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Biomass estimates from Canadian research vessel surveys on the Scotian Shelf and in the Gulf of St. Lawrence from 1970 to 1979

by

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INTRODUCTION

In 1970 a Working Group of ICNAF reviewed the logistics, design and accuracy of groundfish trawl surveys with intensions to implement coordinated and standardized surveys throughout the ICNAF area. The consensus of the Committee was that "groundfish surveys provide, at the very least, valuable data on distribution and abundance of fish..... ." In the same year the Marine Fish Division, Resource Branch, began a continuing series of stratified random trawling surveys covering most of the continental shelf within Subarea 4. Since then, these and similar surveys in other areas have become an increasingly important complement, and in some cases, an alternative to commercial fisheries statistics for asssessment purposes. The 1979 cruises on the Scotian Shelf and in the southern Gulf of St. Lawrence complete ten years of annual surveys using the same ships, gear and sampling methods. The present report summarizes biomass estimates for various species and species groups during this period in ICNAF Divisions 4T, V, W and X.

METHODS

A detailed description of survey methods was presented by Halliday and Kohler (1971).

Surveys on the Scotian Shelf were conducted by R.V. A.T. Cameron, mainly during July of each year. The Gulf surveys were conducted mainly in September by R.V. E.E. Prince . Both vessels used the standard "Yankee" 36 survey trawl with a small mesh liner in the codend. Standard 30-minute hauls at 3.5 kts were made at stations selected prior to the survey. The sampling design was of the stratified random type with stratification based on depth. The sampled area was thus divided into a number of geographical zones or strata (Figure 1), each representing one of four depth ranges ($<$50, 51-100, 101-200 or $>$200 fathoms). Sampling intensity and station allocation within strata has remained more or less unchanged throughout the ten-year period with approximately one station per 350 square nautical miles. Although some ICNAF Division boundaries may divide a stratum, certain strata groups generally correspond closely to ICNAF Divisions. Thus, strata 15-39 correspond to Div. 4T; strata 40-52 to Div. 4V, strata 53-66 to Div. 4W and strata 70-95 to Div. 4X. Gulf surveys with the E.E. Prince were conducted during daylight hours only due to operational limitations of the vessel whereas Scotian Shelf surveys with the A.T. Cameron were conducted on a 24 hour basis. This, as well as any seasonal differences in fish behaviour, could invalidate comparisons of relative abundance between these two areas.

Biomass estimates were calculated for each species as:

$$B = \sum_{n=1}^{k} \left[N_h \bar{Y}_h \right]$$

where B = biomass

N_h = area of the h^{th} stratum in standard units

$\bar{Y}_h$ = mean species catch per unit area in the h^{th} stratum and

k = number of strata in the set.

A unit area represents the area swept by the survey trawl during a standard 30-minute tow at 3.5 kts. It is calculated as 1.75 nm x (nominal wing spread of survey trawl).

RESULTS AND DISCUSSION

In this report, ICNAF Division 4T is referred to as the Gulf of St. Lawrence, and the continental shelf to 200 fathoms which is within Divisions 4V, W and X is referred to as the Scotian Shelf. Note that strata 15, 25, 29 and 31-39 inclusive were omitted from the Gulf survey in 1970. This probably had little effect on the biomass estimates of plaice and cod since they are not common in these strata. Redfish, however, are found exclusively in the omitted strata resulting in a nil catch. Other species may also be considerably underestimated in 1970 but these contribute relatively little to the total biomass.

The components of total fishable biomass are compared for the Gulf of St. Lawrence and the Scotian Shelf in Figures 2 and 3 and Tables 1 and 2. On the average, American plaice and cod accounted for 68% of the biomass in the Gulf. Silver hake, haddock and spiny dogfish are virtually absent in the Gulf but are important components on the Scotian Shelf. Other finfish, representing fish other than the main categories in each area, excluding pelagics and squid, represent 12% of the biomass on the Shelf but only 2% in the Gulf. The dominance of only two species in the southern Gulf of St. Lawrence reflects the uniform environment of the area relative to the more diverse conditions and communities surveyed on the Scotian Shelf.

The trends in total biomass differ considerably between the two areas. The Gulf shows a definite increase during the ten-year period, caused mainly by increases in cod and plaice. No apparent trend is evident on the Scotian Shelf as a whole. Here relatively large changes from year-to-year in overall abundance are caused by changes in a few highly variable species such as redfish and dogfish, whose estimates are influenced by a few exceptionally large catches. Despite the high variance of some individual species, total fishable biomass on the Scotian shelf has varied little ($<\pm 20\%$) around the ten-year mean of 784.5×10^3 metric tons, with the exception of 1977. This year of high abundance was followed by declines during the last two years, with most of the decline attributable to either redfish or dogfish.

Total finfish biomass (excluding squid) in each ICNAF division is shown in Figure 4. Biomass in Div. 4T increased steadily from the lowest value of the four divisions in 1970 to the highest in 1979. Values in Div. 4V have changed little during the period and were generally lower, on the average, than the other divisions. This is probably due to the relatively smaller area sampled (14,202 nm^2 in Div. 4V compared to 20,399, 17,274, and 18,556 for Div. 4T, W and X, respectively) rather than to lower standing stock per unit area. Values in Div. 4W were highly variable, with peaks in

1970, 1975 and 1978 mainly caused by large catches of redfish and in 1973 by exceptional catches of cod. Biomass estimates in Div. 4X were generally lower after 1974 than before, again with the exception of 1977, a year of particularly high estimates of haddock, dogfish and pollock in this area.

Cod

Biomass estimates of cod (Figure 5) in div. 4T were generally greater than those of other divisions. A decrease occurred from 1970 to 1975 with the subsequent dramatic increase probably facilitated by TAC reductions beginning in 1976. Div. 4V also showed a general decline during the first half and an increase during the second half of the ten-year period. Biomass in Div. 4W was relatively low from 1970 to 1975 except for the possibly anomalous high value in 1973 (90% of this estimate can be attributed to two exceptionally large catches). An increase in biomass was also evident in Div. 4W after 1975. Cod biomass remained relatively stable throughout the decade in Div. 4X, with no apparent trends. Substantial increases in cod appear to have occurred in subarea 4 as a whole during the last five years.

Haddock

Haddock abundance (Figure 6) was negligible in Div. 4T and 4V. Div. 4X generally had higher and more variable estimates than Div. 4W. Biomass in Div. 4W remained relatively stable and low during the first six years of the decade, increased sharply during the next two, and has apparently leveled off in 1979. Both divisions show similar trends, with a net decrease between 1970 and 1972, a minor peak in the mid-70's and maximum values toward the end of the decade. As with cod, substantial increases of haddock occurred in Subarea 4 as a whole during the second half of the survey period.

White hake

On the average, white hake abundance was greatest in Div. 4X, followed by Div. 4T, 4W and 4V (Figure 7). Similar trends in biomass indices were seen among all 4 divisions throughout the survey period. Initial estimates were low in the adjacent Divs. 4T and 4V, and decreased during the first year in Divs. 4W and X. Values in all four areas then increased to maxima during the mid-70's, subsequently declined to minimum values between 1975 to 1977, then increased again to a lesser peak in 1977 or 1978. Abundance declined again in all areas during the last year. The similar trends in all areas suggest that the same factors simultaneously influence changes in biomass or availability of white hake throughout their distribution in Subarea 4.

Silver hake

Biomass of silver hake (Figure 8) was roughly divided equally between Div. 4W and 4X, with insignificant estimates in Div. 4T and 4V. Fluctuations in Div. 4W paralleled those of Div. 4X, showing four peaks (1970, 1973 or 1974, 1976 and 1979) and three lows (1971 or 1972, 1975, and 1977 or 1978) during the ten-year period. The large fluctuations in stock abundance of silver hake during relatively short periods of time are apparently caused by large variations in recruitment (Clay 1979) and this may also be true for white hake.

Redfish

Redfish biomass estimates are difficult to interpret due to their inherent high variance (Figure 9). The 4T values, however, were relatively stable during the survey period and appeared to be somewhat lower during the second half of the decade. Similarly, 4X redfish decreased from a maximum in the early 70's with no subsequent recovery. Values in Divs. 4V and W also decreased initially with 4V showing slight recovery after 1975. It is likely that the peaks of 1975 and 1978 in 4W are anomalous or exaggerated. If this is true, the overall impression in Subarea 4 is of decreasing redfish biomass during the first half of the period with little or no recovery during the second half.

Flatfish

Flatfish in Div. 4T increased greatly from 1970 to 1976 after which they appeared to level off. They remained relatively stable on the Scotian Shelf with no long-term trends evident (Figure 10). Most of the flatfish biomass in the surveyed area consisted of American plaice. On the average, this species accounted for 86% of total flatfish biomass in the Gulf of St. Lawrence and 53% on the Scotian Shelf. The importance of other species differed between the two areas. In the Gulf (Figure 11), winter flounder was the most important species after plaice, followed by yellowtail, witch and turbot. On the Scotian Shelf (Figure 12), yellowtail was the second most important species, followed by witch flounder, halibut and winter flounder.

The large increases of American plaice abundance in Div. 4T from 1970 to 1976 appears to have leveled off during the last three years. The small but apparent net increases of yellowtail, witch and turbot to 1977 have also leveled off or decreased since then. Winter flounder abundance in the Gulf was rather variable but peak values apparently occurred in the mid-70's, with subsequent reductions. On the Scotian Shelf, peak abundances of American plaice and witch flounder also occurred in the mid-70's. Yellowtail exhibited a net increase to 1977 but appear to have declined since then. Halibut have increased steadily since 1975. Winter flounder are relatively unimportant on the Scotian Shelf and no trends are apparent.

Note that the pattern of peaks and troughs for total flatfish abundance in the adjacent Divs. 4T and 4V is virtually identical (Figure 10) although the correlation (r = 0.5031) is not significant. The pattern is still apparent but less marked when plaice alone are compared (r = 0.4502). The parallel patterns of variation suggest that the variation is not spurious but due to real changes in abundance or availability. Consideration should be given to the possibility of flatfish stock relationships between Div. 4T and V.

Skate

Skate biomass (Figure 13) remained relatively stable during the survey period, generally being highest in Div. 4V and lowest in Div. 4T. Overall abundance increased to a maximum in the mid-70's with net declines since then. A similar pattern is exhibited by the individual divisions. Thorny skate dominated skate biomass on the Scotian Shelf and in the Gulf of St. Lawrence.

Squid

Squid biomass (Figure 14) averaged higher throughout the surveyed area during the second half of the decade, probably in response to widespread changes in hydrographic conditions (Koeller 1980). Abundance was always highest in Div. 4W except in 1976 when unusually large numbers of squid were present in Div. 4X. Squid continued to increase in Div. 4T from 1976 to 1978 but declined on the Scotian Shelf after the record high in 1976. The overall abundance index of squid for 1979 was the second highest on record.

Pelagics

Herring appeared to decline in the Gulf and on the Scotian Shelf during the first half of the survey period (Figures 15 & 16). They remained relatively low on the Scotian Shelf during the second half of the decade but values in the Gulf were too variable to distinguish a trend after 1974. Mackerel on the Scotian Shelf declined to 1974, then appeared to increase thereafter. Mackerel catches in the Gulf were always insignificant. Alewife and shad values on the Scotian Shelf averaged higher after 1975 than before. Alewife and smelt in the Gulf appeared to increase to 1974, declined in 1975, and have remained low until the present.

Although both cruise series cover areas of high pelagic fish abundance, pelagics have consistently higher estimates in the Gulf. Sampling is conducted in water as shallow as 10 fathoms in the Gulf but the Shelf survey's inshore limit outside the Bay of Fundy is the 50 fathom contour. This would exclude much of the traditional herring fishing grounds of southwest Nova Scotia.

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Halliday, R. G., and A. C. Kohler. 1971. Groundfish survey programmes of the St. Andrews Biological Station, Fisheries Research Board of Canada - objectives and characteristics. ICANF Res. Doc. 71/35.

Koeller, P. A. 1980. Distribution, biomass and length frequencies of squid (*Illex illecebrosus*) in Divisions 4TVWX from Canadaian research vessel surveys: an update for 1979. NAFO SCR Doc. 80/II/17.

Table 1. Minimum biomass estimates from Canadian research vessel surveys - Div. 4VWX (mt x 10^{-3}).

Species	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	$\bar{X}$ (1970-79)
Cod	113.0	142.4	113.2	249.3	80.2	81.7	96.0	133.7	164.3	142.2	131.6
Haddock	63.2	65.9	33.4	38.5	83.6	59.1	54.0	206.5	115.7	147.3	86.7
White hake	67.7	12.5	20.8	42.3	35.6	48.8	22.3	35.5	31.8	20.2	33.8
Silver hake	23.5	7.9	15.3	38.2	36.1	7.5	18.6	8.2	11.0	36.3	20.3
Redfish	172.3	186.3	229.3	196.5	89.6	245.4	83.5	171.6	276.0	73.3	172.4
Flatfish	81.0	80.8	79.2	81.7	133.2	101.6	116.6	112.3	70.7	104.4	96.2
Skates	48.2	34.3	47.8	77.8	52.2	87.6	41.9	50.3	43.3	40.9	52.4
Dogfish	43.6	141.9	26.0	35.9	51.7	7.2	8.6	163.1	2.5	24.7	50.5
Other finfish	97.3	52.8	81.3	96.3	86.7	89.6	94.2	167.7	118.9	96.2	98.1
Squid	1.9	14.7	3.2	8.9	9.5	24.8	203.7	46.6	11.2	70.3	39.5
Total	711.7	739.5	649.5	865.4	658.4	753.3	739.4	1095.5	845.4	755.8	781.5
Div. 4V (Strata 40-52)	187.1	250.9	198.0	169.6	173.4	169.3	231.3	221.6	163.4	201.1	196.6
Div. 4W (Strata 53-66)	244.7	149.6	120.3	337.6	191.2	330.2	173.5	282.8	461.5	263.1	255.5
Div. 4X (Strata 70-95)	279.9	339.0	331.2	358.2	293.8	254.7	334.6	591.1	220.5	291.6	329.5

Table 2. Minimum biomass estimates from Canadian research vessel surveys - Div. 4T (mt x 10^{-3}).

Species	1970*	1971	1972	1973	1974	1975	1976	1977	1978	1979	$\bar{X}$ (1970-79)
Cod	104.0	79.8	77.3	88.6	72.1	54.8	70.5	88.6	146.3	217.5	100.0
Plaice	36.1	58.8	61.8	75.7	116.7	120.5	192.4	173.2	118.6	187.6	114.1
Other flatfish	5.4	10.7	13.2	12.1	31.5	15.2	42.4	17.4	23.8	19.9	19.2
Redfish	-	34.0	43.2	44.1	43.9	19.5	14.0	30.0	32.4	16.1	27.7
White hake	1.7	4.3	6.0	15.8	26.3	10.8	8.6	6.6	20.9	19.4	12.0
Skates	2.3	8.5	5.8	9.6	9.0	5.0	4.0	6.6	4.1	7.0	6.2
Pelagics	21.5	56.3	22.1	20.8	19.7	29.5	8.9	8.9	35.6	5.0	22.8
Other finfish	4.3	7.2	5.8	2.8	8.5	5.9	10.3	3.0	6.7	8.8	6.3
Squid	-	0.4	0.2	0.5	-	1.0	16.9	15.3	30.8	15.1	8.0
Total	175.3	260.0	235.4	270.0	327.7	262.2	368.0	349.6	419.2	496.4	316.3

*Strata 15, 25, 29 and 31-39 inclusive were not surveyed in 1970.

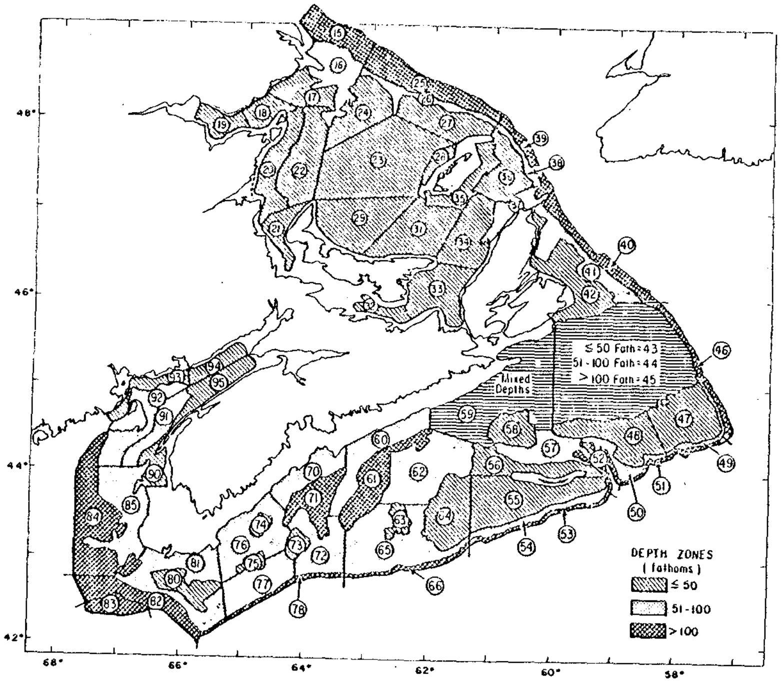


Figure 1. Stratification scheme for ICNAF Div. 4T, V, W and X.

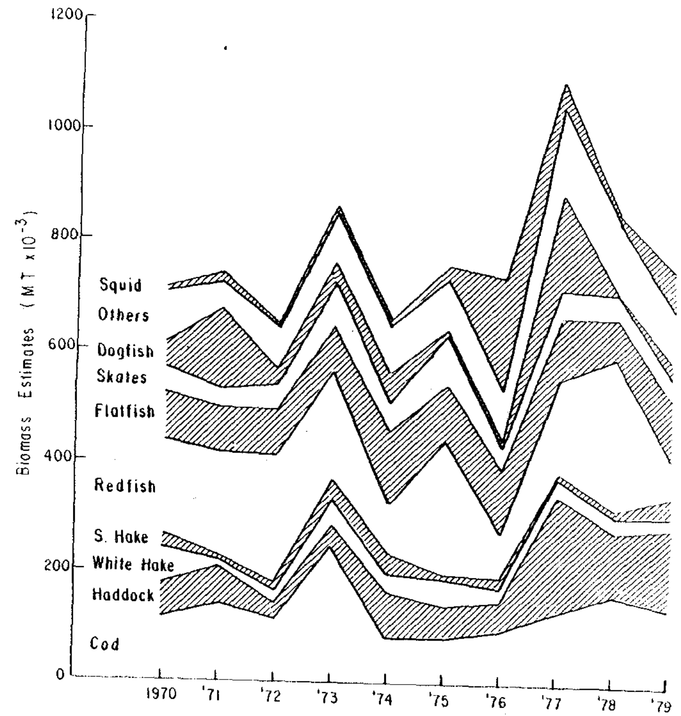


Figure 2. Survey biomass estimates - Scotian Shelf.

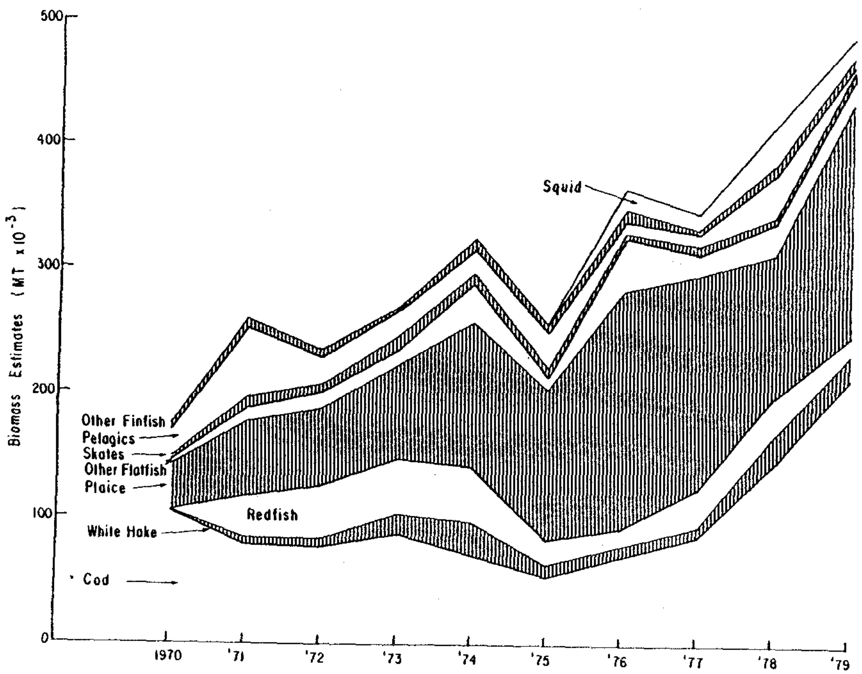


Figure 3. Survey biomass estimates - Gulf of St. Lawrence.

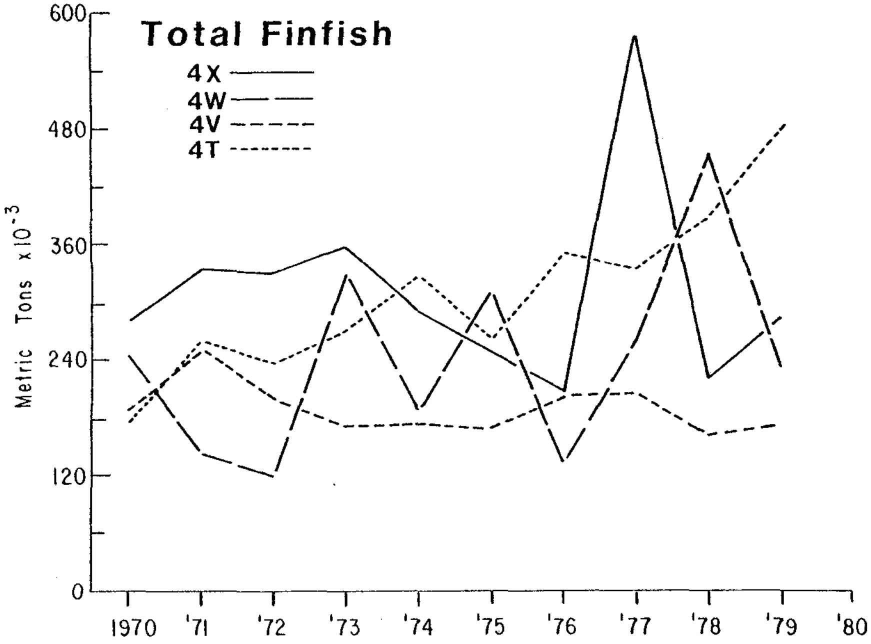


Figure 4

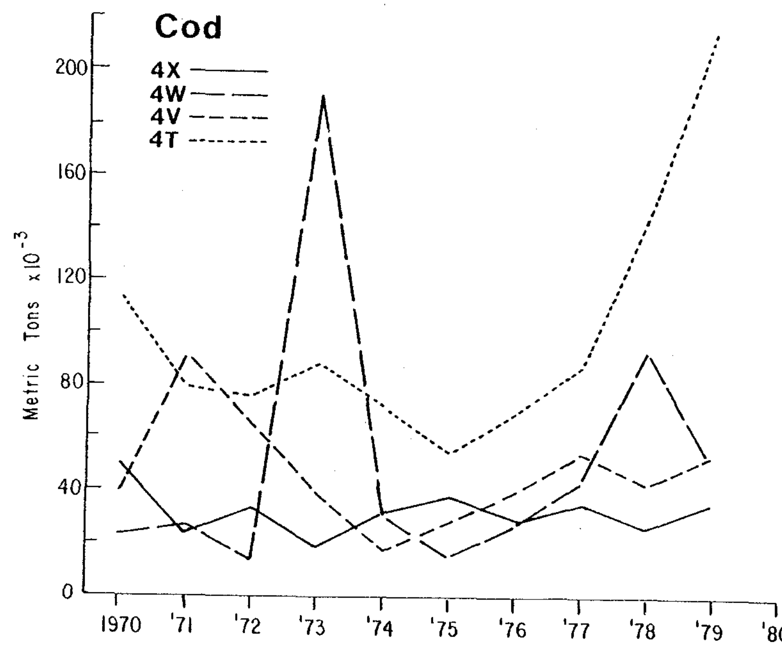
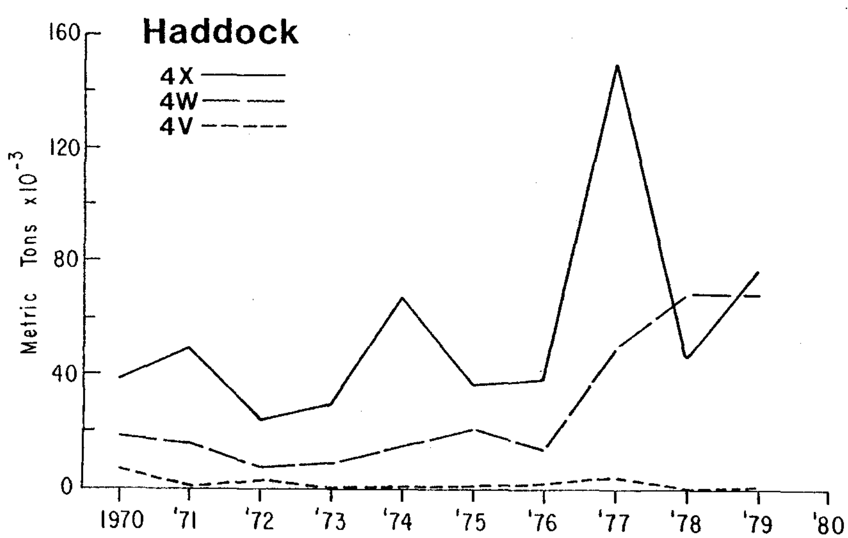


Figure 5



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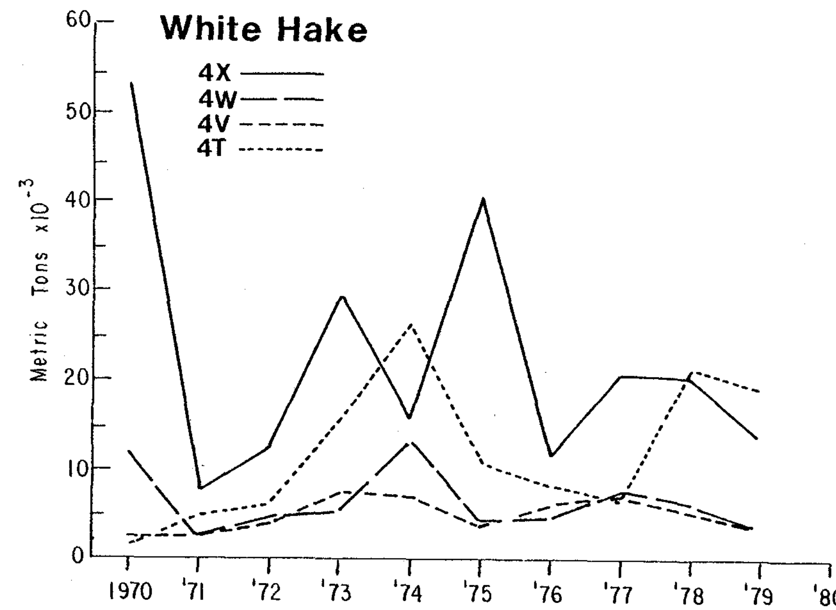

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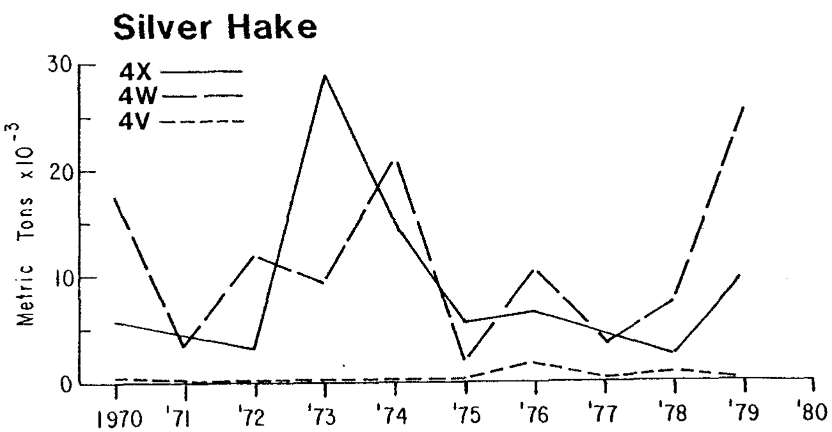

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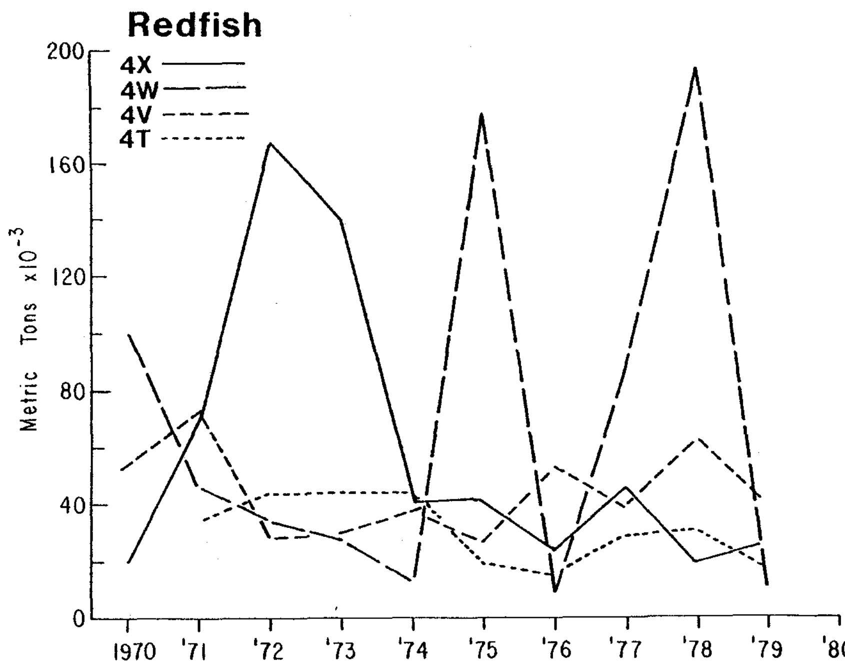


Figure 9

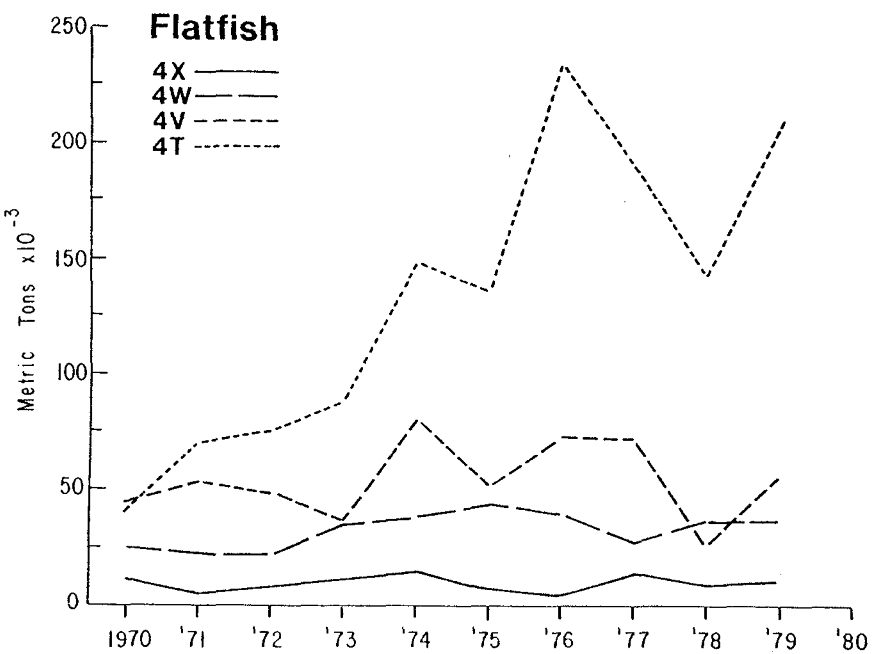


Figure 10

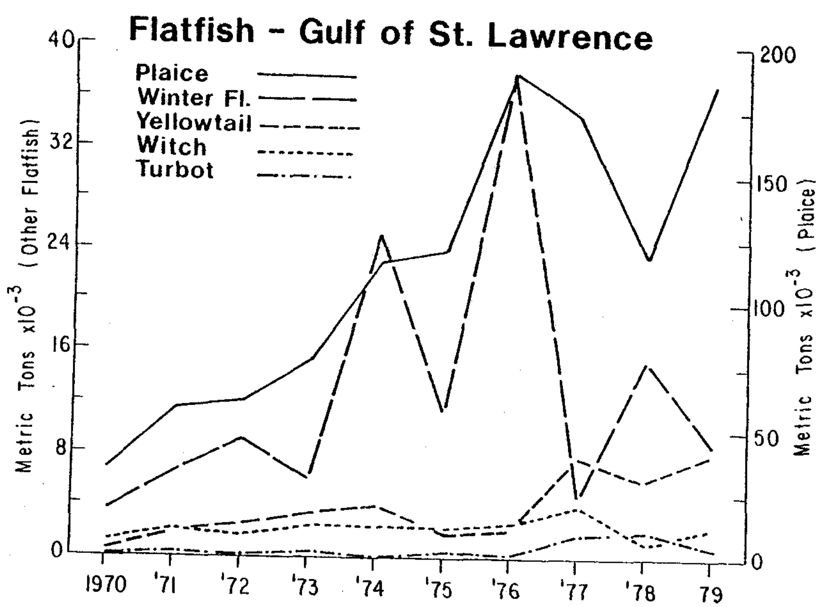
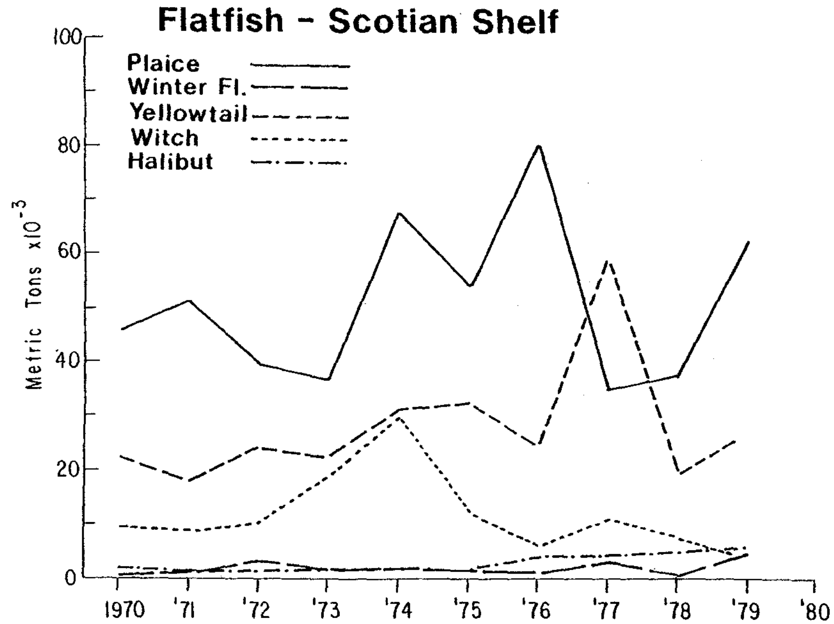


Figure 11



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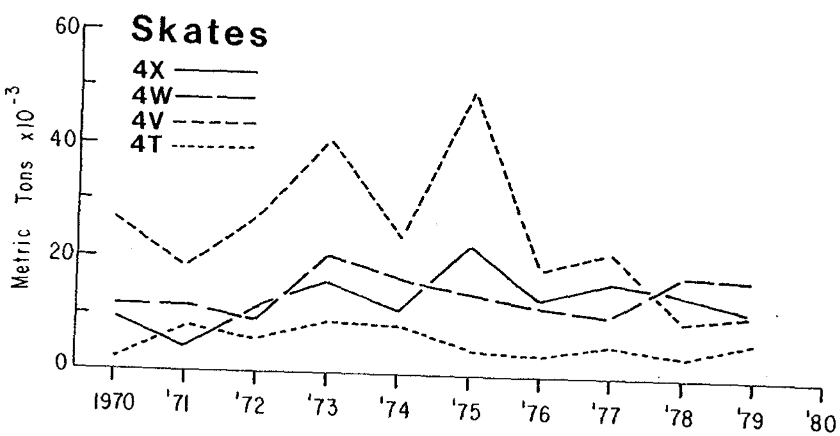

Figure 13

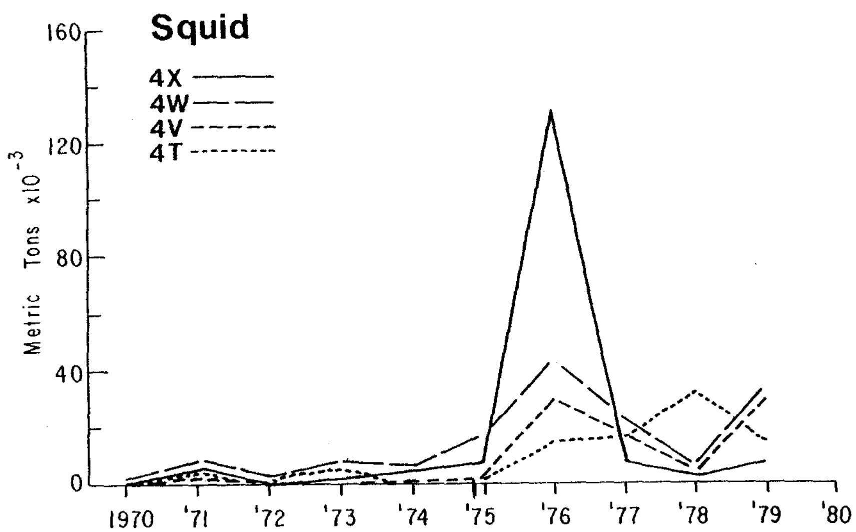

Figure 14

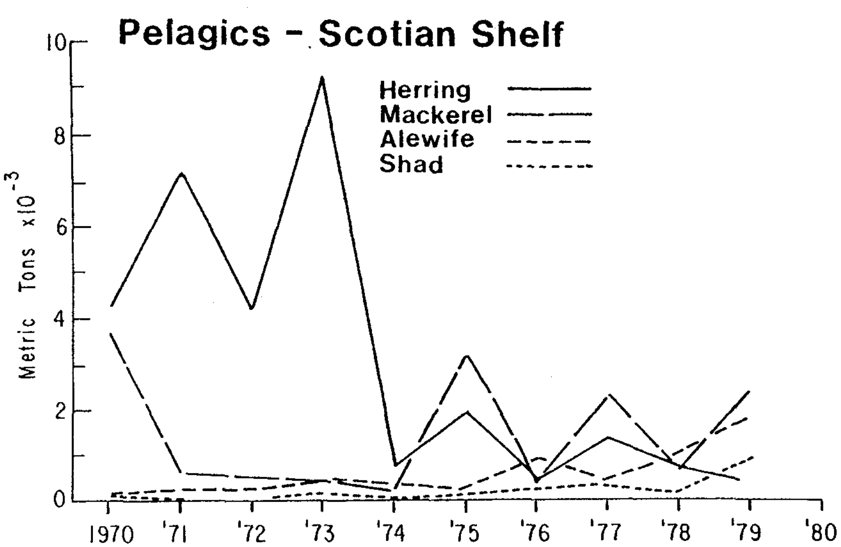

Figure 15

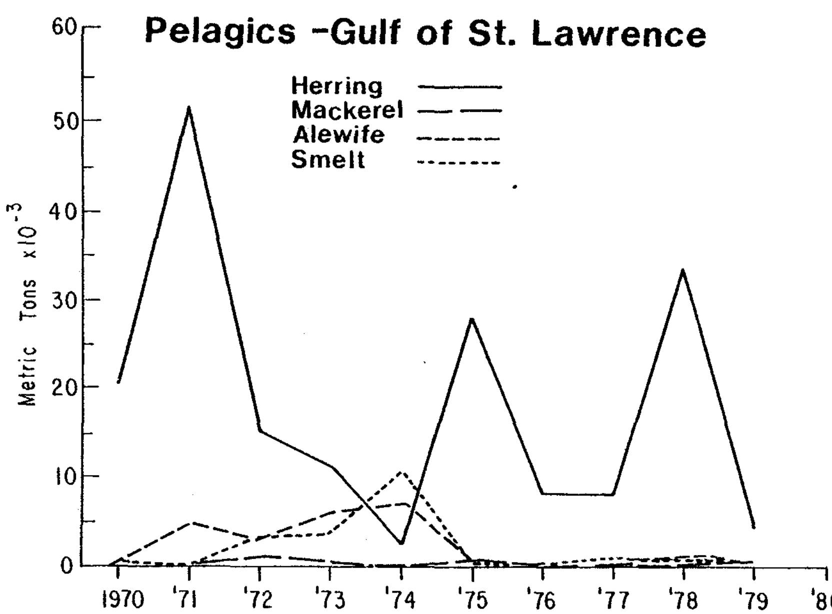

Figure 16