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Division 4VWX Redfish: Assessment and Estimate of Total Allowable Catch for 1982.

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ABSTRACT

Landings of Scotian Shelf redfish have declined since the early 1970's, and are now about 13,000 tons per year. An analytical assessment of these fish was not attempted. Instead time series of catches, commercial catch rates, research vessel biomass estimates and length frequencies were examined. These seem to indicate a major decline in biomass during the 1970's, which appears to be continuing. A considerable reduction in the TAC is, therefore, necessary.

RESUME

Les débarquements de sébaste du plateau néo-écossais diminuent depuis le début des années 1970 et sont présentement de 13 000 t par an. Nous n'avons pas tenté d'évaluation analytique de ces poissons. Au lieu de cela, nous avons étudié les séries chronologiques des prises, des taux de capture commerciaux, des estimations de biomasse par navires de recherche et des fréquences de longueur. Ces données semblent indiquer un déclin important de la biomasse dans les années 1970, et qui semble se poursuivre. Une importante réduction du TPA s'impose donc.

SUMMARY OF FISHERY TO 1980

Redfish landings from the Scotian Shelf reached a maximum of over 60,000 tons in 1971, and have subsequently declined continuously (see figure 1). 1979 landings were 13,154 tons (NAFO provisional statistics). Canadian vessels landed 13,085 tons in 1980 (Statistics Branch, Department of Fisheries and Oceans). A total allowable catch (TAC) was first imposed in 1974 and subsequently reduced (see table 1). Total landings have never reached the TAC but some national quotas were filled before 1978. Thus, some of the early decline in the fishery may have been due to regulation.

The initial TAC was reduced, over two years, to 20,000 tons. This was retained until 1980, when it was increased to 30,000 tons, This TAC was not changed for 1981.

METHODS

While attempts have been made to prepare analytical assessments of Scotian Shelf redfish (e.g. Mayo and Miller, 1976; Mohn, 1978; Clay, 1979), these have not been very successful. Thus, (following Clay, 1980), no such assessment was attempted for 1982.

Therefore, time series of indices of redfish abundance were examined to determine the overall "condition" of this population. Data are available for series of catches, research vessel survey biomass estimates and commercial catch rates. Length frequencies, based on research vessel survey catches are also available, and give some indication of past and forthcoming recruitment. Commercial length frequencies involve too many uncertianties (e.g. mesh size, discards; Clay, 1979) to be useful for this purpose.

These series were prepared both for the whole of Divisions 4VWX and for each Division separately. The latter is necessary because of the apparent relative immobility of redfish. These fish cannot be tagged, and thus their movements are not known in detail. However, inshore *Sebastes* have been tagged, both in the Atlantic (Kelly and Barker, 1961, 1963; Hansen, 1961, 1964) and in the Pacific (Frey, 1971; Carlson and Haight, 1972; Love, 1980). All these studies have shown remarkably little movement. One species, *S. flavidus*, has shown active homing when displaced (Carlson and Haight, 1972). These results are not directly applicable to Scotian Shelf redfish, but they are supported by studies of morphology (Kenchington, 1980) and parasites (Sindermann, 1961). It thus appears likely that these fish make only limited migrations during the course of a year.

Redfish do, however, seem to make some considerable movements over a period of several years. These may include a drift into deeper water with increasing size (Mayo, 1980) as well as others following the contours (Templeman and Squires, 1960).

Thus, unless the fish are able to adjust their long-term movements in such a way as to even-out variations in population density, it is possible for local depletion to occur. This would only be detected by examination of local time series. Since commercial data are not generally available on a scale finer than Division-level, and research vessel biomass estimates are too variable when further subdivided, separate series have been prepared for each Division.

Catches

Nominal catches of redfish were drawn from ICNAF Statistical Bulletins. (Late-reported catches by Japan and the German Democratic Republic were included in the Divisions 4VWX totals, although given only as "Subarea 4" in the Bulletins). These data were not fully separated by Division until 1954, so those for earlier years include Gulf of St. Lawrence catches. However, the Gulf fishery did not begin until 1952 (Martin, 1961), so figure 1 probably adequately represents removals from the Scotian Shelf.

Research Vessel Series

The research vessel data are from the July groundfish cruises (Halliday and Kohler, 1971). While these data show great variability, they are free of the many uncertainties which afflict time series of commercial catch rates. They are, however, subject to uncertainties of their own, which are discussed below.

Much of the variability in these data is caused by aggregation of the fish (Pennington and Grosslein, 1978), which is especially pronounced with redfish. The extent of their aggregation is shown in figure 5. This histogram shows the number of sets (as dependant variable) which took various weights of redfish (independent variable). The weights are grouped into 25 kg units (e.g. $0 < X \leq 25$). The "less than 0 kg" unit includes those sets which took no redfish.

Data from all strata and all years are included. It should be noted that data from a single stratum and year (were sufficient tows taken) might be less skewed. Nevertheless, this figure clearly shows the strong aggregation tendency in redfish.

The six sets which took over one ton appear to be "outliers", distinct from the rest of the distribution. An attempt was made to recalculate the biomass estimates with each of these replaced by a value of 1000 kg. This had no effect on the interpretation of the time series, and its results are not presented here.

When variability has such a cause, it can be greatly reduced by using an appropriate statistical estimator. Two were used here; firstly that provided by the standard "STRAT2" computer program which is based on a linear mean catch-per-tow within each stratum. This has here been called "LINEAR". The second involved a logarithmic transform (here called "LOG"):

$$\text{LOG} = \exp(\overline{Y}) - 1.0$$

$$\text{where } Y_i = \ln(X_i + 1.0)$$

and Xi is the weight (in kilograms) of redfish, caught in the i^{th} set (from "STRAT2" output). For both estimators, average catch-per-set in each stratum was converted to a trawlable biomass estimate. These were summed to provide Division estimates.

Since redfish are long lived and slow growing, with low natural mortality and prolonged recruitment, and since landings from the Scotian Shelf have been in almost continuous decline through the 1970's, their abundance should show a constant trend from year to year. Thus, it is appropriate to smooth these time series. A program based on 3-year running medians ("M3R"; S.J. Smith, pers. comm.) was used.

The following terms will be used when describing biomass:

"Absolute Biomass of Redfish" - the total weight of fish of the species within a certain area.

"Trawlable Biomass of Redfish" - the weight of those redfish which would be taken if the survey swept all parts of the seabed (assuming that all characteristics of the trawl remained constant).

"Trawlable Biomass Estimate" - an estimate of the trawlable biomass, based on one year's survey.

Commercial Catch Rates

Catch and effort data were taken from ICNAF Statistical Bulletins for the years 1958 to 1978. Data for Maritime Canadian vessels, for 1979 and 1980, are from Statistics Branch, Department of Fisheries and Oceans. Those for USA trawlers in 1979 are from a NAFO advance release. In all cases, single nation-gear-tonnage class combinations of redfish-directed effort have been used, in an attempt to minimize the uncertainties and biases in this type of data. Annual CPUE was calculated from annual sums of catch and effort. This makes the index sensitive to changes in the season worked. However, the data included many months where only a single vessel-trip was made. These often had poor catch rates, though some had excellent ones. Annual CPUE calculated with equal weighting for each month would be affected by such variability.

The most complete time series is for Canadian (Maritimes and Quebec) side trawlers of tonnage class 4 (OTB 1-4). As shown in figure 4, these vessels have taken a major share of the landings since the late 1960's.

The same class of US vessels dominated the fishery for much of the 1960's and was again important in the early 1970's. (Effort data for these vessels was not divided by main species until 1959, and for Division 4X, not until 1964).

A time series of catch rates of Maritime Canadian class 5 stern bottom trawlers (OTB2-5) is also presented. These boats are increasingly important in the fishery. Finally, a CPUE series for Maritime and Quebec class 4 midwater trawlers (OTM-4) represents catch rates in the midwater fishery. These vessels, in directed catches, have taken 50% of all Divisions 4VWX midwater redfish catches.

Most of the catches not included in any of these series were taken by the Soviet mixed species fishery. Since the ICNAF Statistical Bulletins only provide one datum point per Division-month-gear-tonnage class combination, a Chikuni procedure can not be used, and no equivalent directed CPUE can be calculated.

Newfoundland landings are increasingly important, but their CPUE series have not been examined. It is expected that they would be very similar to the ones for Maritime vessels.

These time series have been smoothed using the same M3R technique applied to the research vessel data. Where a series is divided, only runs of four or more years have been smoothed.

Length Frequencies

Clay (1980) presented figures of redfish length frequencies based on research vessel data. Frequencies from the 1980 survey were extracted from the STRAT outputs to update the series.

RESULTS

Nominal Catches

The time series is shown in figure 1. These fish were heavily exploited in the 10 years after 1945. This was followed by a period of fairly steady catches during the late 1950's and the 1960's (averaging about 30,000 tons per year). Catches then rose, peaked in 1971, and have declined continuously ever since.

Figure 2 shows these landings by individual Division. All except Subdivision 4Vn follow the overall pattern. Catches from that area have shown much more stability.

The redfish fishery is carried out almost exclusively by otter trawlers. On the Scotian Shelf, bottom trawling predominates. Midwater trawls have been used here since 1972 and took about 10% of the landings from 1973 to 1978. They were mostly used in Subdivision 4Vn. Since 1978, the midwater fishery has declined, such that Canadian landings comprised only 17 tons from directed effort and 10 tons bycatch in 1980.

For the last 10 years the fishery has been predominantly Maritime Canadian, with increasing Newfoundland landings (see figure 3). USA and USSR vessels have accounted for most of the remainder.

Almost all USA, and a majority of Maritime Canadian, landings have been from redfish directed effort. The Soviet fishery was "mixed". Newfoundland landings have not been studied in this regard.

Research Vessel Surveys

The time series are shown in figures 6 to 10.

For Divisions 4VWX as a whole, the LINEAR series oscillates with increasing amplitude, but no clear trend. When smoothed, it shows near stability initially, and a drastic decline after 1978. The latter is caused by the final pair of low estimates, and the suddenness of the decline is an artifact of smoothing. However, the LOG series (raw and smoothed) show a clear and continuing decline in trawlable biomass estimates for Scotian Shelf redfish. By 1980, the LOG estimate was less than one third those of the early 1970's.

The 1980 LINEAR estimate of trawlable biomass was 40,431 tons. An average of all eleven LINEAR estimates was 160,380 tons. Inspection of the trends shown in figure 6 suggests that the true trawlable biomass is presently between these values.

For Subdivision 4Vn, the time series show a clear decline during the early 1970's and near stability thereafter. Only the 1979 estimates disrupt this pattern. The 1980 LINEAR estimate was 11,297 tons.

In Subdivision 4Vs, the LINEAR estimates have fluctuated without clear trend, while the LOG ones have shown the same pattern of decline and then near-stability as in Subdivision 4Vn. Both smoothed series reached their lowest points in 1980. The 1980 LINEAR estimate of trawlable biomass for this Subdivision was 15,213 tons.

Trawlable biomass estimates for Division 4W are too variable to be of much value. However, it may be noted that the 1975, 1977 and 1978 estimates were inflated by four large catches. If these years are deleted, the time series shows a slight, but continuing, decline. The 1980 LINEAR estimate was 13,691 tons.

The Division 4X series are similarly influenced by a few large catches. A continuing decline in trawlable biomass estimates, since the mid-1970's, is clear. The 1980 LINEAR estimate was 6088 tons.

Commercial CPUE: Canada (M + Q) OTB1-4

The time series are shown in figures 11 and 12 for the whole area and in figures 13 and 14 for separate Divisions.

For Divisions 4VWX, Maritime Canadian OTB1-4 CPUE rose through the mid-1960's, and has subsequently declined, almost continuously.

The patterns for Subdivisions 4Vn and 4Vs are generally similar to that for the whole area. Division 4W, however, has risen since 1977, while that for Division 4X has shown an even more pronounced increase.

Commercial CPUE: USA OTB1-4
(see figures 11, 12, 15 and 16)

The time series for the whole area is remarkably similar to that based on

Canadian data, although the peak CPUE is rather later and the subsequent decline rather faster.

Data for separate Divisions are rather fragmentary, but do show the same decline and rise in Division 4W as the Canadian data do. For Division 4X a very clear decline in CPUE is shown.

Commercial CPUE: Canada (M + Q) OTB2-5
(see figures 11, 12, 17 and 18)

These data show a massive decline in CPUE in the early 1970's, and a considerable subsequent increase. All four Divisions show very similar patterns.

Commercial CPUE: Canada (M + Q) OTM-4
(see figures 11, 12, 17 and 18)

These data are only useful for Subdivision 4Vn. They show a great decline in CPUE through the mid-1970's, with some subsequent recovery.

Length Frequencies
(see figures 19 to 23. Note that the scale varies between years).

The research vessel surveys have found mainly large (more than 30 cm) redfish in Subdivision 4Vn. A smaller mode appeared in the length frequencies in 1977 (about 20 cm) and again in 1979 and 1980 (about 25 cm). By Clay's (1979) length weight equation, these appear to be the 1970 or 1971 year-class.

The frequencies for Subdivision 4Vs are less clear. In most years there is a lack of large fish. One mode can be seen entering the fishery through the mid-1970's, while another appeared in 1978. The latter appears to be the 1972 or 1973 year-class (by Clay's (1979) equation).

Division 4W length frequencies remain remarkably constant. Neither recruitment nor growth of the adult population is clearly shown.

Following Clay (1980), the Division 4X length frequencies are presented in two units: East and West. The latter includes the Fundian Channel and Bay of Fundy, while the former is the rest of this Division. 4X (East) had varied length frequencies. There was some evidence of a recruiting year-class from 1976 to 1979, and another in 1979 and 1980.

4X (West) has exclusively large redfish. The source of recruitment of these is not known and does not appear on the length frequencies.

DISCUSSION

Time Series of Biomass Indices

All of these time series (except the length frequencies) are intended as indices of the biomass of redfish present in Divisions 4VWX (or a part of that area). Since they differ in pattern it is necessary to select the reliable ones and reject the rest.

Catch data are a poor index of biomass, since they are too greatly affected by changes in effort. However, the declining catches are not inconsistent with a decline in biomass (such as is suggested below).

Commercial CPUE data are commonly accepted as indices of abundance, but they are subject to many uncertainties. With redfish, there is some tendency towards constant CPUE despite changes in abundance (Clay, 1979, 1980; Mayo, 1980). This could have many causes, and has been observed in other groundfish species (Pope and Garrod, 1975) as well as schooling pelagics. Changes in the effort expended in a fishery may be related to the diversion of more- or less-efficient vessels into or out of the fishery, with unpredictable effects on CPUE. Where catch and effort data are grouped into "directed" fisheries on the basis of which species comprises over 50% of the landings, a decline in abundance of the major species can result in less-efficient vessels' landings being classified as "bycatch", and hence a rise in calculated directed CPUE (Sissenwine, 1978). Changes in the length of the fishing season will affect CPUE when calculated as in this document. A contracting season (as has occured with Divisions 4VWX redfish in recent years) will usually result in CPUE rising relative to abundance, but the reverse is possible. The efficiency of fishing fleets generally rises with time, as larger, more powerful and better equipped vessels are introduced. Mayo and Miller (1976) described such changes in the USA redfish fleet, and suggested a 30% increase in efficiency between 1952 and 1964. No information is available for subsequent years, nor for equivalent changes in the Canadian fleet.

Thus, commercial CPUE series are subject to many uncertainties in their relation to redfish abundance. If biomass were steadily decreasing, CPUE could fall quickly or even rise, but would probably fall more slowly than biomass, i.e. q would increase as biomass fell. The effects of fishing discrete aggregations (Mayo, 1980) of concentration of the remaining fish (Pope and Garrod, 1975), or searching for aggregated fish (Paloheimo and Dickie, 1964; MacCall, 1976; Radovich, 1979; Pope, 1980), of a shortened season, of improvements in the fleet with time, and of diversion of the least efficient (for redfish) vessels to other fisheries, or the classification of their catches as directed towards other species would all tend towards this result. The reverse trend (i.e. CPUE falling faster than biomass) is possible, but seems altogether less likely.

The research vessel time series are not without uncertainties of their value as indices of biomass. In particular, they have limited depth range and great variability between years. The surveys only extend to the 200 fm (365 m) contour (Halliday and Kohler, 1971). While most Scotian Shelf redfish probably occur above this depth (Clay, 1980), Kenchington (1980) reported some from below it and there may be many there (D. Clay, pers. comm.). The commercial fishery does not appear to exploit areas deeper than 200 fm, thus fish which are invulnerable to the survey trawls could only be taken by the fishery if they moved up the slope. Evidence for the absence of seasonal migrations has been summarized above. Even if these fish did display such movement, the research vessel survey (in July) should encounter them at the same depths as the fishery (primarily June to September). Thus, insofar as depth is concerned, the research vessel surveys probably measure the biomass of redfish vulnerable to commercial trawling adequately.

The variability in trawlable biomass estimates has here been reduced by the use of the LOG estimator and by smoothing. The numerical values of LOG estimates are biased downwards (Bliss, 1967), but they accurately reflect trends in biomass. Smoothing can produce artifacts, as well as remove them, but these can usually be detected by reasonable interpretation of the time series.

Thus, the series of LOG estimates of trawlable biomass are the most reliable indices of trends in the abundance of redfish vulnerable to the fishery. The LINEAR series may be expected to follow the same trends, but with more variability. The commercial CPUE series may follow similar trends, but in a situation of declining biomass (as indicated by the LOG estimates) they would probably decline more slowly.

These LOG series show clear, and continuing, declines for Divisions 4VWX as a whole and Subdivisions 4Vn and 4Vs separately. The latter two show most of the decline early in the 1970's. The patterns for Divisions 4W and 4X are less clear but do suggest slow declines in recent years. As expected, the LINEAR series are similar, if more variable. Commercial CPUE series for side trawlers (OTB1-4), both US and Canadian, are also generally in agreement. Again as expected, CPUE has declined more slowly than the research vessel trawlable biomass estimates in most cases. Exceptions to this general agreement are that Canadian CPUE for Divisions 4W and 4X rose in the late 1970's, as did USA CPUE for Division 4W, while for Subdivision 4Vn it fell very fast in the early 1970's.

Both the Division 4W and the Subdivision 4Vn changes coincide with considerable reductions in the respective fisheries. Thus, they are very likely to represent the loss of less-efficient and more-efficient vessels respectively from the fishery. The Canadian OTB1-4 redfish fishery in Division 4X during the late 1970's took far less fish than the equivalent USA fishery (as much as an order of magnitude less). Thus, the USA time series (which agrees with the research vessel one) is the more reliable.

Maritime tonnage class 5 stern trawler (OTB2-5) CPUE time series have a totally different pattern, and it is not possible for both this and the above series to be adequately representing redfish biomass. The OTB2-5 series include a period of rapidly increasing CPUE during the late 1970's. From figures 11, 12, 17 and 18 this can be seen to have involved a 10-20% per year increase. However, Rivard (1980) calculated surplus production for these fish, from 1974 to 1978, to have been 0-2% of biomass. Landings at that time averaged nearly 20,000 tons per year. Depending on conclusions of research vessel trawlable biomass, and assuming 25% catchability (see below) this represents 3-12% of absolute biomass. Thus, biomass may be expected to have decreased 1-12% per year, and the sort of increase suggested by the OTB2-5 CPUE is entirely unreasonable. These series must have been greatly affected by some factor other than redfish biomass, and hence do not form reliable indices of it.

Midwater trawler CPUE (Canada (M + Q) OTM-4) series suggest a great decline in the mid-1970's. The subsequent increase coincides with a decline in the fishery, and so may be spurious. However, these vessels might exploit different fish to the bottom trawlers, and hence their CPUE might be an index of a different abundance.

Status of the Population

While these time series cannot give conclusive proof, they do give a strong indication of a decline in biomass through the 1970's which may have slowed in recent years, but appears to be continuing. Declines in biomass are not necessarily undesirable, but the LOG series of research vessel trawlable biomass estimates indicates that the biomass in 1980 was substantially less than half that in 1970 (itself presumably less than the unexploited level). Thus, present abundance seems to be well below the 2/3 of unexploited which is considered optimum (Doubleday, 1976). Hence, these time series indicate that Scotian Shelf redfish are seriously depleted.

This depletion is the combined result of fishing and natural changes in biomass. The former has removed at least 320,000 tons of redfish from Divisions 4VWX since 1970 (based on ICNAF catch data). The latter has seen a change in age structure towards older, less productive fish. Thus surplus production has dropped from 7-8% of biomass in 1965 to 1970 to 0-2% in 1974 to 1978 (Rivard, 1980). These older fish may tend to move into deeper water, as has been noted in the Gulf of Maine (Mayo, 1980), and so become invulnerable to both commercial and survey trawling.

LINEAR estimates of trawlable biomass for Divisions 4VWX redfish were approximately 200,000 tons in the early 1970's, and averaged 160,380 tons from 1970 to 1980. The 1980 LINEAR estimate was 40,431 tons, but this appears low, when compared to the trends of the LOG series. The actual trawlable biomass in 1980 was probably between 40,000 and 80,000 tons. The actual weight of fish present is much greater than this. Clay (1980) gave a figure of hourly mean catch rates against time of day, based on the research vessel survey data. From this, it seems that the average catch is about 1/3 that at noon. Thus, the availability of redfish in survey trawls is 33% or less, because of vertical migration alone. This suggests that Edward's (1968) and Scott's (1971) estimate of overall availability-vulnerability of this species (27%) may be too high. The absolute biomass might be four times the research vessel trawlable biomass, or more.

Thus, the biomass of redfish in Divisions 4VWX may have been about 800,000 tons in 1970 and 160,000 - 320,000 tons in 1980. Such biomasses, with Rivard's (1980) values of surplus production and the known catches, make a decline in population inevitable. Although they do not predict quite such a rapid decline as the research vessel surveys indicate, the difference is well within the probable errors of the two methods.

CONCLUSIONS

While the time series presented here could be interpreted in various ways, they appear to indicate a considerable decline in Scotian Shelf redfish abundance during the 1970's. That decline appears to have slowed, but seems to be continuing. If the decline is to be halted, a considerable reduction in catches is necessary, and hence a TAC of much less than 13,000 tons.

Given the many uncertainties surrounding these fish, the data and the methods used here, this conclusion should be treated conservatively.

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The chosen method, the conclusions and any errors are exclusively my own.

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Table 1. TAC's, Quotas, Allowances, and Catches since 1974.

	1974	1975	1976	1977	1978	1979		1980		1981
TAC	40000	30000	20000	20000	20000	20000		30000		30000
Landings	32837	27983	18459	17845	16094	13154		-		-
Canada:										
Quota	20000	14860	12000	13000	17500	13000	18000	18500	29000	18500
Landings	15739	17025	12625	14712	13576		12240		13085	-
France:										
Quota	1000	740	250	250	250	500[a]	500[a]	500[a]	500[a]	500[a]
Landings	420	186	279	63	121		20		-	-
Poland:										
Quota	1300	970	Subsequent catches included with "Others".							
Landings	803	230								
USSR:										
Quota	6600	4900	1000	500						
Landings	6692	4849	1021	175	Subsequent catches included with "Others".					
USA:										
Quota	10000	7430	6000	6000	1500	See "Others"		10500	0	See "Others"
Landings	8891	5465	4446	2876	2147					
Others:										
Quota	1100	1100	750	250[b]	250[b]	6500	1500	500	500	11000
Landings	288	228	88	19	250		894		-	-

\- data not yet available

a St. Pierre vessels only

b bycatch only

Landings to 1978 are from ICNAF Statistical Bulletins.
1979 Landings are from NAFO Provisional Data
Since 1979 quotas have been amended during the year, initial and final ones are given.

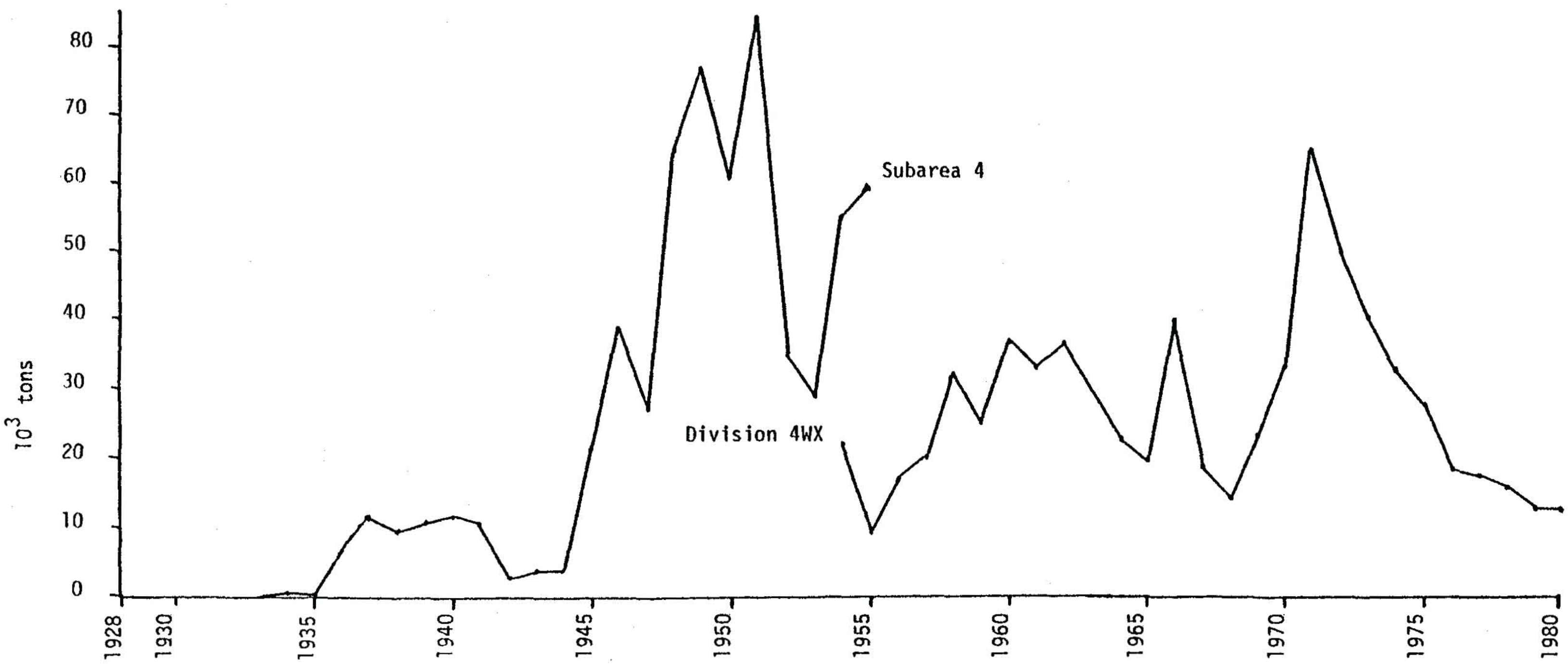

Figure 1. Commercial Redfish Landings from Subarea 4 (to 1955) and Division 4VWX (since 1954). (1980 landings are for Canada only)

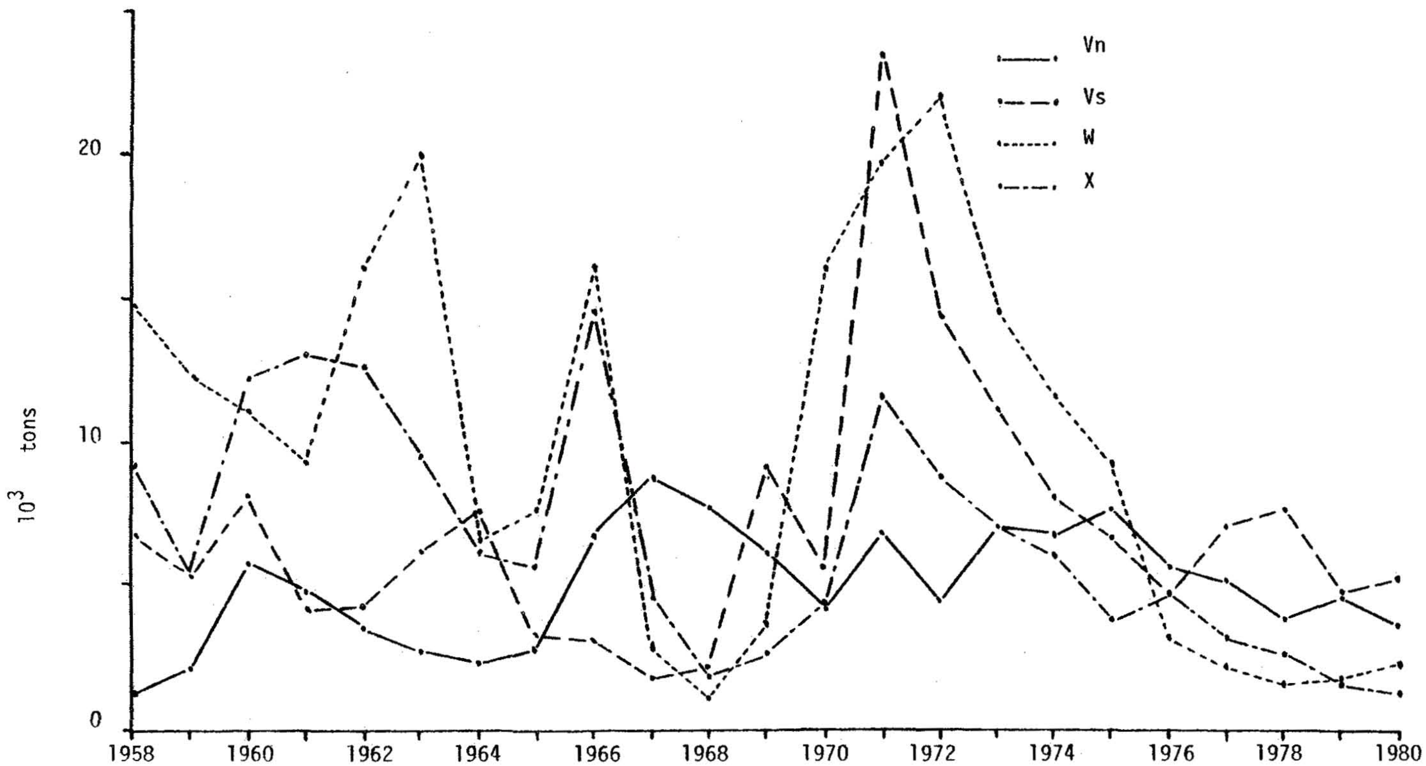

Figure 2. Landings by Division (1980 data is for Canada only).

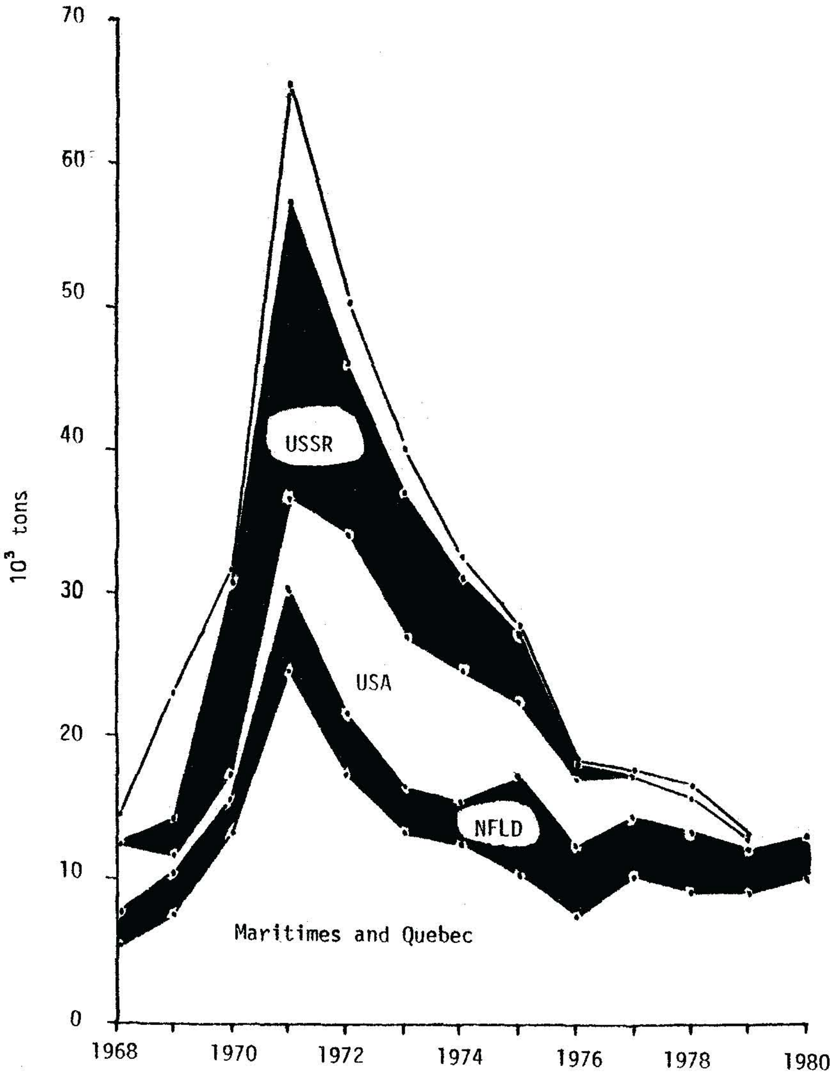

Figure 3. Recent commercial redfish landings from Divisions 4VWX, shown cumulatively by nation.

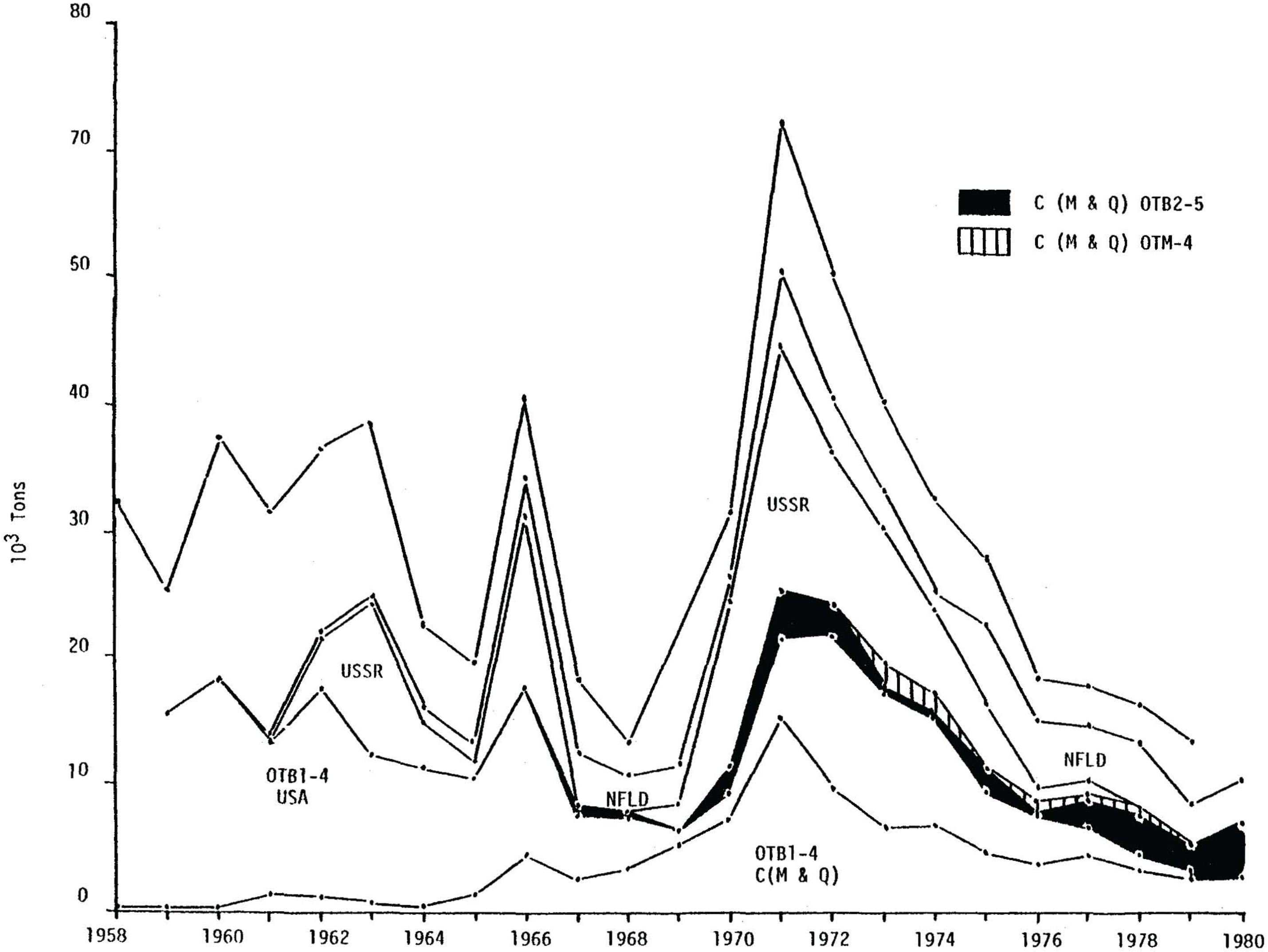

Figure 4. Commercial redfish catches in Division 4VWX, with cumulative plots of effort categories.

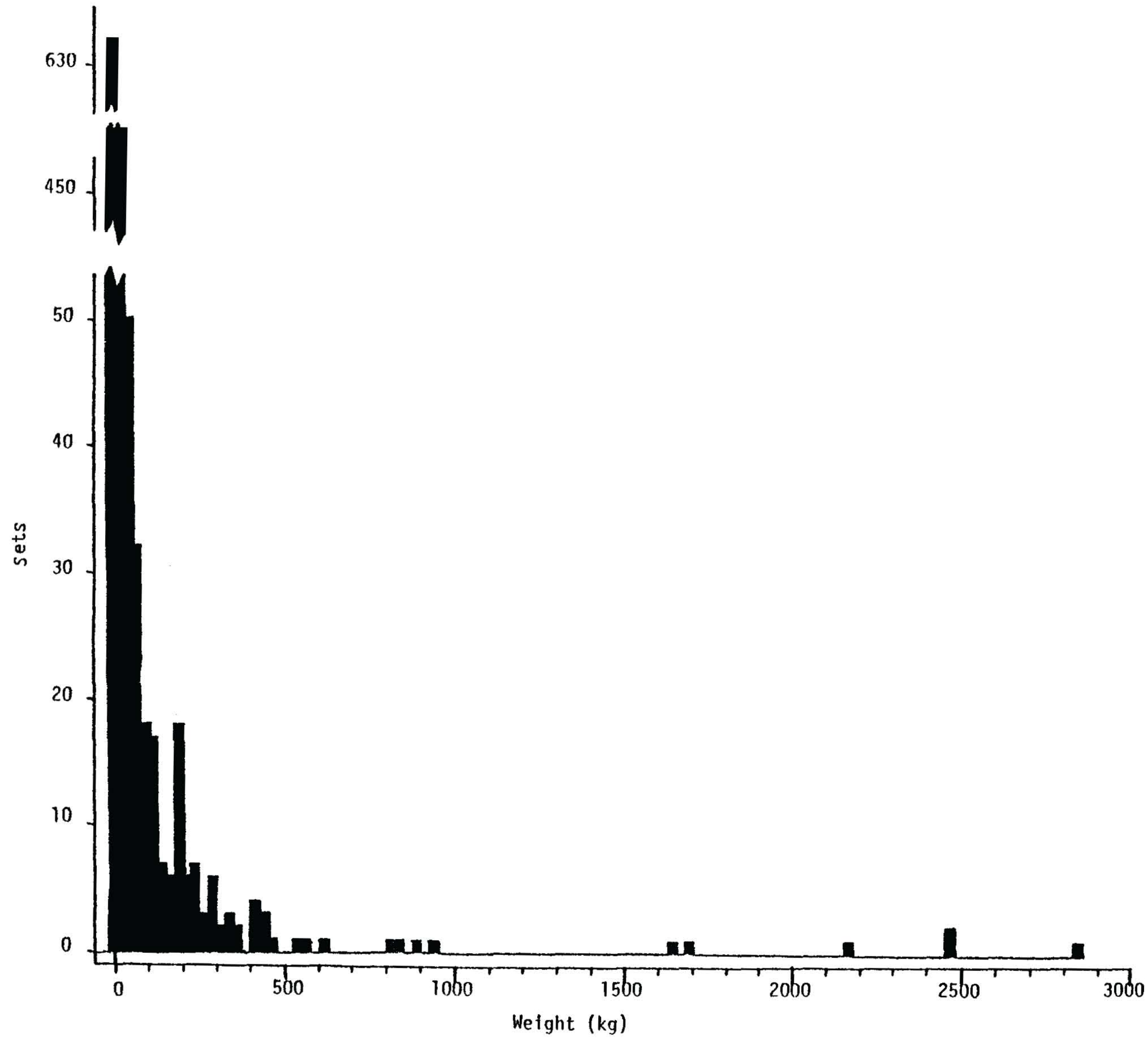

Figure 5. Relationship between weight of redfish caught and number of sets taking that weight in Scotian Shelf July groundfish surveys.

(The scale on the ordinate is constant, but is broken at two places to accommodate the 0Kg and 0-25Kg points.)

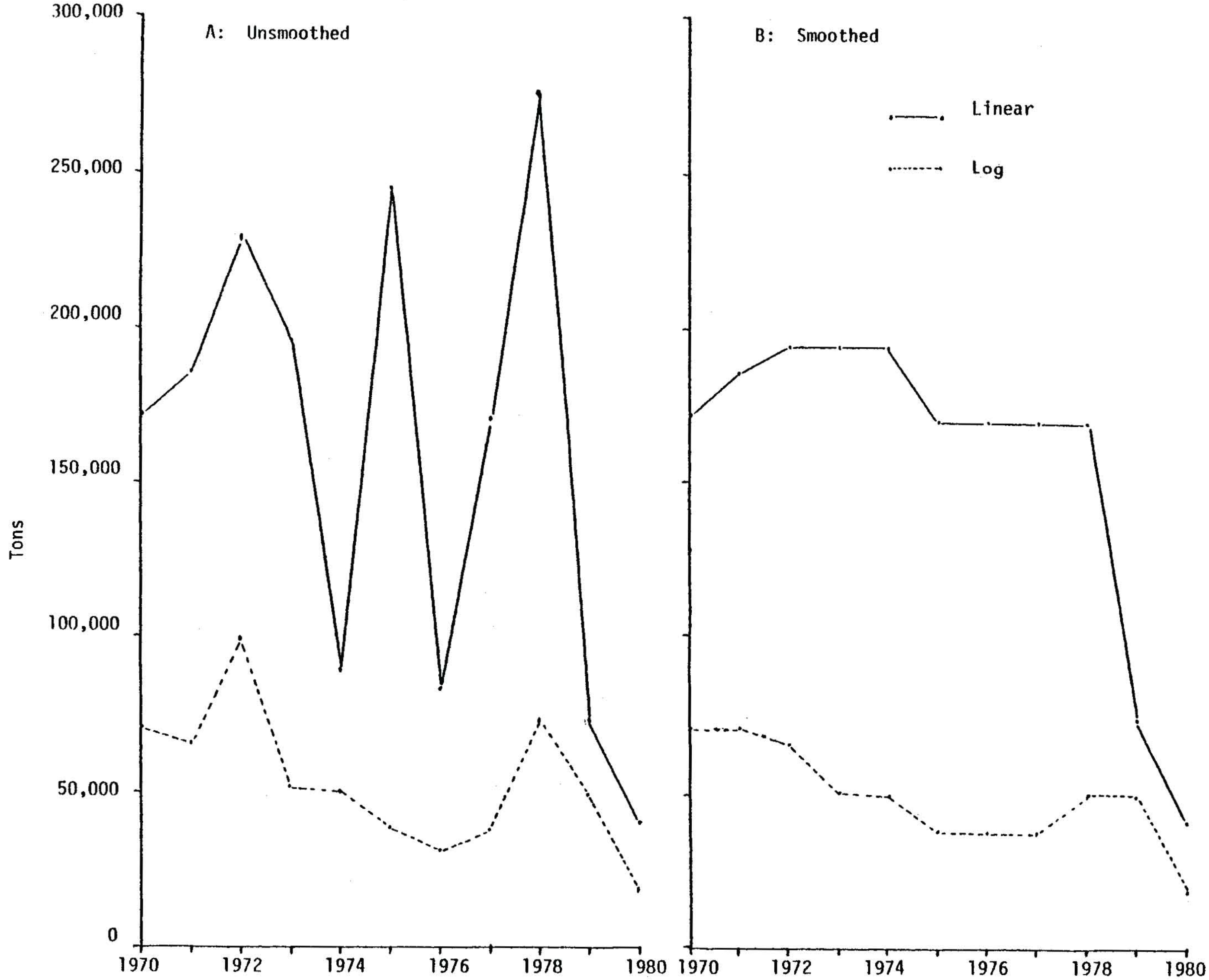

Figure 6. Redfish Biomass from R. V. surveys, 4VWX

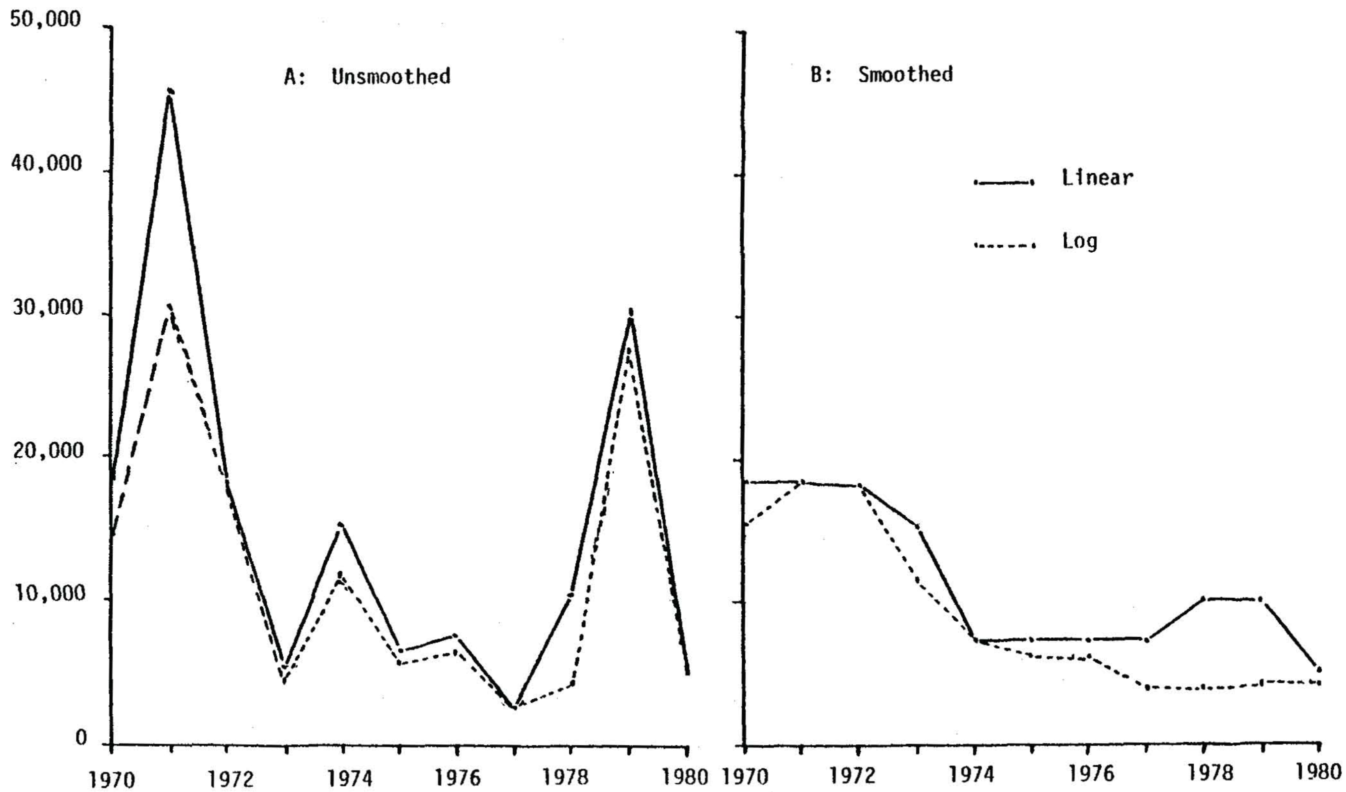

Figure 7. Redfish Biomass from R. V. Surveys 4Vn.

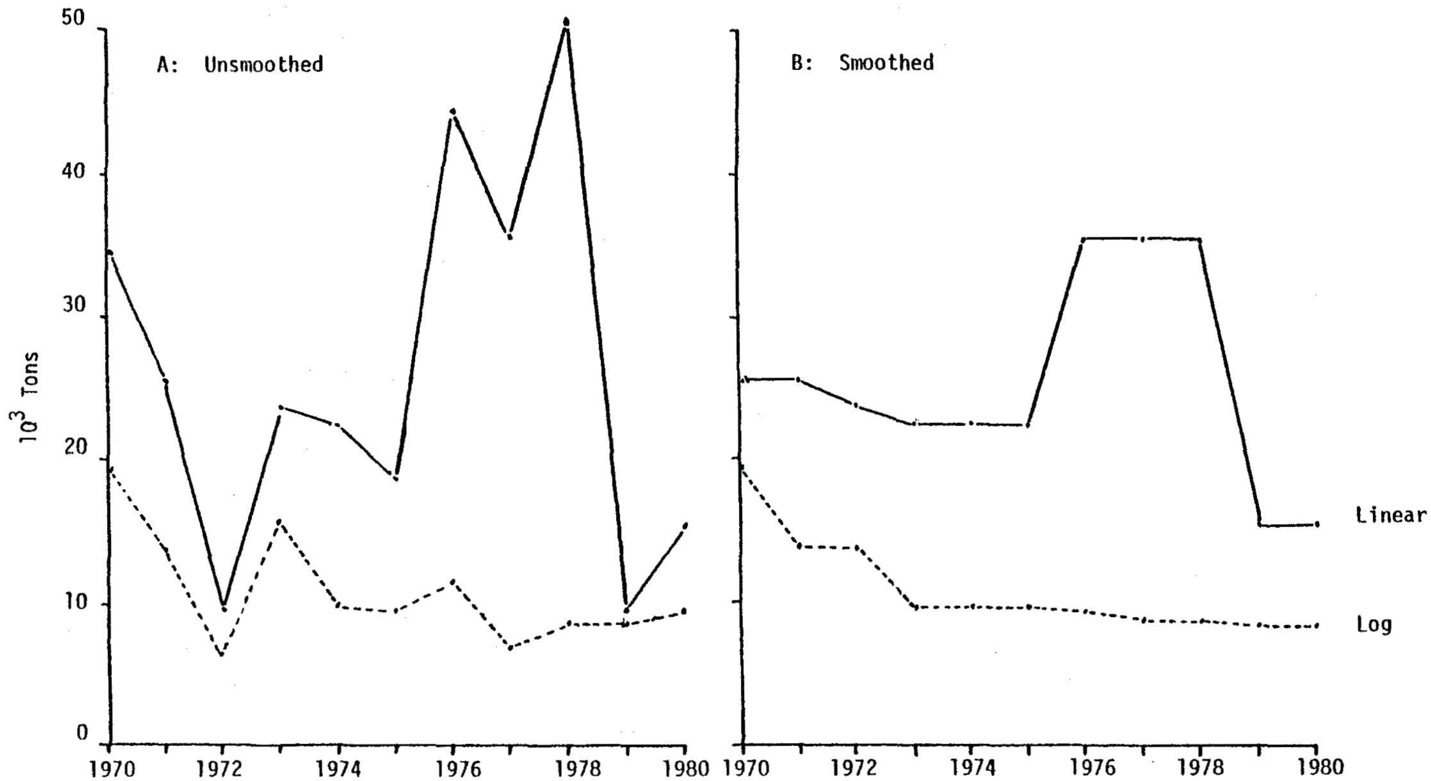

Figure 8. Redfish biomass from R. V. Surveys. 4Vs

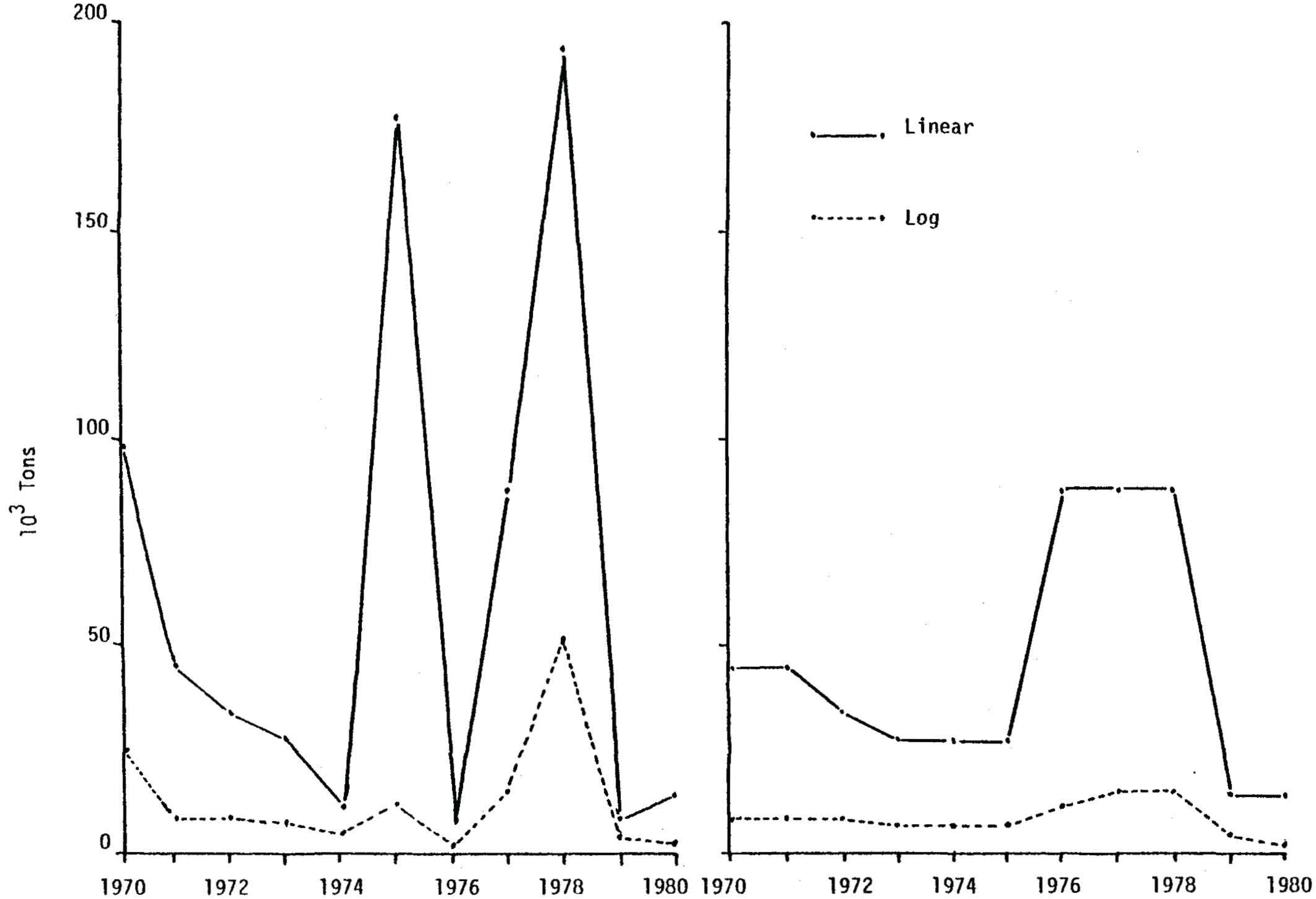

Figure 9. Redfish biomass from R. V. Surveys 4W.

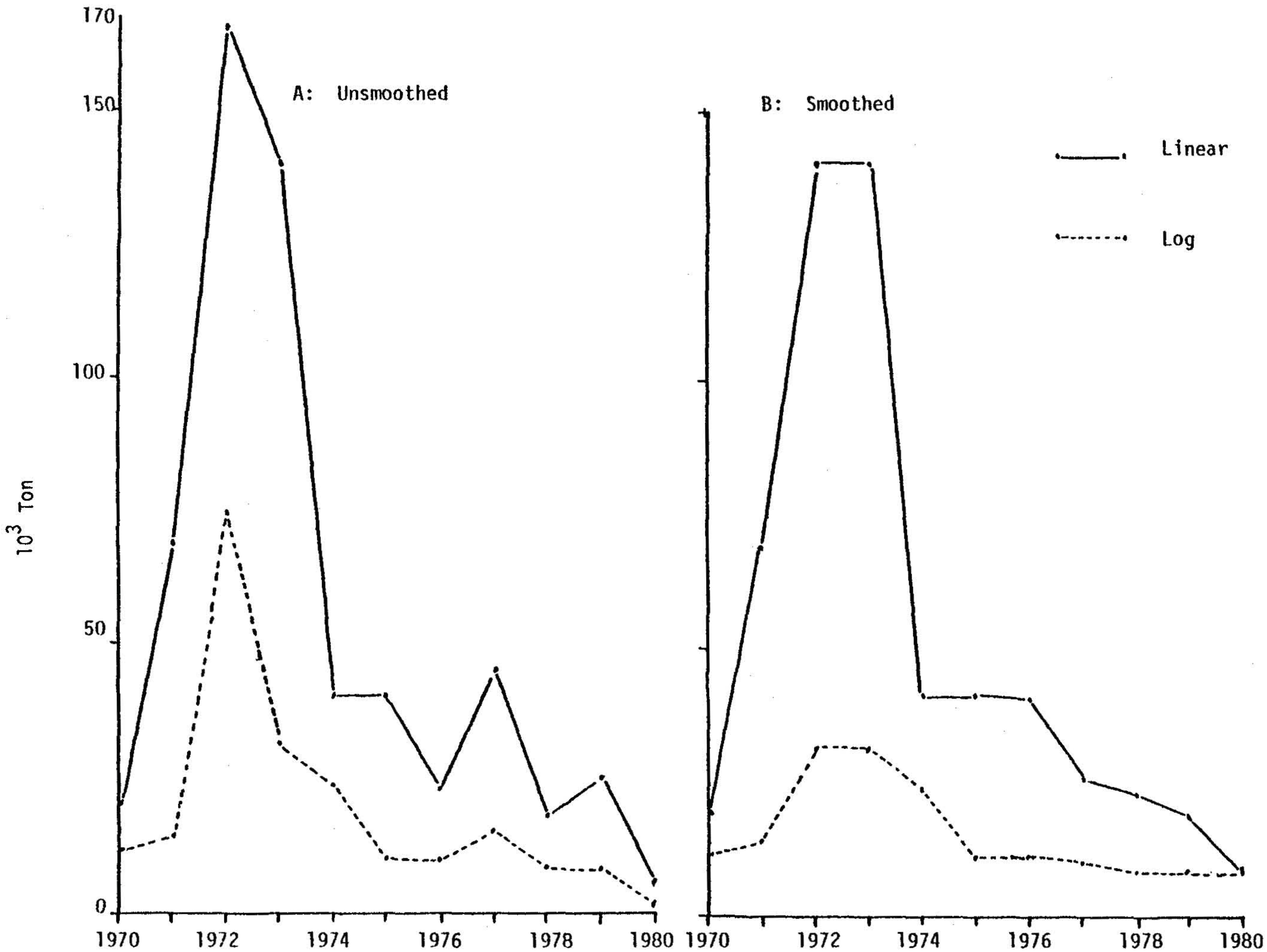

Figure 10. Redfish biomass from R. V. Surveys 4X.

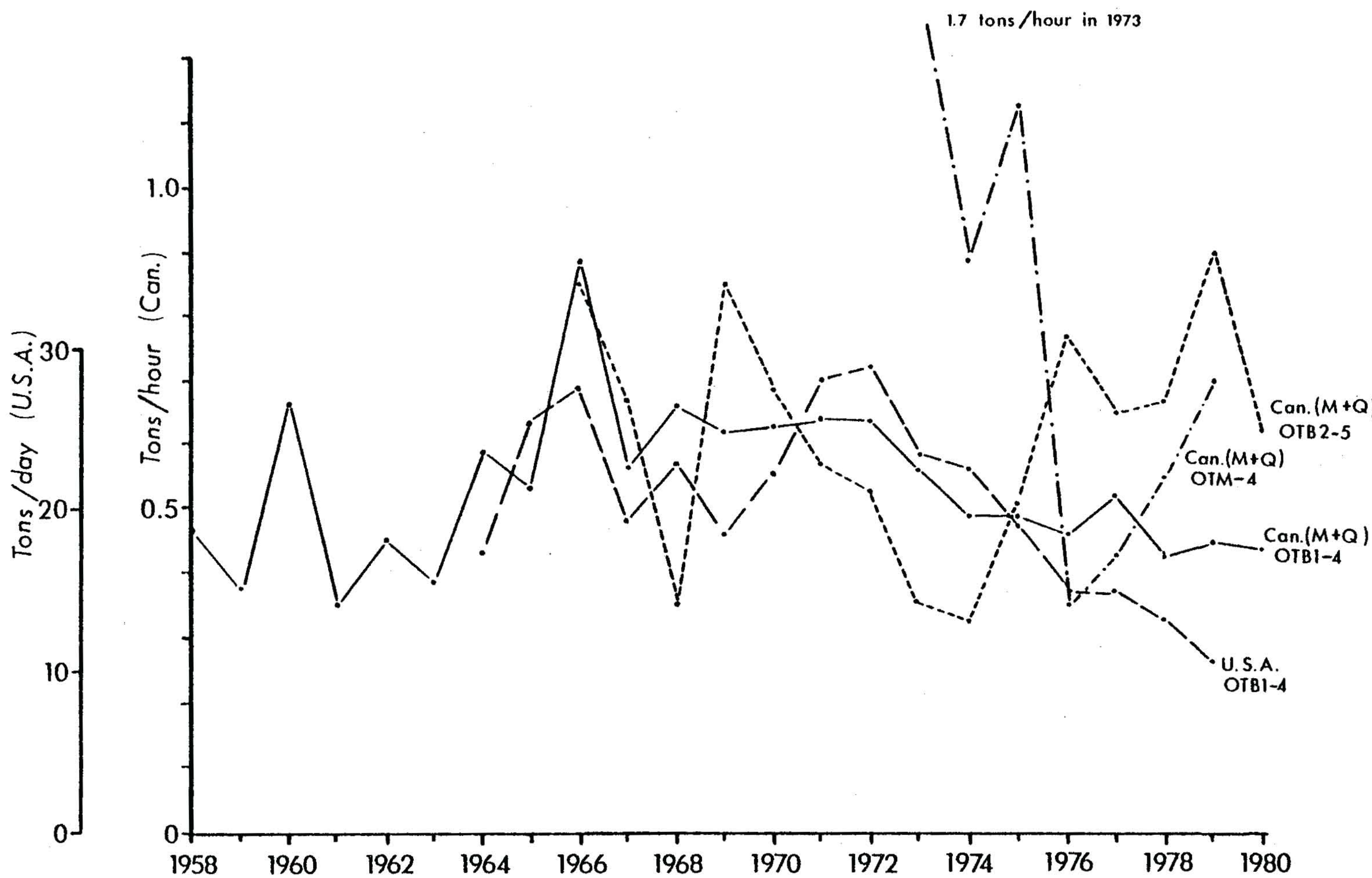

Figure 11. Commercial directed catch per unit effort in 4VWX, by vessel class.

Figure 12. Commercial directed catch per unit effort in 4VWX (Smoothed)

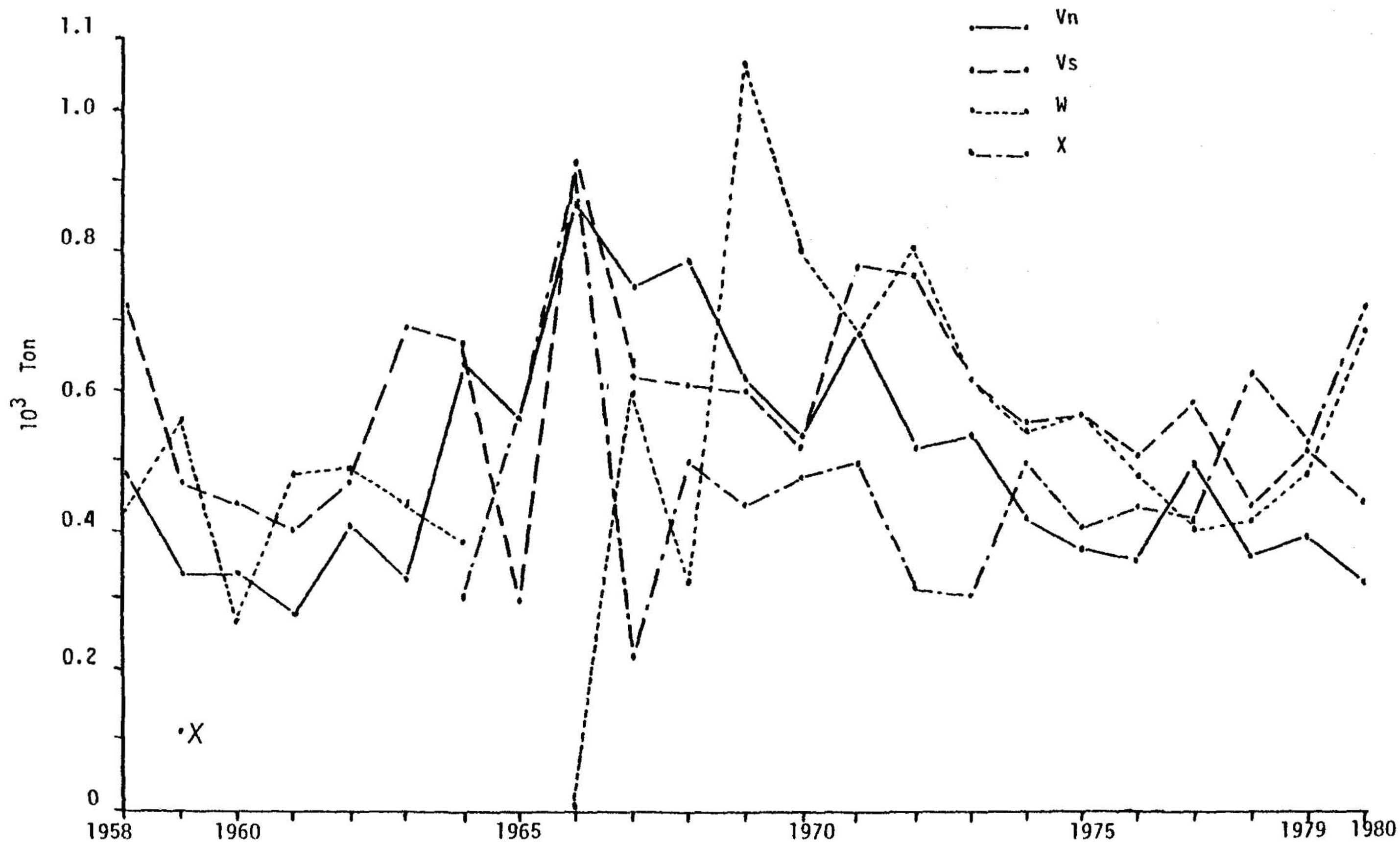

Figure 13. Commercial directed catch per unit effort. Maritime Canada: Side Bottom Trawlers: Class 4. (1979 does not include Quebec data).

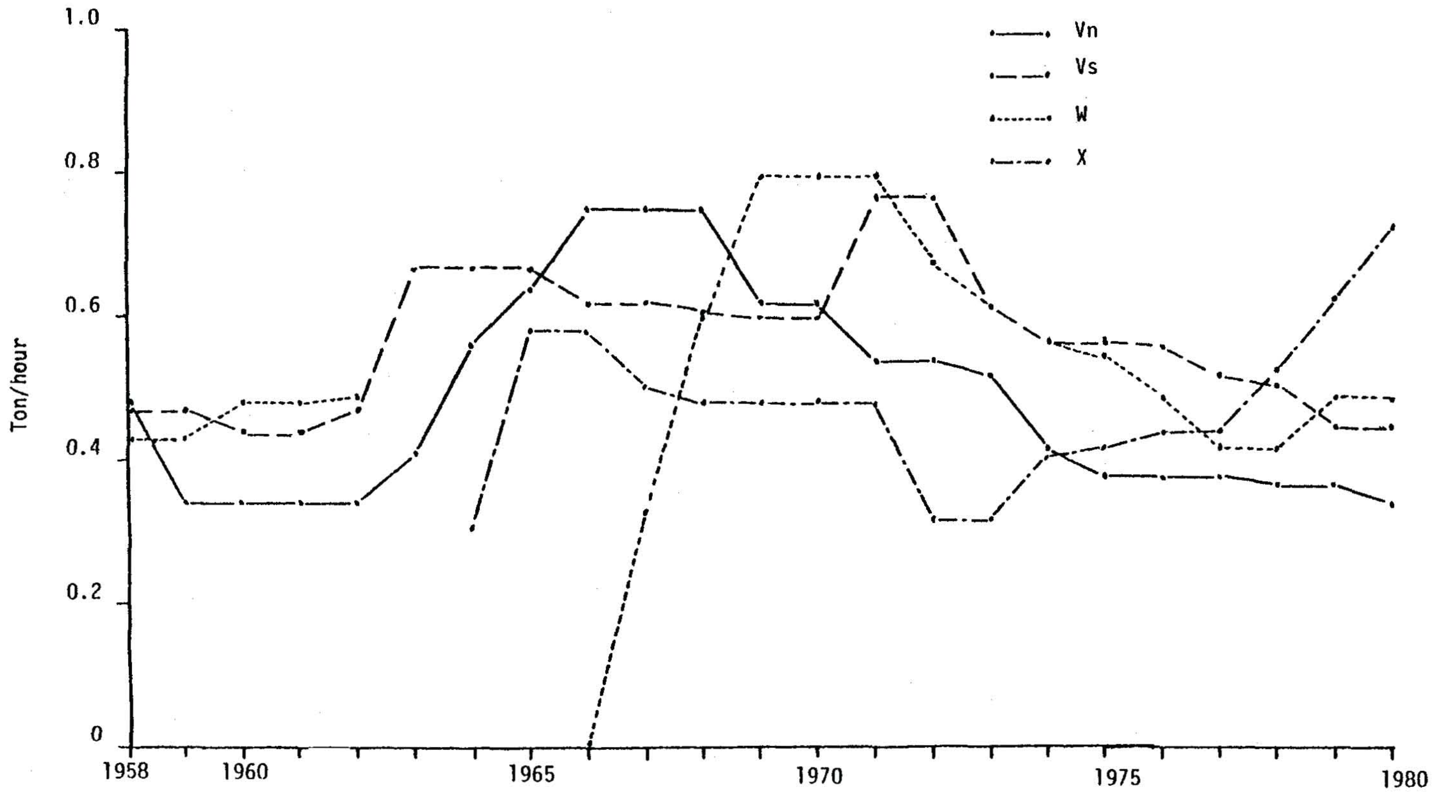

Figure 14. Smoothed directed CPUE. C(M + Q) OTB1-4.

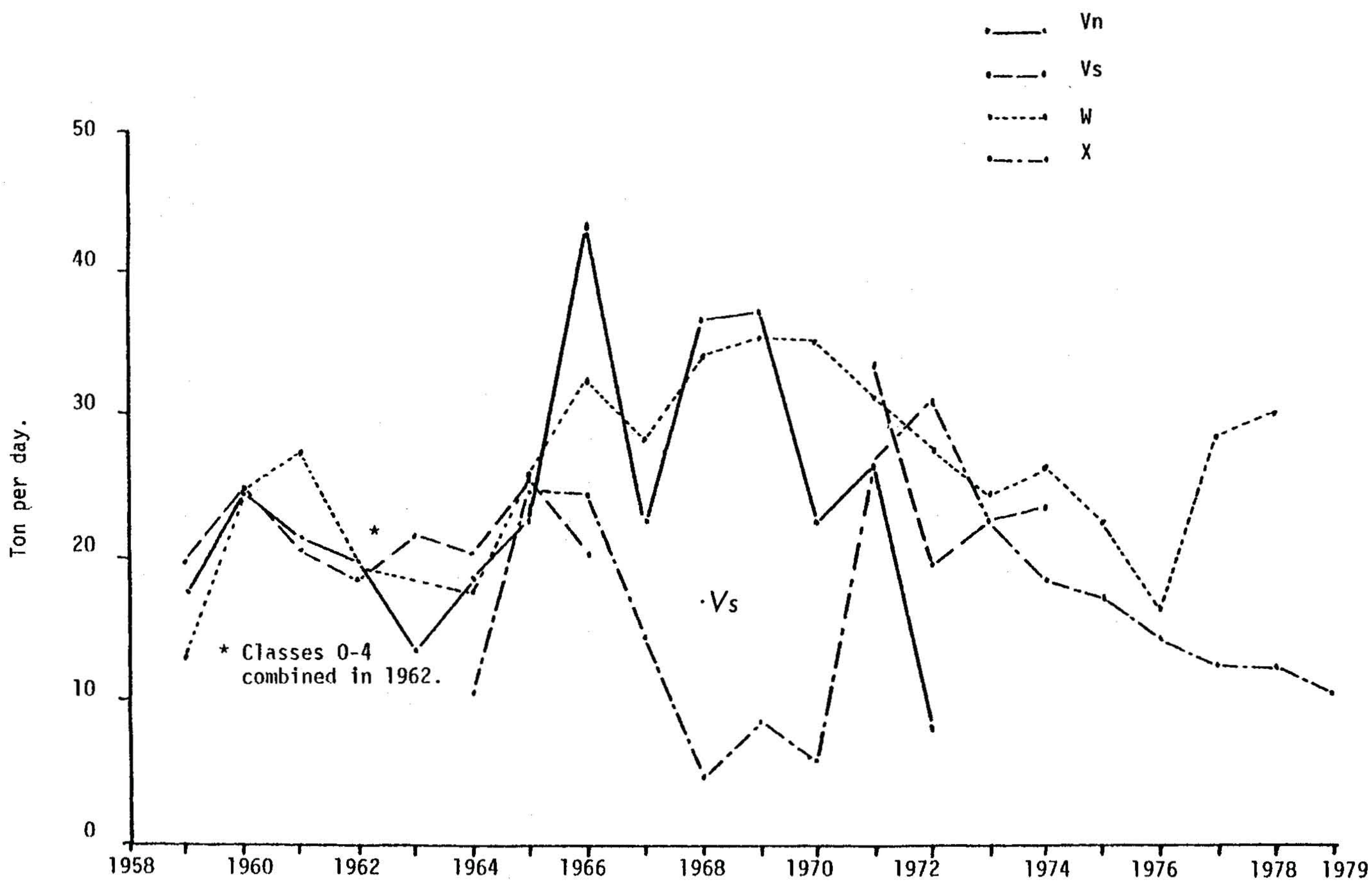

Figure 15. Commercial directed catch per unit effort USA OTB1 Class 4.

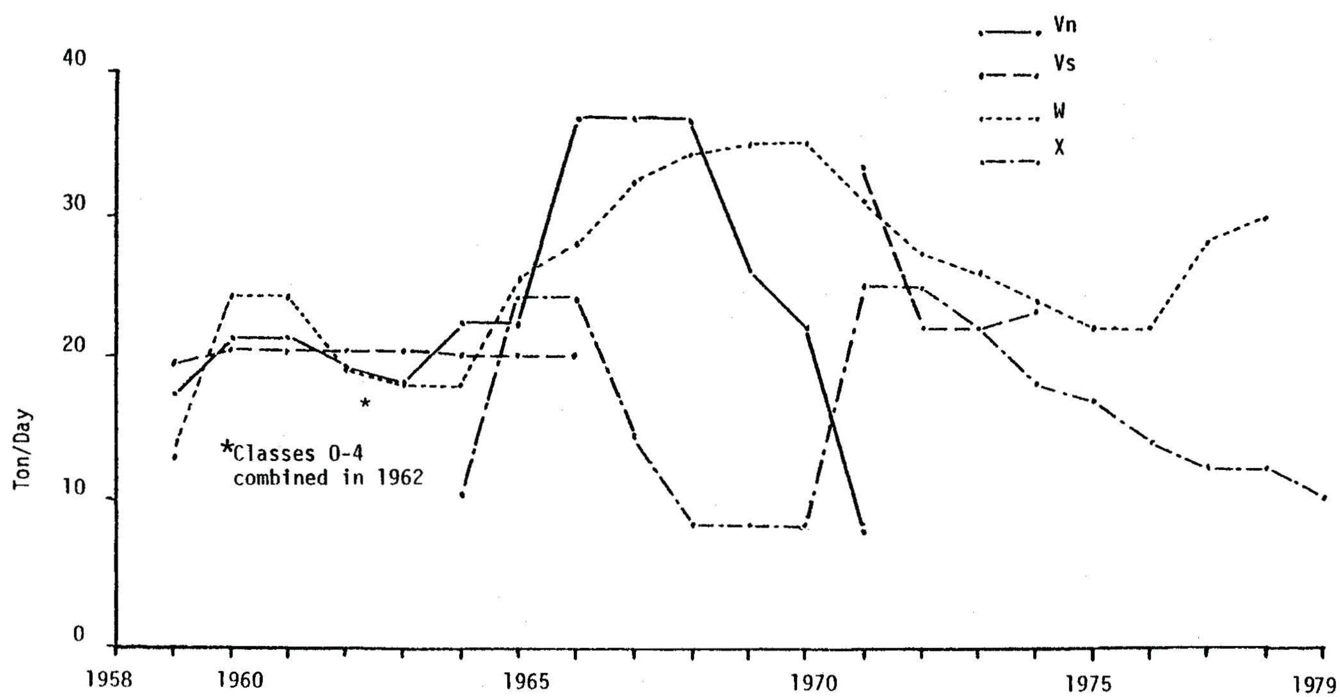

Figure 16. Smoothed directed CPUE. USA OTB1-4.

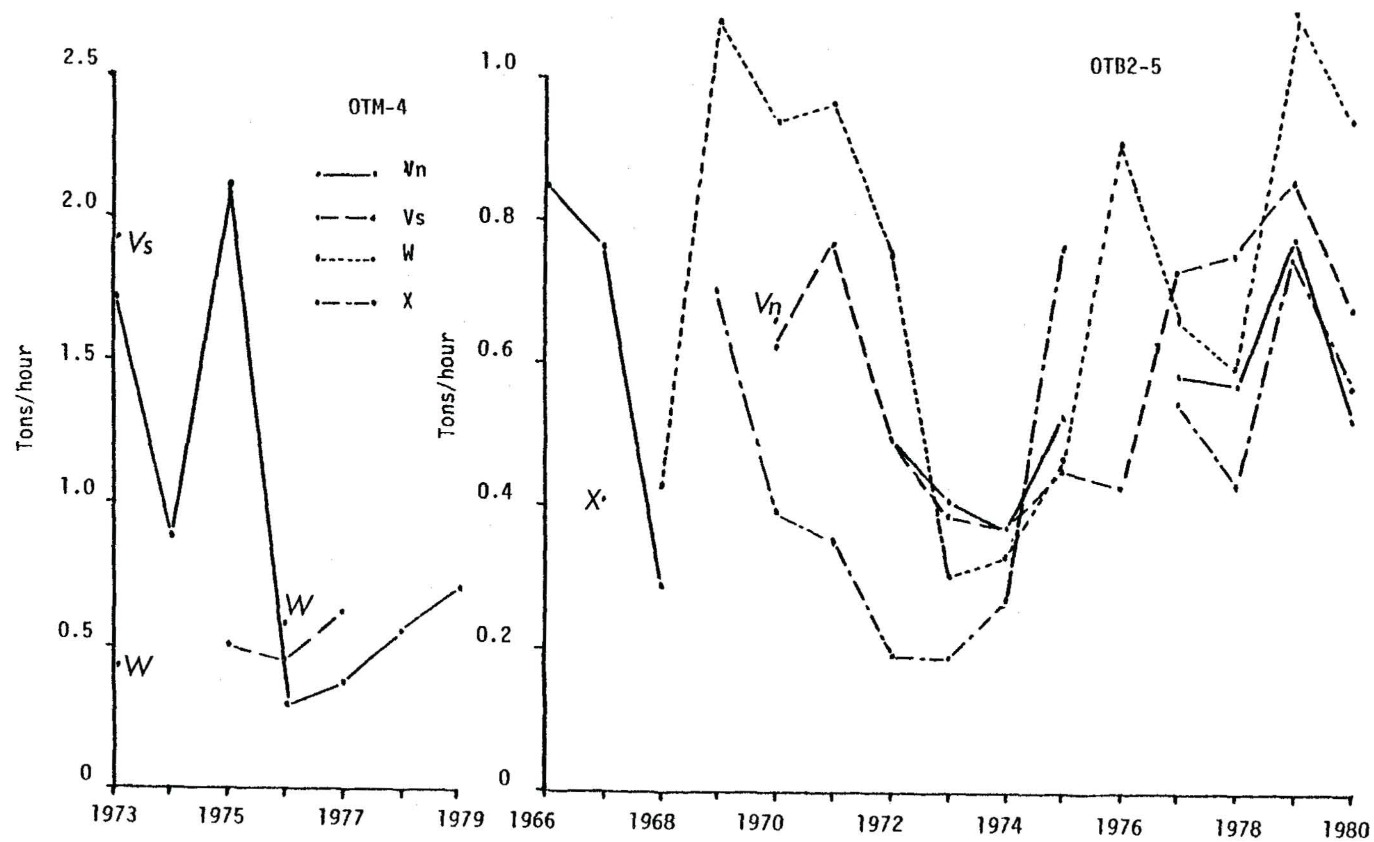

Figure 17. Commercial directed catch per unit effort Maritime Canada OTM Class 4 and OTB2 Class 5.

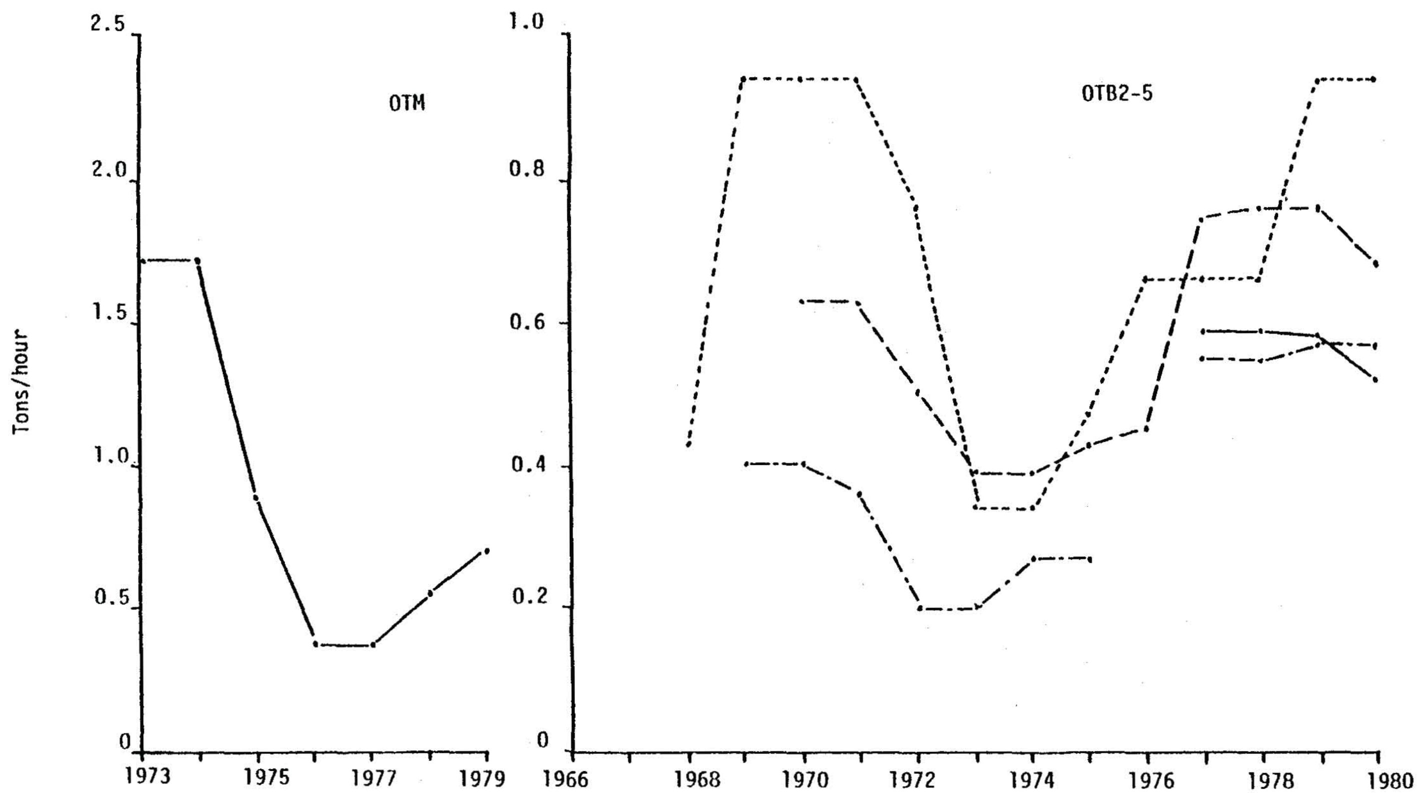

Figure 18. Directed CPUE smoothed C (M + Q): OTM Class 4 and OTB 2 Class 5.

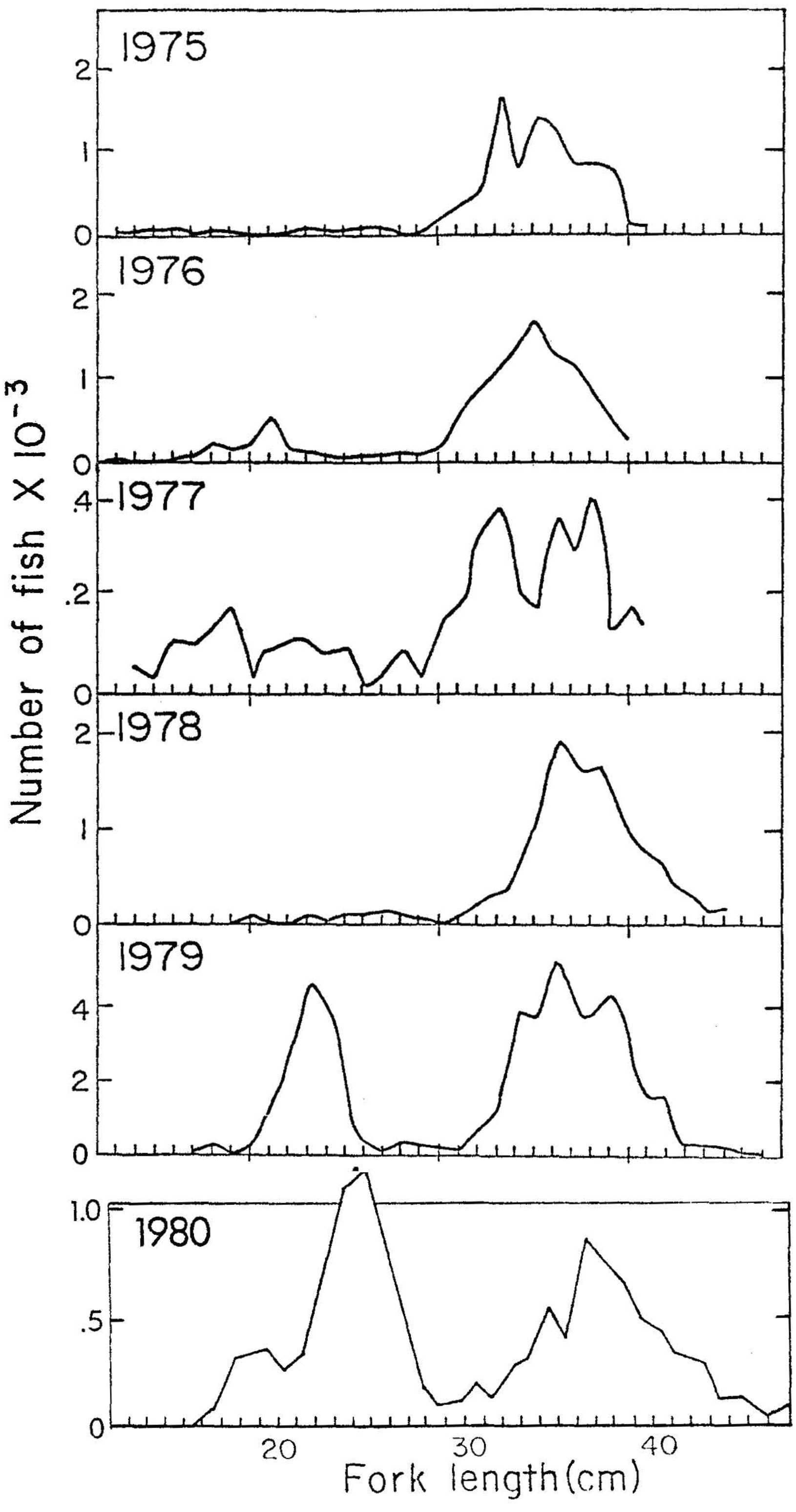

Figure 19: LENGTH FREQUENCIES - DIVISION 4Vn.

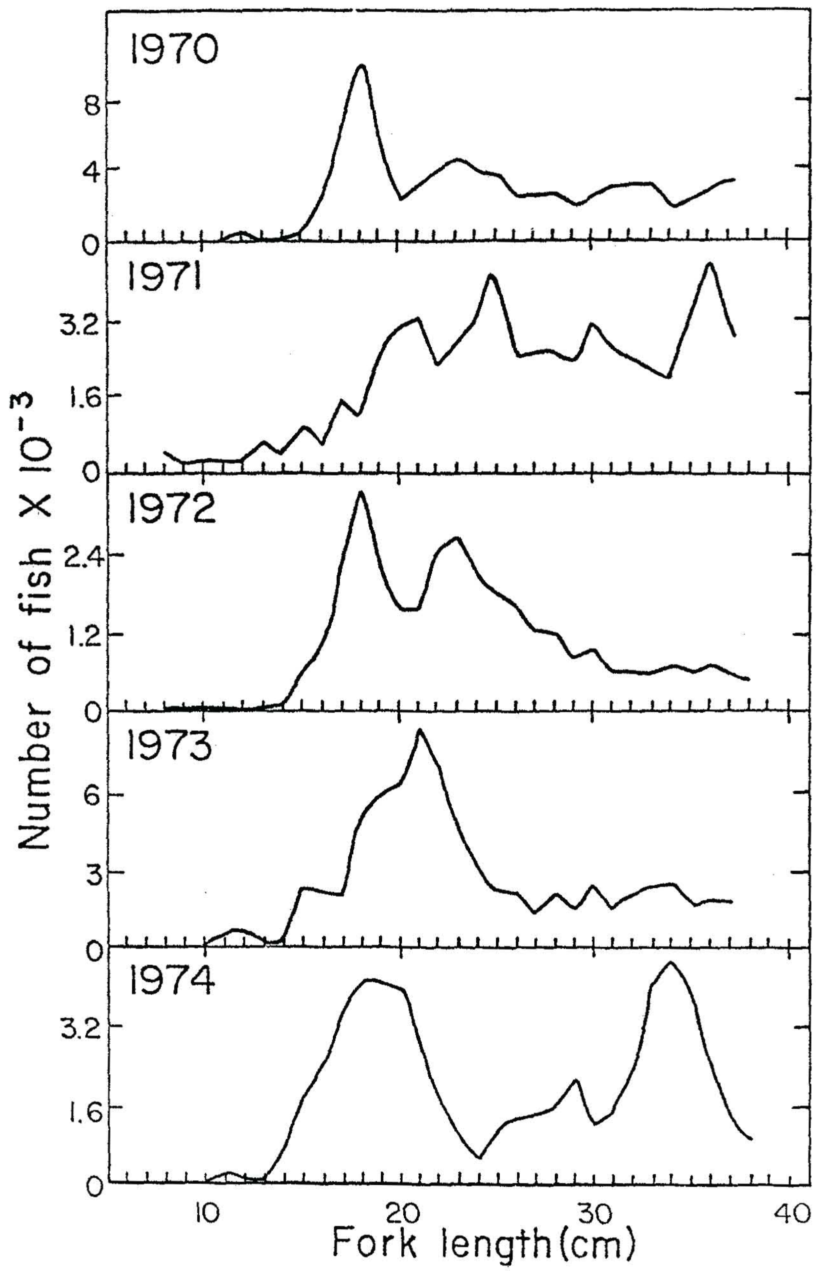

FIGURE 20: LENGTH FRENQUENCIES - DIVISION 4Vs.

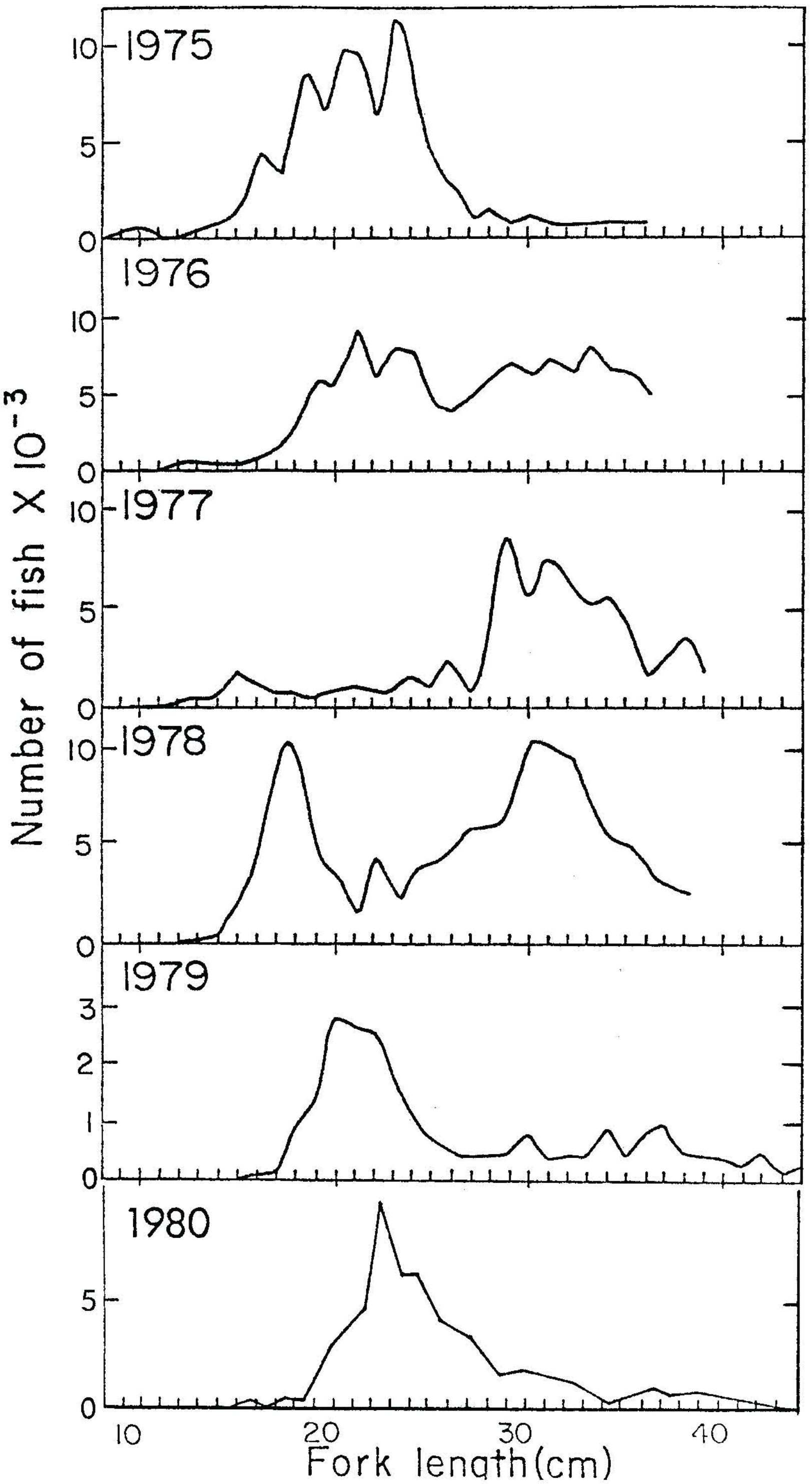

FIGURE 20(cont.): LENGTH FREQUENCIES - DIVISION 4Vs.

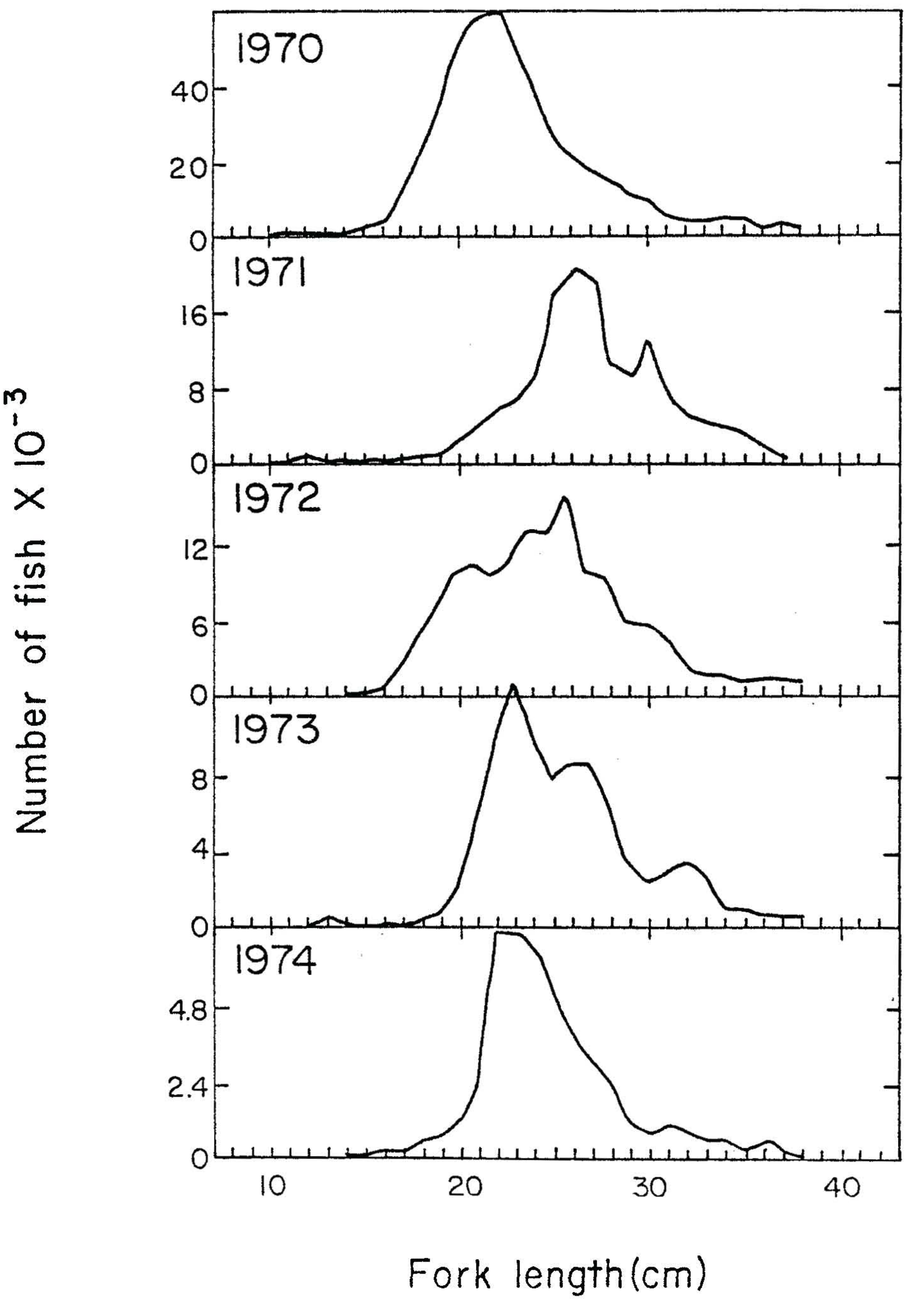

FIGURE 21: LENGTH FREQUENCIES - DIVISION 4W.

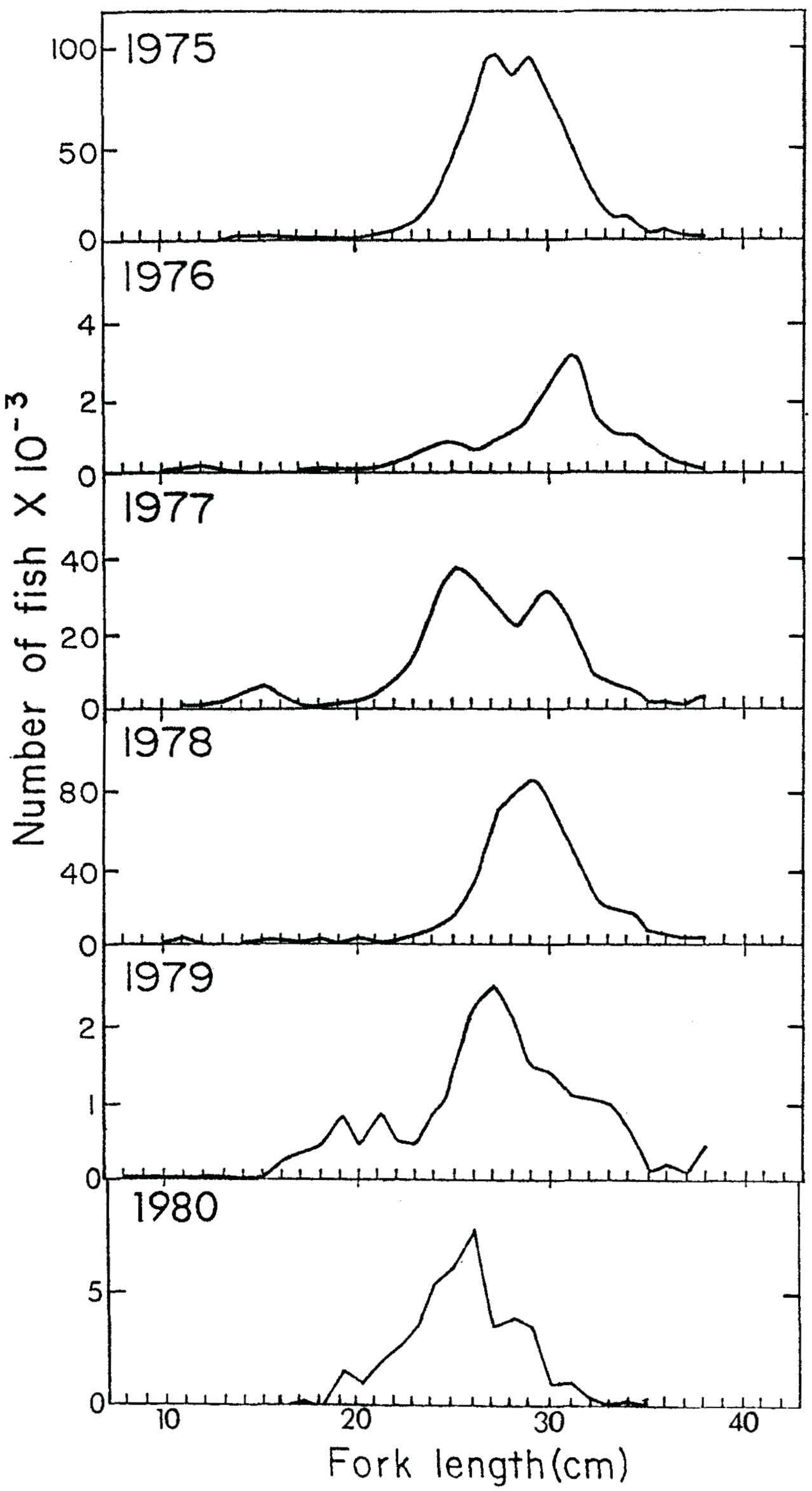

FIGURE 21(cont.): LENGTH FREQUENCIES - DIVISION 4W.

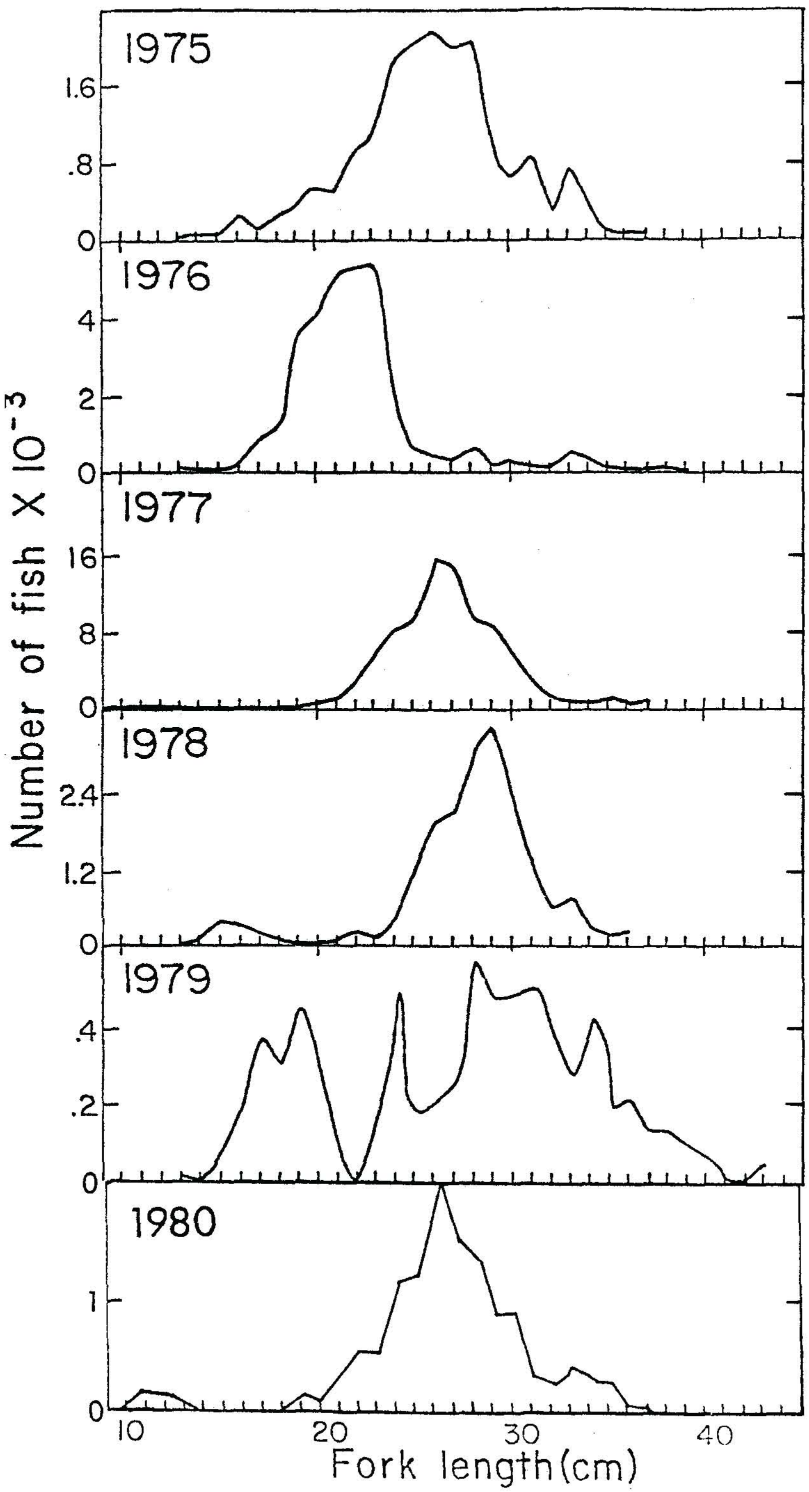

FIGURE 22: LENGTH FREQUENCIES - DIVISION 4X (East).

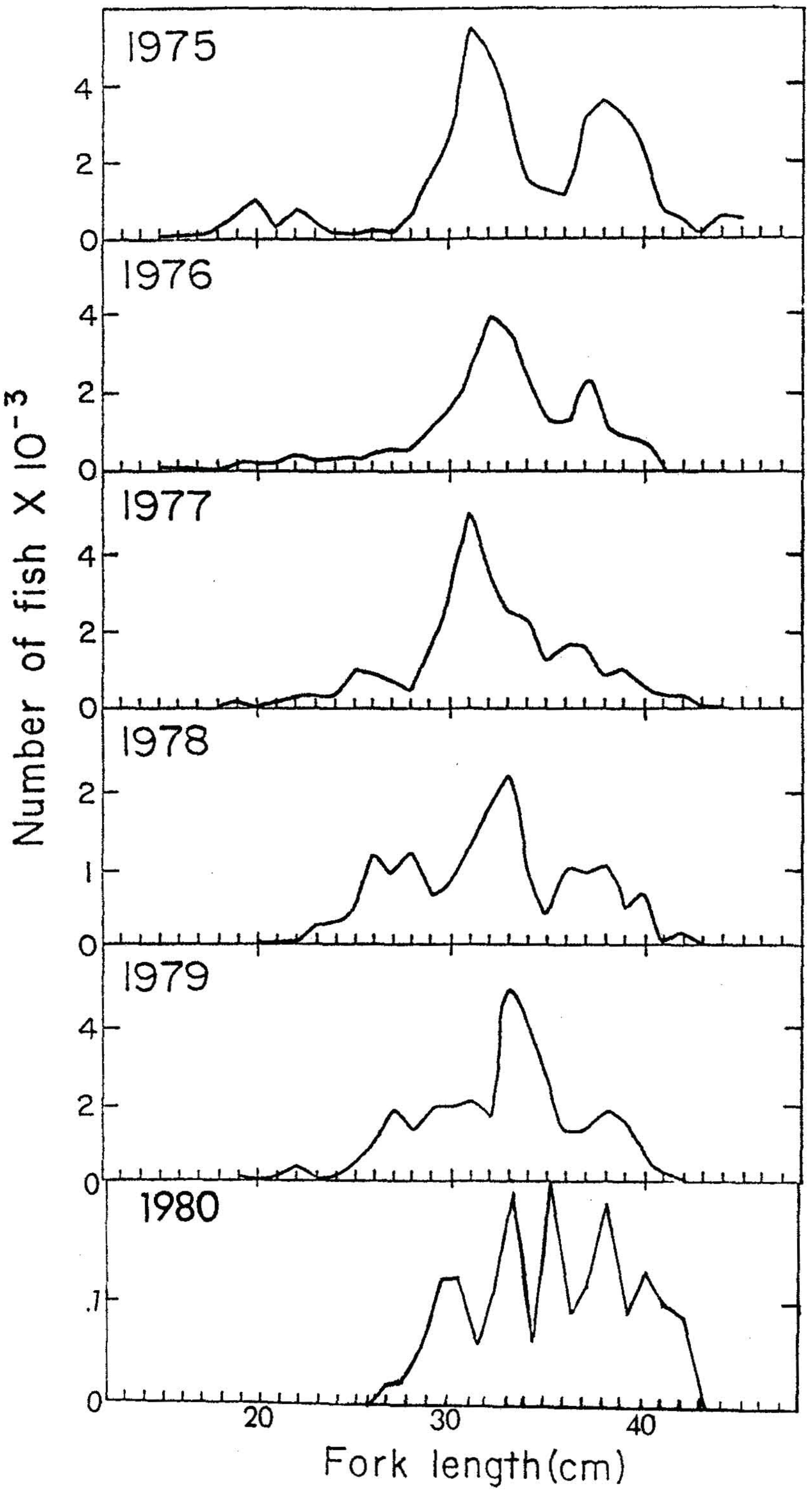

FIGURE 23. LENGTH FREQUENCIES - DIVISION 4X (West).