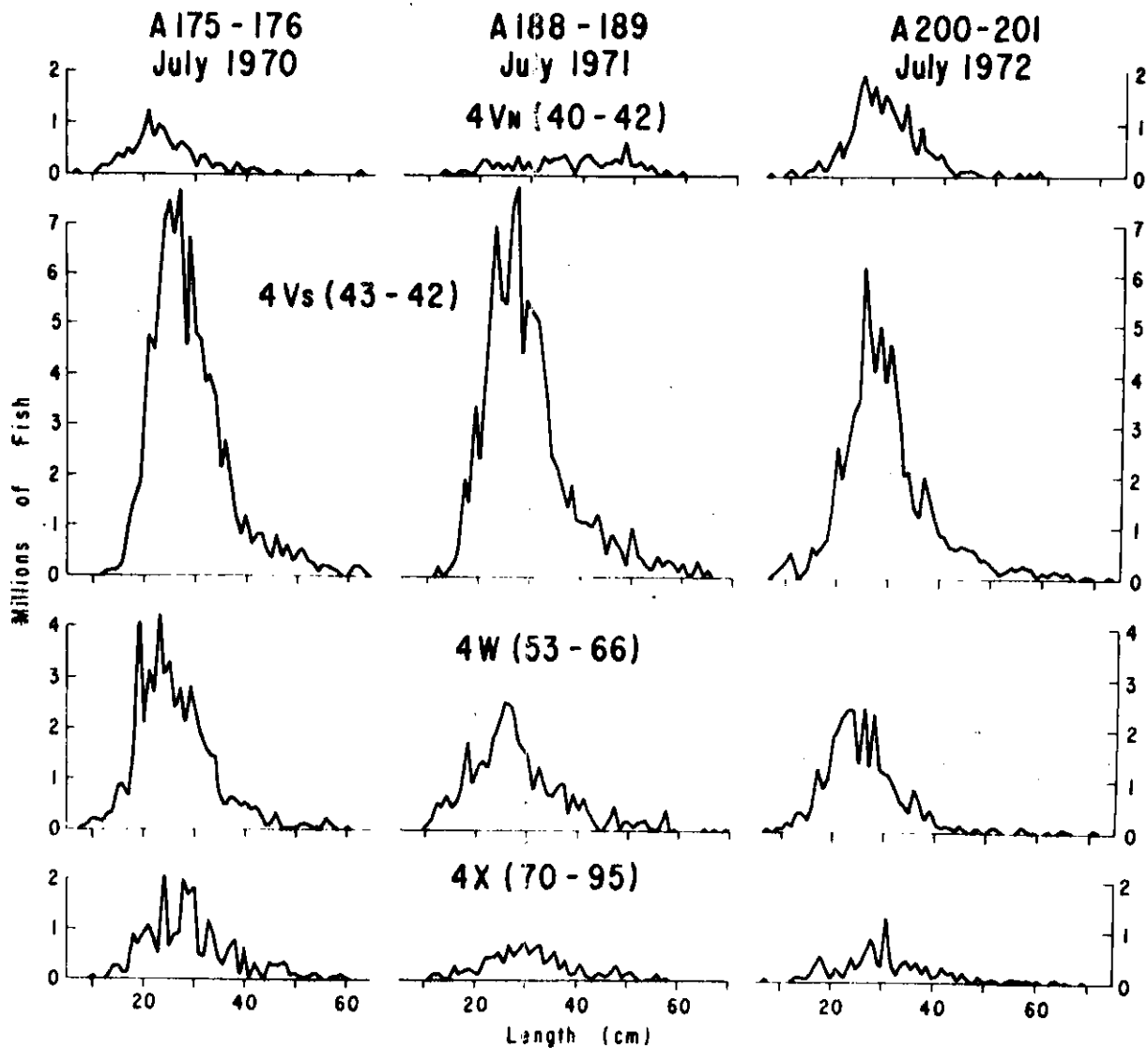


Fig. 9. Plaice : size composition of the population by Division estimated from Canadian research vessel surveys, 1970-72.

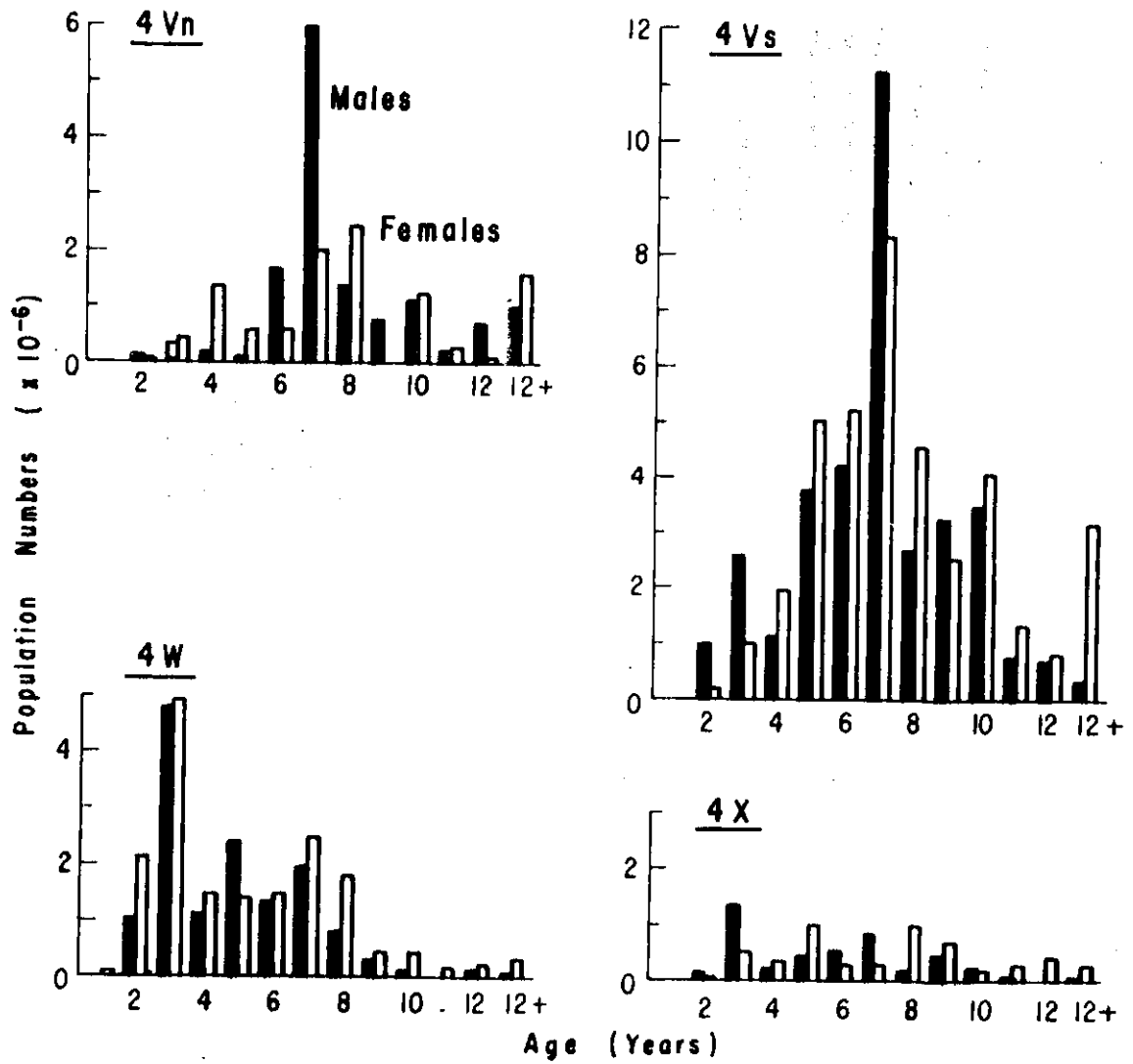


Fig. 10. Plaice : age composition of the population by Division estimated from the Canadian research vessel survey in 1972.

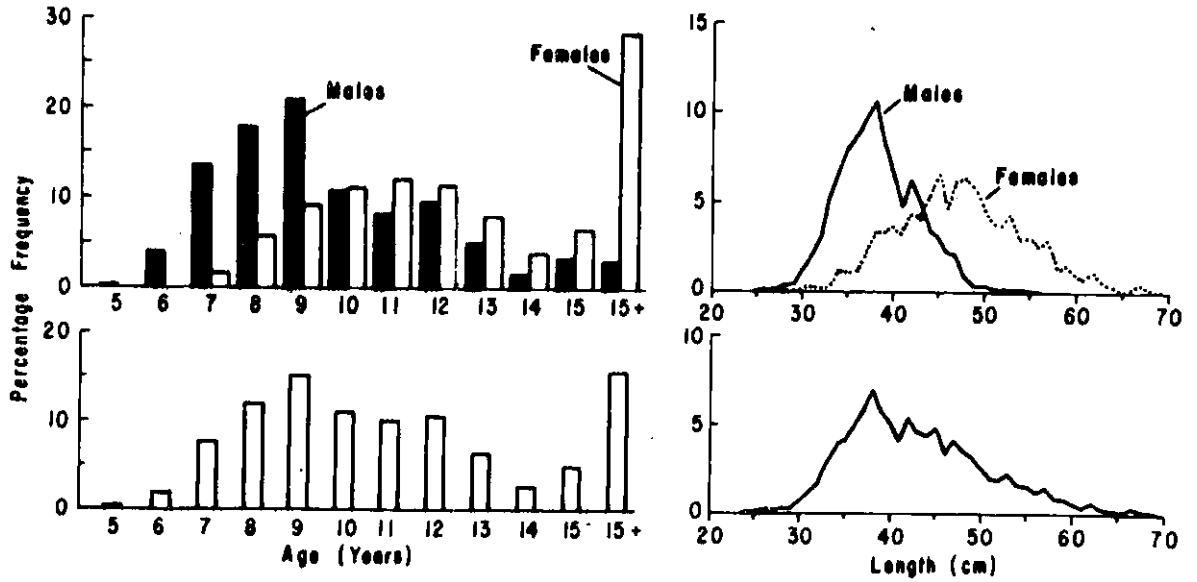


Fig. 11. Plaice : size and age composition of Canadian landings from Div. 4Vn and Div. 4Vs in 1968-72.

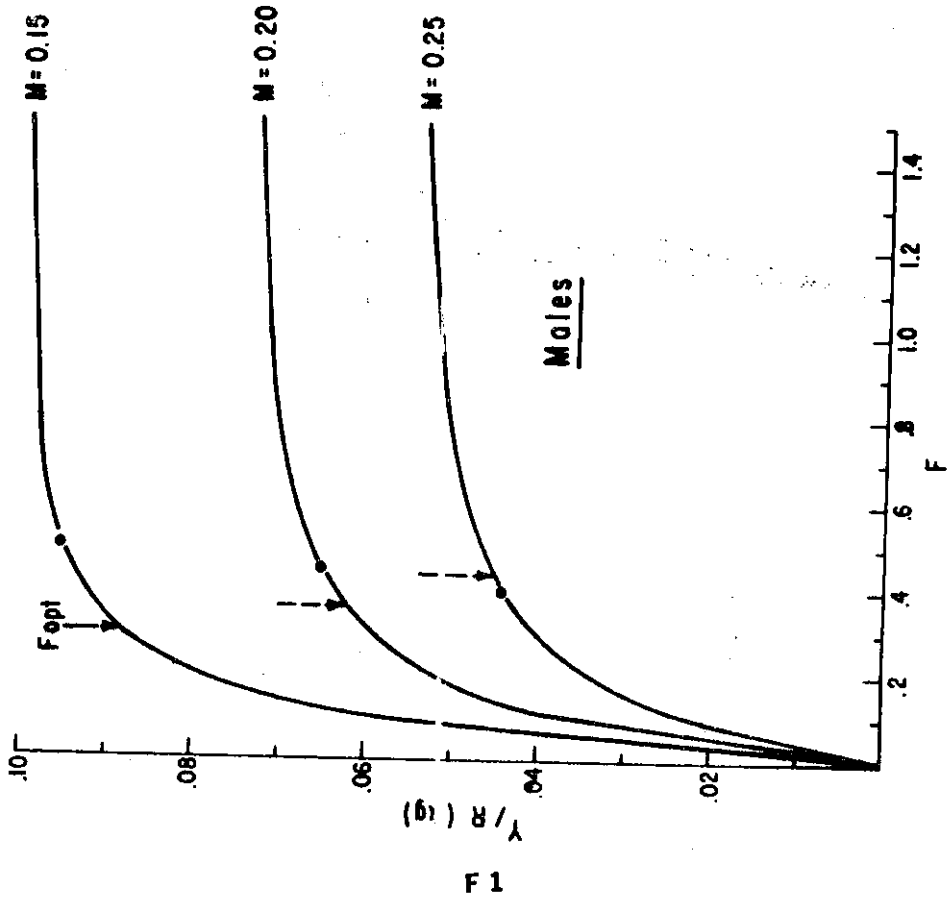


Fig. 12. Plaice : yield per recruit of males ($t_{p1} = 7.5$ yrs). Dots indicate current F values.

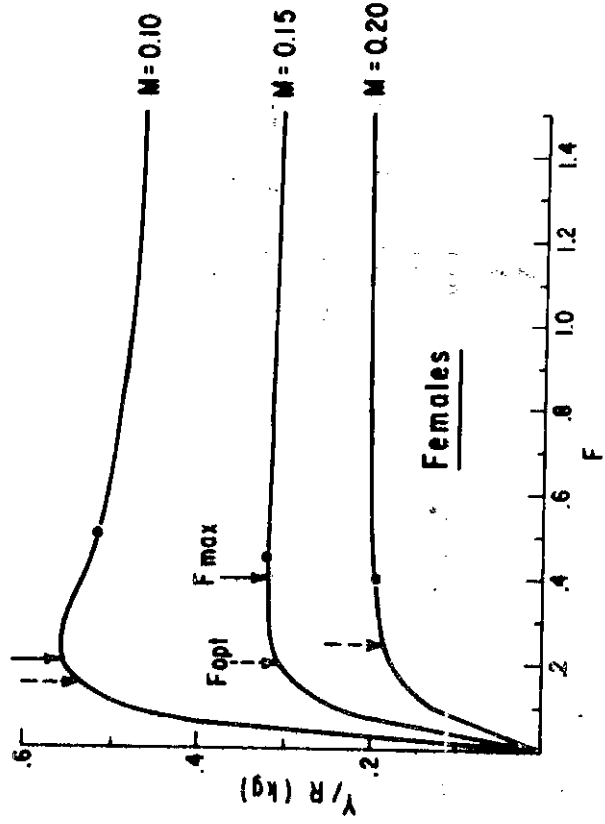


Fig. 13. Plaice : yield per recruit of females ($t_{p1} = 9.5$ yrs). Dots indicate current F values.

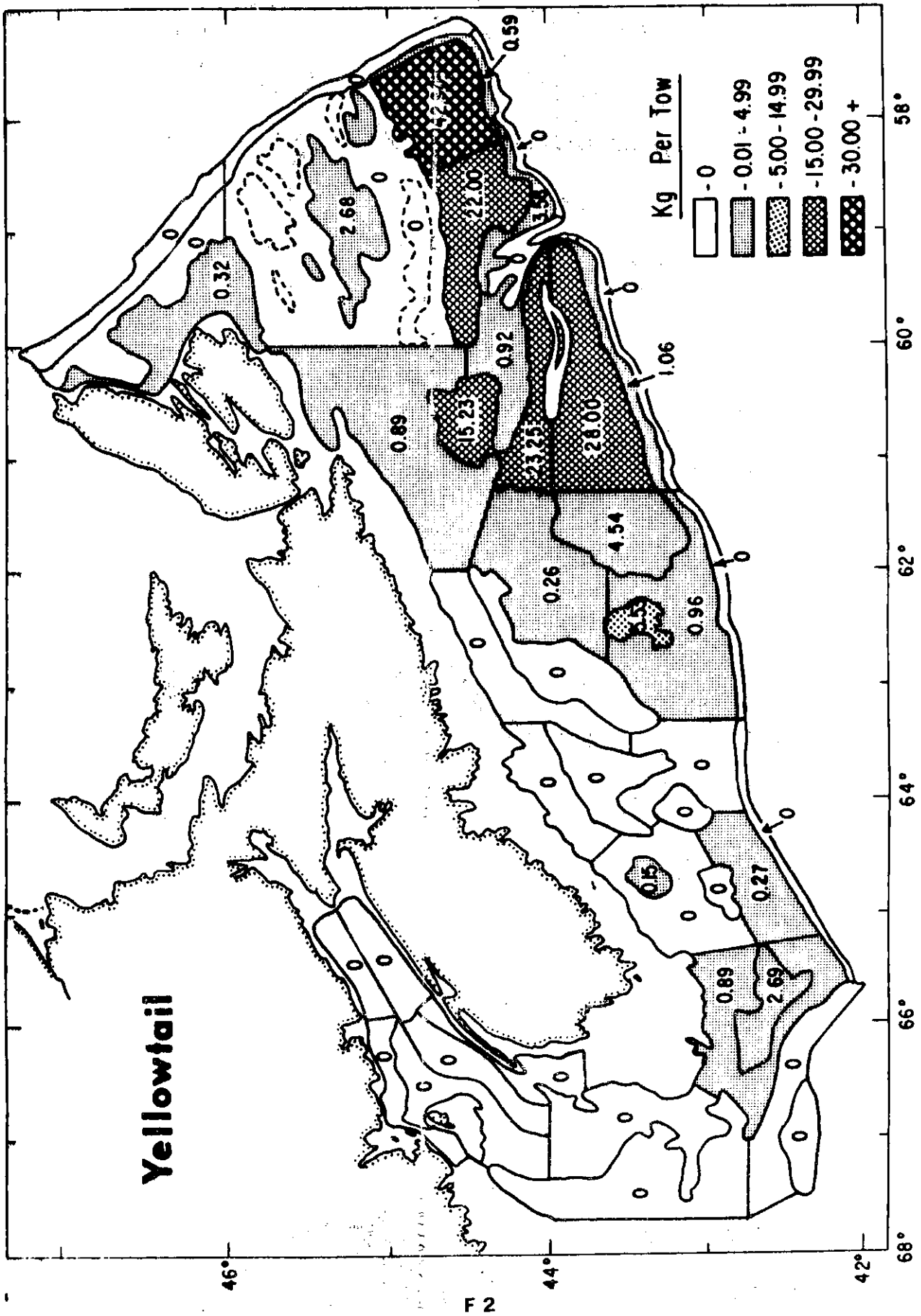


Fig. 14. Yellowtail : abundance on the Scotian Shelf from 1970-72. Contour lines represent abundance vessel surveys.

YELLOWTAIL

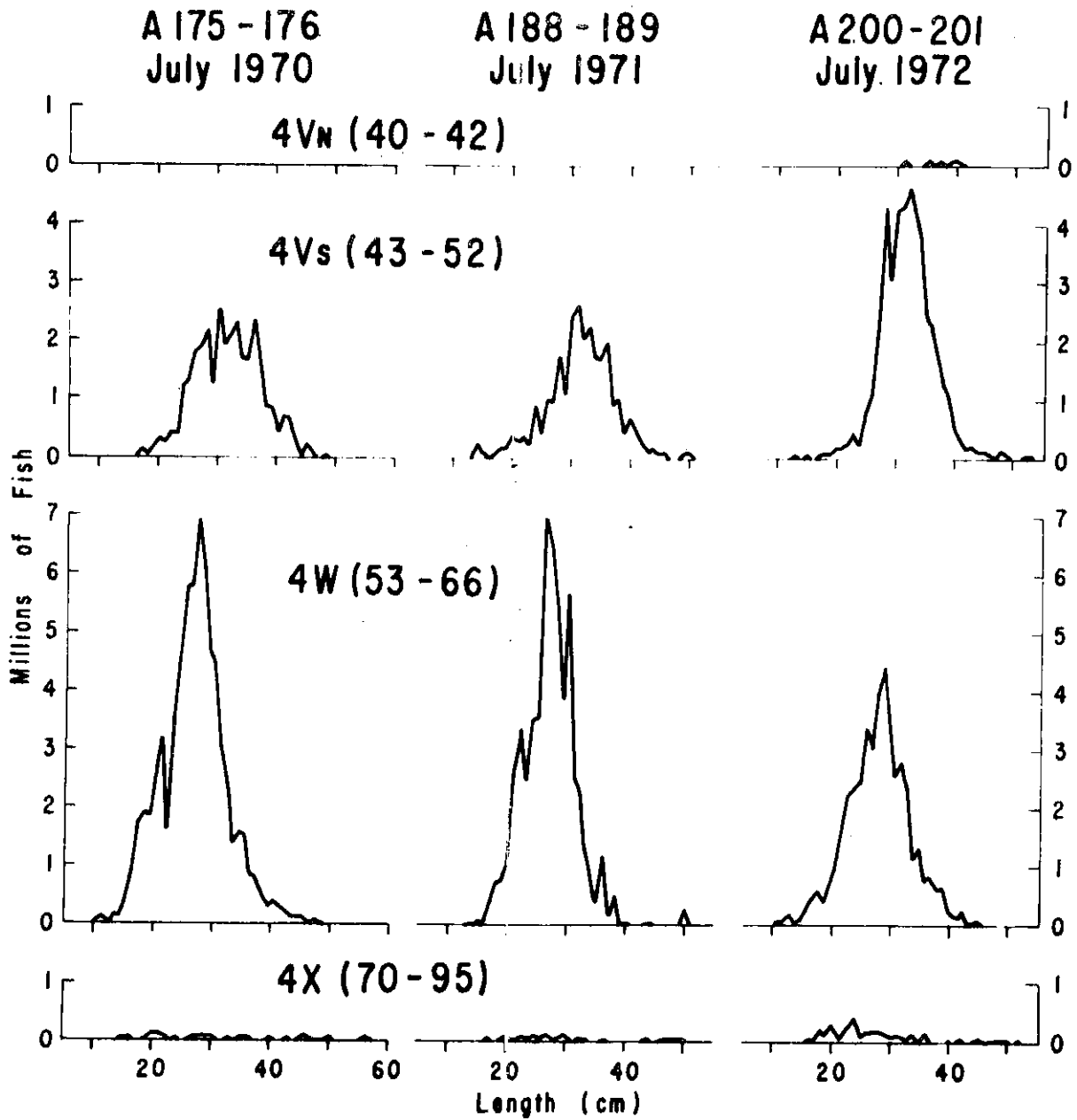


Fig. 15. Yellowtail : length compositions of the population by Division from Canadian research vessel surveys, 1970-72.

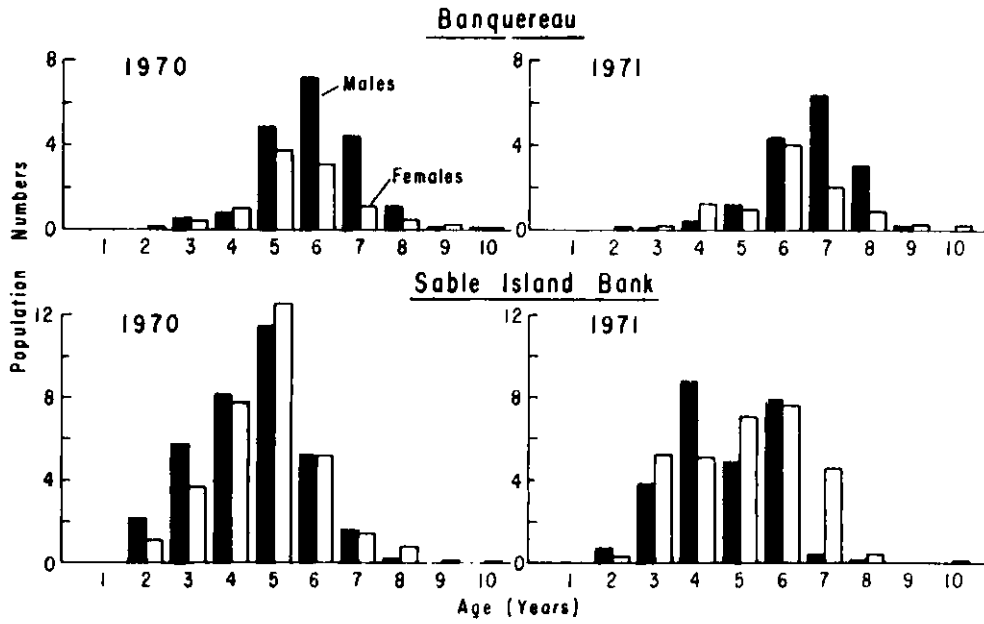


Fig. 16. Yellowtail : age composition on Banquereau and Sable Island—Middle banks in 1970 and 1971 from Canadian research vessel surveys.

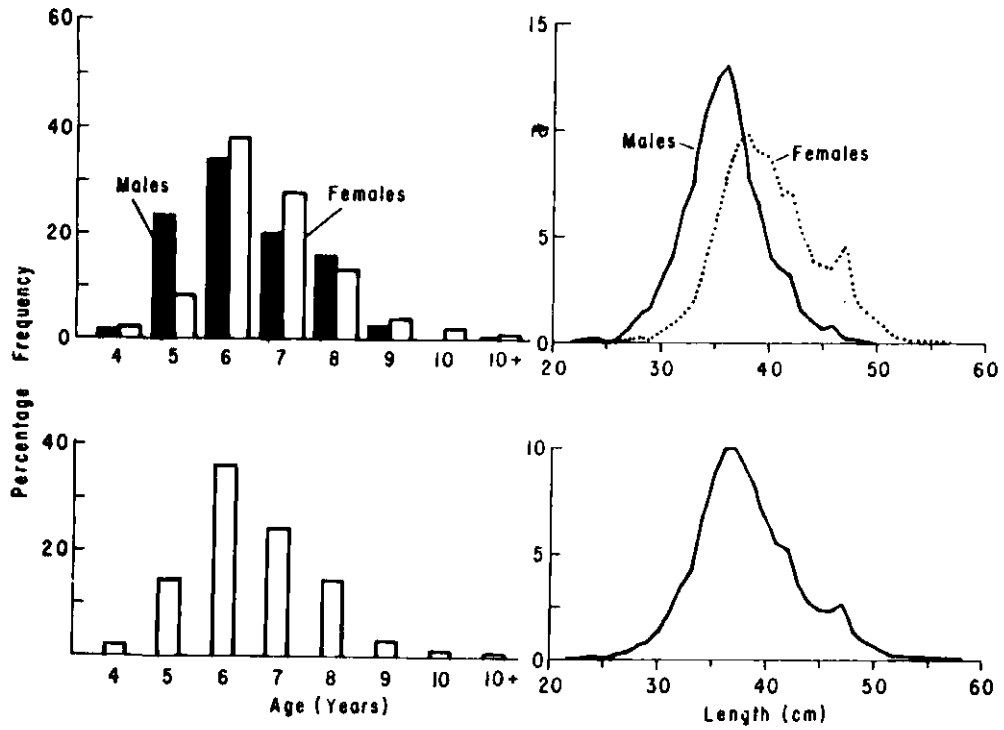


Fig. 17. Yellowtail : length and age compositions of Canadian commercial landings, 1960-69.

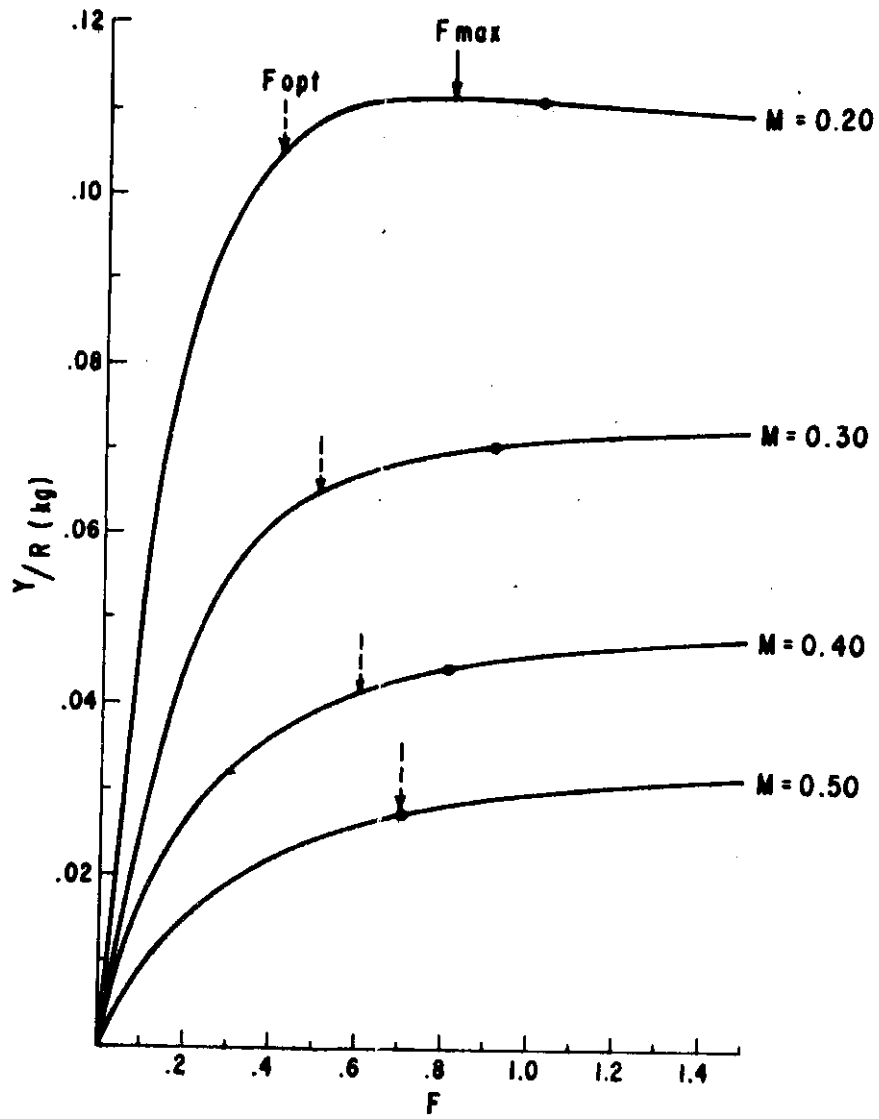


Fig. 18. Yellowtail : yield per recruit curves for $t_{p1} = 5.5$ yrs. Dots indicate current F values.