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Redfish in Management Unit 4VWX: A History of Stock Definition and Assessment of Present Status

by

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Abstract

A history of the definition of redfish stock structure in Division 4VWX is presented in conjunction with an assessment of its present status.

Soon after its formation in 1950, the intent of ICNAF was to define biologically sound stocks for all commercially exploited redfish in the Northwest Atlantic. Between 1953 and 1984 a number of studies were undertaken to define biologically sound stocks of redfish in the Northwest Atlantic by the examination of meristics, morphometrics, age at first maturity, fecundity, growth characteristics, parasite distribution, and larval distribution of redfish. No single study, nor the combined efforts of all these studies, resulted in the definition of a biological stock resident in 4VWX. In 1974, all redfish in 4VWX were arbitrarily lumped into a single stock and a TAC of 40,000 t established. Although various proposals for a redefinition of this management unit have been put forth, none have provided the conclusive evidence to warrant such a redefinition and none have been implemented.

In addition to the stock problem, the presence of several species of redfish in the Northwest Atlantic has added a further level of complexity. Recent studies have indicated that only *Sebastes fasciatus fasciatus* and *Sebastes norwegicus mentella* occur in sufficient numbers to be of importance to the commercial fisheries in 4VWX. Of these, *S. fasciatus* appear to be the most abundant while *S. mentella* occurs mainly below 350 m along the edge of the continental slope. Unless there is a major shift in the fishery to these deeper waters it will continue to exploit mainly *S. fasciatus*. If it is determined that within 4VWX *S. fasciatus* is distributed in several isolated or self perpetuating populations, the possibility of localized over-fishing or under-utilization should be considered. At present no evidence to indicate the presence of localized stocks of *S. fasciatus* within 4VWX is available.

Landings of redfish in Division 4VWX decreased to a provisional total of 10,295 t in 1984. This provisional total is 20% less than that landed in 1983 and represents 34% of the TAC for 4VWX redfish established for 1984. Catch and effort data indicate that stern trawler catch rates declined in both 1983 and 1984 with a concomittant decline in catches. Side trawler catch rates have increased since 1980 with increases being most evident in Divisions 4W and 4X.

Redfish biomass estimates from RV surveys have been extremely variable but indicate a decline throughout the 1970's. Between 1980 and 1984, biomass estimates have increased steadily. Redfish directed surveys in 1982 and 1983 indicated that between 25% and 30% of the estimated total biomass may occur below 370 m.

Redfish with a modal length of 15 cm where well represented in the length-frequency distribution from the 1984 summer survey. Analyses of both fall and summer RV length-frequency data indicate that this mode is composed of two relatively strong year-classes. The first appeared in the fall of 1981 whereas the second and apparently larger year-class first appeared in 1982. Both of these are more numerous than any observed since the surveys began in 1970.

Résumé

On fait l'historique de la définition de la structure du stock de sébastes de la Division 4VWX et l'on évalue la définition actuelle.

Peu après la création de la CIPANO, en 1950, on a voulu définir des stocks biologiquement sains pour tous les sébastes commercialement exploités dans le nord-ouest de l'Atlantique. De 1953 à 1984, on a réalisé dans ce but un certain nombre d'études sur les caractéristiques méristiques et morphométriques, l'âge au début de la maturité, la fécondité, la croissance, la distribution des parasites et la distribution des larves de sébaste. Aucun de ces travaux, ni l'ensemble des données qu'ils ont apportées, n'a mené à la définition d'un stock biologique établi dans la Division 4VWX. En 1974, on a arbitrairement regroupé en un seul stock tous les sébastes de cette division et l'on a fixé le TPA à 40 000 t. On a proposé à diverses reprises une nouvelle définition, mais comme aucune des propositions avancées n'apportait d'éléments justifiant une redéfinition, elles n'ont pas été appliquées.

La présence de plusieurs espèces de sébastes dans le nord-ouest de l'Atlantique complique encore davantage la question. Des études récemment effectuées indiquent que seuls les Sebastes fasciatus fasciatus et les Sebastes norwegicus mentella sont suffisamment nombreux pour avoir de l'importance au point de vue de la pêche commerciale dans la Division 4VWX. Les S. fasciatus semblent les plus nombreux; quant aux S. mentella, on les trouve surtout à plus de 350 m, le long du talus continental. À moins qu'il se produise un changement majeur et qu'on en vienne à pêcher dans ces profondeurs, on devrait continuer d'exploiter surtout S. fasciatus.

Si l'on constate que dans la Division 4VWX les S. fasciatus forment plusieurs populations isolées ou autorégénérées, il faudra envisager la possibilité qu'il y ait localement surexploitation ou sous-utilisation. D'après les données que nous avons actuellement, rien n'indique la présence de stocks de S. fasciatus localisés dans la Division 4VWX.

Les débarquements de sébastes dans la Division 4VWX ont baissé; ils s'élèvent provisoirement à 10 295 t en 1984. Cette valeur est de 20 % inférieure aux débarquements de 1983; elle représente 34 % du TPA de sébastes fixé pour 1984 dans la Division 4VWX. D'après les données qu'on possède sur les prises et l'effort de pêche, le taux de capture des chalutiers à pêche arrière a diminué en 1983 et en 1984 et cette diminution s'est accompagnée d'une baisse des prises. Le taux de capture des chalutiers à pêche latérale a augmenté depuis 1980; l'augmentation est surtout apparue dans les Divisions 4W et 4X.

La biomasse de sébastes, estimée d'après les résultats des relevés par navires de recherche, a été très variable, mais les données indiquent qu'elle a baissé durant toutes les années soixante-dix. De 1980 à 1984, elle a régulièrement augmenté. D'après les relevés visant spécifiquement le sébaste qu'on a effectués en 1982 et 1983, entre 25 % et 30 % de la biomasse totale estimée se trouverait à plus de 370 m de profondeur.

Les sébastes de longueur modale de 15 cm étaient bien représentés dans la distribution de fréquence des longueurs établie d'après les résultats du relevé de l'été 1984. D'après l'analyse des fréquences de longueurs déterminées avec les résultats des relevés par navires de recherche d'automne et d'été, ce mode se compose de deux classes d'âge relativement importantes. La première est apparue en automne en 1981, tandis que la seconde, apparemment plus considérable, est apparue en 1982. Ces deux classes sont plus nombreuses que toutes celles qu'on a observées depuis le début des relevés, en 1970.

History of Stock Definition

The delineation of redfish management units for the fisheries of the northwest Atlantic was formally considered soon after the formation of the International Commission for North Atlantic Fisheries (ICNAF) in 1950. In the ICNAF Annual Report for 1952-53 it is stated that the work of the Commission was to centre on cod, haddock, redfish, and halibut and that the main purpose of the Commission's work would be to "so regulate the fisheries as to avoid over-fishing and obtain the maximum long-term yield". At that time it was considered that the central questions were:

1) What principle fish stocks are there, where, how divided and how now used?
2) How do intensity and method of fishing affect the stocks and the long-term yield?
3) How are the stocks affected by natural factors?

To answer the first of these questions the Commission recommended that information be collected on "units of stocks and their distribution and movements...". They felt that this should be achieved by research vessel surveys, tagging experiments, studies on meristics and morphometrics, determination of age at first maturity, fecundity, growth characteristics, and the distributions of parasites. In other words the apparent intent was to define biologically sound stocks for each of the species in question. Martin (1953) summarized the knowledge to date on major groundfish stocks in Subarea 4. He indicated that the redfish of Subarea 4 differed from those of adjacent subareas by virtue of their growth characteristics, meristics, and parasitization. The latter was most evident by the absence of *Sphyrion lumpi*. He also stated that Subarea 4 contained many isolated deepwater populations which differed from one another in some unstated manner, including a number of heavily exploited populations off Western Nova Scotia, central Nova Scotia and Cape Breton and a population of large redfish along the outer edge of the Nova Scotian offshore banks and along the Laurentian Channel to the Gaspé. He felt that there were many gaps in the understanding of redfish populations in Subarea 4 and that further research would be required before it would be possible to describe these in detail.

During that same year the U.S.A. reported (ICNAF, 1953) that studies of the incidence of *Sphyrion lumpi* indicated no appreciable migration of redfish out of the Gulf of Maine to other areas. They also stated that other evidence led them to conclude that none of the redfish stocks in Subareas 4 or 5 undertook extensive migrations. From the above it would appear that there was some attention being directed toward separating SA4 and SA5 redfish stocks but that the biological basis for this division was still lacking or considered tenuous.

In the Report of the Standing Committee on Research and Statistics to the 1956 Annual Meeting of the Commission (ICNAF, 1958) it was obvious that the question of redfish stocks was still far from settled. The question being asked was "How is *Sebastes marinus* divided into stocks and how can these stocks be distinguished?". It was indicated that the U.S.A. was conducting morphological studies aimed at stock delineation in Subareas 4 and 5 while Canada was conducting similar research in Subareas 2, 3, and 4. In addition, the U.S.A. and Canada both were conducting investigations on the distribution of *Sphyrion lumpi*, spawning studies through larval distribution, comparison of growth rates between various areas, and tagging studies in inshore areas (Eastport Maine).

In 1959 this same committee (ICNAF, 1959) recommended "that the U.S. compile present knowledge on the division of stocks of our four principle species of fish in the Convention Area". They felt that the redfish symposium which was planned to bring together experts and information on redfish in 1960 would provide the necessary information for that species.

Wise and Jensen (1960) published their views on the stocks of redfish in the ICNAF Convention Area just prior to the redfish symposium. They made it quite clear that the information available on distribution and biology of redfish did not allow for detailed breakdown of redfish stocks. Nevertheless they felt that the evidence suggested three non-migratory stocks of redfish within the convention area. The first was made up of all redfish in Subareas 4 and 5 and Divisions 30 and 3P (now 3Pn and 3Ps). The second stock was said to be composed of all fish in Subarea 2 and Divisions 3K and 3L. The third was composed of all redfish on the Flemish Cap. Mead and Sindermann (1961) summarized the contributions for the Redfish Symposium relating to Systematics and Natural Marks and came to the same conclusions as Wise and Jensen (1960). They felt that the redfish in the Convention Area were composed of three stocks for assessment purposes. The first in Subareas 4 and 5 and Divisions 30 and 3P. The second was made up of Subarea 2 and Divisions 3K and 3L. They felt that there was some overlap between these two stocks in Division 3N. The third stock was composed of those redfish inhabiting the Flemish Cap (Division 3M). Both of these papers (Jensen and Wise, 1960; Mead and Sindermann, 1961) concluded that within these large groupings there was local variation in parasite infestation rates such as those of *Sphyrion lumpi* (see Sindermann, 1961; Perlmutter, 1953) and morphometric and meristic characters (see Templeman and Pitt, 1961; Kelly *et al*., 1961). It is also quite clear that even these large divisions of the redfish in the Convention Area were based on a paucity of data. The division of the two northern stocks (SA23KL, and 3M from SA453NOP) appears to reflect contributions by Travin *et al*. (1961) whose results were based on commercial fishing operations, larval distribution, morphometrics and parasite infestation rates. The combination of all SA4 and SA5 redfish into a single stock appears to have resulted from a lack of detailed understanding of these areas.

Kelly and Barker (1960) indicated that patterns of larval distribution in the Gulf of Maine coupled with known current dynamics would tend to concentrate large numbers of larvae over the south and central parts of the Gulf. They also assumed that some redfish larvae originating from the Scotian Shelf populations would be transported into the Gulf by the westerly currents around Cape Sable Island.

At the 1961 Annual Meeting of the ICNAF Standing Committee on Research and Statistics (ICNAF, 1961) the work by Travin *et al*. (1961) was used to conclude that for halibut and redfish it would be advantageous not to divide stocks using deepwater channels as boundaries since these represent areas of greatest concentration. However in the 1962 Report of the Working Group of Scientists on Fishery Assessment in Relation to Regulation Problems (ICNAF, 1962) evidence presented seemed to favour treating SA5 and Division 4VWX redfish separately. This was based primarily on the results of a study comparing changes in length frequencies in commercial catches over a period of increasing exploitation. The Gulf of Maine redfish showed no decrease in modal or mean length over the period of increasing exploitation whereas the Division 4X redfish did show a decrease in modal length. Calculations of total mortality rates indicated that for both areas only small changes in Z were associated with large changes in effort. This led them to postulate that within each general area redfish are made up of a number of small self contained stock units and that each of these were exploited in succession thus buffering the effects of increasing effort. At any rate this represents the first mention of Subarea 5 and Division 4VWX redfish as separate "stocks".

Kohler (1968) in his review of the stocks of Subarea 4 indicated that on the basis of limited knowledge the redfish stocks in the Subarea should be divided into 4RS, 4TVnWfgj and 4WdklX. It appears that this was based on separating 4TVnWfgj from 4RS because of the Laurentian Channel which showed concentrations of redfish both along its northern and southern edge but none in the middle. The second division between 4WdklX and 4TVnWfgj was based on the area of relative shallow redfish poor waters running from Scatarie Bank to Middle Ground to Western Bank. No mention was made of the earlier hypotheses concerning the connection with SA5 and Divisions 3Pn, 3Ps, and 3Ø redfish.

Bainbridge and Cooper (1971) reporting on the results of the Continuous Plankton Recorder surveys stated that their finding corroborate the stock structure proposed by Mead and Sindermann (1961); namely that SA4 and SA5 and Divisions 3Ø and 3P appear to constitute one large group (at least according to the timing and distribution of larvae in surface waters). However, since these surveys appear to have concentrated their efforts in more northernly areas this conclusion could be construed as somewhat tenuous.

In 1973 the ICNAF Assessments Subcommittee (ICNAF, 1973) reported that quotas for redfish should be applied in 1974 to stocks in Divisions 3LN, 3Ø, 3P, 4VWX, and 5YZ in order to prevent over exploitation which could result from a diversion of effort from fisheries on the currently regulated species". The Division 4VWX management unit has remained in effect to the present time.

From the foregoing discussion it is apparent that the Division 4VWX management unit is not considered to be a biological stock. Indeed it appears to have been defined contrary to evidence suggesting that deepwater channels and holes are areas of concentration and should not be used as boundaries between groups of redfish. However, these artificial management units have been used as the basis for managing the redfish fishery since 1973 when the first TAC was set although other proposals have been put forth.

The Species Problem

In the foregoing discussion no mention has been made of redfish species composition, which adds a further level of complexity to the problem of stock delineation. Kenchington (1980) states that it is now generally accepted that three species of redfish occur in the Northwest Atlantic; Sebastes marinus, S. mentella, and S. fasciatus. In addition to the three species of Sebastes there are also small numbers of Helicolenus dactylopterus (black belly rosefish), but these are too small and too few in number to be of commercial value. The three remaining species have caused a number of problems in the literature and present potential difficulties to management;

1) identification and nomenclature;
2) distribution and abundance of the three separate species;
3) identification of intraspecific stocks; and
4) measurement of species/stock specific population parameters.

Kenchington (1984) presents a thorough review of the nomenclature. He indicates that the redfish of the North Atlantic are composed of three sibling species, two of which contain subspecies;

Sebastes fasciatus fasciatus Storer
Sebastes fasciatus kellyi Storer Litvinenko
Sebastes norwegicus norwegicus (Ascanius)
Sebastes norwegicus mentella (Ascanius) Travin
Sebastes viviparus Krøyer

Since S. viviparus does not occur in the Northwest Atlantic and S. fasciatus kellyi refers to a localized shallow water population from the Eastport Maine area no further mention need be made of them. The three remaining species are of interest. S. norwegicus norwegicus merely replaces S. marinus by virtue of nomenclatorial precedence. S. norwegicus mentella is thus a subspecies of S. norwegicus norwegicus and S. fasciatus fasciatus is a distinct species. For ease of discussion these three groups will henceforth be referred to as S. fasciatus, S. norwegicus, and S. mentella, recognizing that the first two are distinct species while the latter is a subspecies of the second.

Kenchington (1980) states that all three species of redfish occur on the Scotian Shelf with the additional presence of a related genus Helicolenus dactylopterus. However, only S. fasciatus and S. mentella occur in sufficient numbers to be of importance to the commercial fisheries. As was previously stated Helicolenus dactylopterus is small and occurs only in small numbers and S. norwegicus has only been reported twice from the Scotian Shelf. Of the two important species S. fasciatus appears to be the most abundant while S. mentella occurs only below 350 m along the edge of the continental shelf. The presence of a form intermediate between these two species has also been noted from shelf slope waters in 4VWX (Kenchington, 1980).

Although there are only two species to consider on the Scotian Shelf there remains the problem of identification. The differentiation of these species was based on a series of electrophoretic, meristic, and morphometric characteristics with no single characteristic being a completely reliable indicator. It is obvious that the routine classification of catches according to species composition would be a major undertaking, if indeed it is desirable, since to date there have been no studies to indicate that the two species differ in the dynamic attributes of their populations.

Ni (1982) divided the redfish stocks of the Northwest Atlantic into five management units based on meristic characteristics. In his scheme Division 4VWX redfish would be combined with Subareas 3 and 2 redfish to form several stocks. All redfish living below 600 m in Division 4W would be included in the "Northern stock" which also contains all redfish from Subareas 0, 1, 2, fish living below 300 m in Division 3K, those below 550 m in 3L and below 600 m in 3N. The remainder would be grouped into "Grand Bank and Scotian Shelf stock" and would include redfish in 3N and 3Ø living as deep as 350 m, all redfish in 4RS to 200 m, all redfish in 4V to 250 m, and all redfish in 4WX to 350 m. The intermediate depths in Divisions 4VWX are included in two heterogeneous groups which include fish from various Divisions and depth zones namely 2J3LNØP4RTVX and 3LMØP4VW respectively. In general terms this scheme attempts to define stocks of redfish on the basis of species composition with the shallow and more southernly waters containing S. fasciatus and the deeper, more northernly waters containing S. mentella. The areas of overlap in both latitude and depth are combined into the two heterogeneous groups referred to above.

The most obvious drawback of this proposal is its intractable complexity as a series of management units. It also, as Kenchington (1984) points out, does not result in groupings displaying some degree of intra-specific homogeneity but rather defines large areas with constant species composition (a little like assigning all cod in the Northwest Atlantic to a single stock). Kenchington (1980) concludes that since there are no distinguishing characteristics which are practicable for routine use, and S. mentella is not subjected to a major fishery by virtue of its depth distribution, the problem becomes one of defining the stocks of S. fasciatus which make up the majority of the fishery. No conclusive proof for the existence of separate biological stocks was presented although Kenchington (1980) felt that separate management of Subdivisions 4Vn, 4Vs, and Divisions 4W and 4X was desirable. Kenchington (1984) goes on to propose that Division 4VWX redfish might be distributed between several management units. The first consisting of 3Pn4RSTVn, 3ØPs + the eastern portion of 4Vs, the second of western 4Vs + 4W + eastern 4X, and the third of western 4X and 5Y. These management units are based on the postulated existence of recruitment units for redfish. These recruitment units are said to arise from a combination of larval retention and drift, and a contranatant migration of adults counterbalancing losses through larval drift. The larval retentions and drifts are driven by the hydrodynamics of the area which suggest that larval exchange might occur quite readily within the Gulf of Maine - Bay of Fundy - Georges Bank - Browns Bank unit (4X5Y). Another such unit combines Banquereau, Canso, St. Pierre and the western Grand Banks (3PØ + eastern 4Vs). A third unit is made up of the Gulf of St. Lawrence and Sydney Bight. It is not quite clear how the fourth unit comprising western 4Vs + 4W + eastern 4X is produced.

From the above discussion it is apparent that the present management unit of 4VWX redfish is arbitrary since it is known to encompass two species and perhaps several stocks. However, the evidence presently available indicates that the species problem may not be a major one unless there is a large shift in effort to the deeper waters (greater than 350 m) of the Scotian Slope.

Distribution and Abundance -- An Historical Perspective

The redfish fishery on the Scotian Shelf appears to prosecute mainly a single species but conclusive evidence for its biological stock structure is not yet available. In the absence of this knowledge the fishery continues to be managed as a single management unit. If this larger unit does indeed contain smaller populations which have different dynamic characteristics and are subjected to different fishing pressures the possibility of localized over-fishing or under-utilization should be considered. As a first step towards investigating this question the results of the Scotian Shelf groundfish survey conducted by the Department were analyzed to determine the distribution of the resource. The results of this analysis are summarized in Figure 1. This indicates three main areas of concentration with an average estimated biomass of more than 5,000 t per stratum. The deepwater (greater than 183 m) along the edge of the Laurentian Channel in Subdivisions 4Vn and 4Vs (Strata 40 and 46), the inshore edge of the LaHave Basin in Unit Areas 4Xm and 4Xo (Stratum 70), and finally in Unit Areas 4Xp 4Xq (Stratum 84). With some degree of overlap it would appear that each of these areas of highest concentration fall conveniently into Subdivisions 4Vn, 4Vs, and Division 4X with the inshore and deepwater areas of 4W showing relatively consistent concentrations of between 1,000 and 4,000 t per stratum. Evidence gathered by the International Observer Program indicates that the commercial fishery for redfish targets on these areas of concentration. Therefore the following analyses can be viewed as separate analyses of each component of the fishery as a whole.

Although Figure 1 indicates the general distribution of redfish biomass over the past 15 years it does not allow us to draw any conclusions regarding changes in biomass levels or distribution during that time. To facilitate this analysis annual geometric and arithmetic mean biomass estimates for 4VWX as a whole and for individual divisions and subdivisions were calculated.

Estimates of total redfish biomass for management unit 4VWX are presented in Figure 2. The arithmetic series is extremely variable with some interannual fluctuations of over 200,000 t. Since redfish are a relatively slow growing and long-lived species it is unlikely that these represent actual fluctuations in biomass but rather variability as a result of sampling deficiencies. It is therefore difficult to state with certainty what this time series indicates, although in a general sense there does appear to have been a decline in redfish biomass throughout the 1970s. Since 1980 this estimate has increased steadily from less than 50,000 t to almost 190,000 t in 1984. The geometric mean series does not suffer from the large interannual fluctuations of the arithmetic series yet the two demonstrate similar trends over the time period.

To aid in the interpretation of these data, three year running mean biomass estimates were also calculated for each series (Figure 3). For the arithmetic series the decrease from 1972 to 1981 is quite clear with an ensuing increase between 1981 and 1984. The geometric mean series shows a relatively steady decline to 1982 with subsequent increases in 1983 and 1984.

In summary the foregoing discussion has indicated that the redfish in 4VWX are relatively concentrated (5,000 t/stratum) in the deepwater areas of 4Vn and 4Vs, the landward edge of the LaHave Basin in 4Xm and the deepwater areas of 4Xp and 4Xq. Division 4W shows a more widespread concentration of 1,000-4,000 t per stratum. The time series of annual redfish biomass estimates for the entire management unit indicates a general decline throughout the 1970s with a subsequent increase in the early 1980s.

Although the preceding gives a general indication of distribution and overall trends in the resource it does not allow for conclusions regarding more localized changes. To this end biomass estimates for each division and subdivision were analyzed separately. Examination of these data on this smaller scale results in a smaller number of samples being available annually and thus increases the possibility of spurious results. For this reason the arithmetic mean series is shown only for the sake of completeness since the geometric series is the more conservative of the two estimates.

Subdivisions 4Vn and 4Vs (Figure 4) show very similar patterns with a gradual decline from 1970 to 1977 and relatively stable biomass levels from 1978 to the present. The peak in 1979 in 4Vn is due mainly to a relatively large catch in Stratum 40 and thus probably does not accurately reflect the population pattern. Divisions 4W and 4X (Figure 5) show much more variability in stable biomass patterns. Division 4W shows a general decrease from 1970 to 1981 with the major peak in 1978 attributable mainly to a large catch in Stratum 60. Biomass levels in Division 4X show trends which are somewhat different from the other three areas. The initial peak in 1972 is due to a series of large catches in Strata 70 and 84 (4Xm and 4Xpq respectively). From this peak, levels decline precipitously until 1980. From 1980 to 1984 estimated biomass increases rapidly, due mainly to steadily increasing levels in Stratum 70 and adjacent Strata (4Xm).

As was done for total annual biomass, three year running mean estimates were also calculated for each area (Figure 6). For 4Vn and 4Vs the geometric series indicates a decline throughout the 1970s with a slow increase in the early 1980s. In general these time series correspond well with those of the annual estimates. The greater variability for Divisions 4W and 4X remains evident in the three year mean time series; however the general trends remain, a decrease in biomass throughout the 1970s (and early 80s in 4W) with a subsequent increase.

To summarize the above discussion, redfish biomass levels in Subdivisions 4Vn and 4Vs have remained relatively stable or have increased slightly since 1977. Levels in Division 4W, although more variable, have shown a gradual decline from 1970 to 1983 with peaks in 1978 and 1984 due to a single large catch in Stratum 60 and two large catches in Stratum 57 respectively. Estimates of redfish biomass in Division 4X declined rapidly from 1970 to 1980 but have shown an equally rapid increase from 1980 to 1984. This increase is attributable mainly to increasing catches in Stratum 70 and adjacent Strata (4Xm).

To estimate the relative levels of redfish biomass contained in each of these strata over the last 15 years five year averages were calculated and are given below:

	4Vn	4Vs	4W	4X
1970-74	15,790	13,044	10,379	31,595
1975-79	9,345	8,964	16,899	10,633
1980-84	6,130	8,994	11,434	16,668

These data indicate that since 1975, Divisions 4W and 4X have contained higher levels of redfish biomass than 4Vn and 4Vs. Between 1980 and 1984 4Vn contained the least redfish, 4Vs somewhat more, and 4W and 4X the highest levels.

Interpretation of the foregoing discussion should be tempered with the knowledge that estimates of redfish biomass are highly sensitive to the small scale distributional patterns of the resource. Contagious distributions such as those demonstrated by redfish can result in large set to set variations in stratified random trawl surveys and lead to large variations in estimates of biomass calculated by aereal expansion.

History of the Fishery

The fishery for redfish in 4VWX was developed in the mid-1930s. No large catches were reported until 1936 when the USA landed 7,195 t. The period of initial exploitation was completed in 1949 with a maximum catch of 77,142 t. Between 1952 and 1970 catches fluctuated between 10,000 and 40,000 t. Landings by Canadian fishermen were relatively insignificant until the beginning of the 1960s when their nominal catches averaged 2,658 t of an average total nominal catch of 33,473 t (1960-1964). Since 1967, Canadian fishermen have landed the largest proportion of the total catch. In 1961 the distant water fleet, composed mostly of vessels from the U.S.S.R., but later augmented by Polish, Japanese, and French vessels, began contributing significantly to total redfish catches from these divisions. The combined efforts of Canada, the USA, and the distant water fleet culminated in a maximum nominal catch of 62,381 t in 1971 (Figure 7). Since the establishment of Canada's 200 mile zone in 1977, the distant water fleet has not contributed significantly to 4VWX redfish catches. However, in 1984 Japan landed 1,329 t.

Landings of redfish by subdivision and division are given in Table 1. Starting in 1971 the catches declined rapidly such that in 1976 only 18,459 t were landed, and then continued to decline more slowly until reaching a low of 10,295 t in 1984. This provisional total is 20% less than that landed in 1983 and represents only 34% of the TAC for the 4VWX redfish established for 1984. A detailed description of TAC, quotas, and landings since 1974 is given in Table 2.

Division 4W and Subdivision 4Vs historically have contributed the greatest proportions of total redfish landings (Figure 8). Since the establishment of the 200 mile fishing zone in 1977; however, 4Vn and 4Vs have contributed the largest proportion of the landings, and since 1982 have accounted for an increasing proportion of the landings. The proportional landing from 1977-1981 and from 1982-1984 are shown below:

	4Vn	4Vs	4W	4X
1977-1981	0.30	0.40	0.14	0.15
1982-1984	0.30	0.26	0.09	0.27

These data indicate relatively stable proportions of landings taken from 4Vn, decreases in 4Vs and 4W, and an increase in 4X. The decrease observed in 4Vs may be somewhat overestimated since a large proportion of the Japanese landings (approx. 1,329 t) were taken from this area, the final amounts and locations of these catches are not yet available.

Of the Canadian landings in 4VWX by far the largest proportion is taken by two classes of vessel; tonnage class 4 side trawlers (OTB1-TC4) and tonnage class 5 stern trawlers (OTB2-TC5). Landings by these vessels are given in Table 3. Prior to 1977 side trawlers accounted for the largest proportion of landings in 4VWX. This distribution of landings has changed significantly since 1977. In Subdivision 4Vn total landings since 1977 have favoured the side trawlers by approximately 30%. Between 1983 and 1984 landings for both declined dramatically. In this same period in 4Vs, stern trawlers landed approximately 40% more than side trawlers. Landings in both vessel categories have declined since 1982. In 4W since 1977, stern trawlers accounted for 95% more catch than side trawlers. In this division catches by side trawlers have increased since 1982 whereas stern trawler catches have fluctuated since 1981 and declined sharply in 1984. Since 1977 landings in 4X have been made largely by side trawlers (72% more than stern trawlers). Side trawlers have shown a significant increase in landings since 1977. In 1984 side trawlers in 4X landed approximately 8 times the amount caught by stern trawlers. Stern trawler landings in 4X have declined dramatically since 1982.

Distribution of landings by vessel category by quarter of the year are given in Tables 4 and 5. These data indicate that landings for both categories in all areas are generally highest in the third quarter of the year with some overlap into the second and fourth quarters but generally lower landings in the first.

To summarize, 4Vn and 4Vs accounted for the largest proportions of redfish landings between 1977 and 1981 (70%). Between 1982 and 1984 landings in 4Vn remained stable at about 30% of the total whereas landings in 4Vs decreased to about 26%. Since 1977 landings in 4Vn have favoured the side trawlers (by 30%) whereas in 4Vs, landings have favoured (40%) stern trawlers. The proportion of landings from 4W has decreased from 14% between 1977 and 1981 to 9% in the last three years. Landings from this division are dominated by stern trawlers (95% more than side trawlers). Landings in 4X have increased from 15% of the total between 1977 and 1981 to 27% since 1982. Landings in 4X have favoured side trawlers by 72%.

From the foregoing it appears that proportional landings in areas dominated by stern trawlers have declined since 1977 while those areas dominated by side trawlers have accounted for stable or increasing proportions of total landings.

Commercial Catch Rate Series

In addition to the research vessel biomass estimates discussed previously a second series of abundance estimates were derived from commercial catch rates. The distribution of landings indicate that OTB1-TC4 and OTB2-TC5 vessels account for the largest proportion of landings in this fishery, therefore a series of catch rates for each was calculated.

I) Catch Rates for 4VWX Combined

Catch rates for OTB1-TC4 and OTB2-TC5 calculated from total annual effort and total annual catch are shown in Figure 9. Stern trawler catch rates increased from 1976 to 1982 but declined in both 1983 and 1984 whereas side trawler catch rates have increased dramatically since 1980. The total directed catch for stern trawlers declined from 3,668 t in 1982 to 1,590 t in 1984. Directed redfish catches by side trawlers have remained relatively stable at an annual average of 3,579 t over the period of increasing catch rates.

To minimize the effects of seasonal variation in catch rates these two series were also calculated using total catch and total effort from the third quarter of each year (Figure 10). This series demonstrates the same general trends as those observed for the annual series. Stern trawler catch rates increased from 1976 to 1982 and declined dramatically from 1982 to 1984. The increase in side trawler catch rates is less abrupt in this series and is evident from 1979 to 1984. Concomittant with the sharp decline in stern trawler catch rates is a large decline in directed catch from 2,657 t in 1982 to 426 t in 1984. Side trawler directed catches have been relatively stable at an annual average of 1,880 t between 1979 and 1984.

In summary these data indicate increasing catch rates for side trawlers since the mid to late 1970s coupled with relative stable annual directed catches. Stern trawler catch rates have declined since 1982 in conjunction with a decrease in directed catch.

II) Catch Rates for 4Vn, 4Vs, 4W, and 4X

Catch rates for the two vessel categories were also calculated by division and subdivision (Figure 11).

a) Catch rates Calculated From Annual Totals of Catch and Effort

i) 4Vn -- Stern trawler catch rates declined rapidly between 1969 and 1973. From 1973 to 1981 catch rates were variable but generally increasing. In 1982 catch rates rose sharply while in 1983 and 1984 they declined. Directed catches by stern trawlers increased from 1,263 t in 1982 to 1,307 t in 1983 and declined sharply to 555 t in 1984. Side trawler catch rates declined steadily from 1968 to 1980, increased from 1980 to 1983, and decreased rapidly in 1984. Directed catches by side trawlers increased from 713 t in 1982 to 1,201 t in 1983 and decreased to 315 t in 1984.

ii) 4Vs -- Stern trawler catch rates declined precipitously from 1971 to 1973 and increased from 1973 to 1982. As was the case in 4Vs catch rates declined in 1983 and 1984; however in this case the decline was accompanied by a decrease in directed catch from 1,506 t in 1982 to 757 t in 1984. Side trawler catch rates declined gradually from 1971 to 1980, increased to 1982 and have remained relatively stable in 1983 and 1984. Directed catches by side trawlers have decreased from 1,593 t in 1982 to 541 t in 1984.

iii) 4W -- Stern trawler catch rates declined from 1970 to 1976, increased steadily from 1976 to 1981 and have fluctuated widely between 1981 and 1984. Directed catches by this vessel category increased from 1980 to 1981 (1,349 to 1,849 t) then decreased to only 155 t in 1982, 540 t in 1983 and 190 t in 1984. Side trawler catch rates declined steadily from 1969 to 1977 increased to 1981, decreased in 1982 and rose sharply in both 1983 and 1984. Directed catches have increased from 143 t in 1982 to 969 t in 1984.

iv) 4X -- Stern trawler catch rates declined from 1969 to 1973 then increased until 1981. Between 1981 and 1982, catch rates declined, increased in 1983 and decreased in 1984. Directed catches have declined from 744 tons in 1982 to 88 tons in 1984. Side trawler catch rates were relatively stable or decreasing slightly between 1968 and 1976. From 1976 to 1981 they increased, declined in 1982 and 1983 and increased in 1984. Directed catches have increased from 143 t in 1982 to 969 t in 1984.

Stern trawler catch rates in all areas showed a generally increasing trend from the early to mid 1970s to 1981 or 1982. Since then catch rates have declined. Side trawler catch rates in 4Vn and 4Vs declined from the late 60s to 1980. Catch rates in 4Vn increased to 1983 but declined in 1984, 4Vs catch rates increased to 1982 and have remained stable. Side trawler catch rates in 4W declined until 1977 and have since increased whereas 4X catch rates were relatively stable between 1968 and 1977 and have since increased.

Comparing these catch rate series to the full year trends of 4VWX combined reveals that the trend observed for stern trawlers is reflected in all areas, most clearly in 4Vs and 4W since stern trawlers have accounted for the greatest proportion of redfish landings there at least since 1977. Comparing the side trawler catch rate series, the increase observed between 1980 and 1984 are due mainly to increases in 4W and 4X, particularly the latter.

Length-Frequencies From Research Vessel Surveys

In addition to the biomass estimates discussed above research vessel surveys have also provided estimates of redfish length-frequency distributions since 1970. As was the case for biomass and catch rate estimates, length-frequency distributions are given for 4VWX as a whole and for each area separately. Since these surveys are conducted using extremely small meshed liners on the trawls all but the smallest size classes of redfish will be sampled. The relative size of these groups of small fish can then be used as an estimator of recruitment to the population. In this sense it does not necessarily indicate recruitment to the fishable population if pre-recruitment mortality is high.

I) 4VWX Combined

Length-frequency estimates for the entire management unit between 1970 and 1984 are given on Figure 12. The features of interest are the large group of fish with a modal length of 17 cm in 1974. This may represent the large 1971 year-class identified by previous investigators (eg. Mayo, 1980) although utilizing the age-length relationship determined by Clay and Clay (1980), this year-class should have a fork length of 10 cm with a range from 8 to 19 cm. The second relatively large cohort is first seen in the 1977 data and can be followed at least until 1981 at about 24 cm. Following Clay and Clay (1980) these fish could be between 9 and 16 years of age. The next major group is first observed in the 1982 data at a modal length of 9 cm; the 1983 and 1984 length frequency distributions suggest that the mode increases to 11 cm in 1983 and 15 cm in 1984. According to these estimates this cohort is the largest to have entered the population since the surveys were started in 1970 and thus it warrants closer examination.

Since 1979 fall surveys have been conducted each year in addition to the regular summer surveys. Since it has been established that newly released year-classes of redfish generally settle to the bottom during the fall months these surveys were also analyzed. It is unfortunate that these have not always achieved full coverage of the survey area. In 1981, Stratum 42 in Subdivison 4Vn was not sampled. In 1982 Strata 40 and 42 were missed (4Vn) as were Strata 47-52 (4Vs), 53-59 (4W), and Strata 76-95 (4X). The results are shown in Figure 13 and indicate that a relatively large group of fish were first observed in the fall of 1981 at a modal length of 9-10 cm. In the fall of 1982 two large groups are seen, one at a modal length of 8-9 cm and a second at 11-12 cm. The size of the first group in 1981 indicates that these are likely the 1980 or 1981 year-class which are then observed again at 11-12 cm in 1982. Similarly, the peak at 8-9 cm in 1982 is likely the 1981 or 1982 year-class. In 1983 both can be seen in 1983 at 11 cm and 13 cm respectively but there is no evidence of any other large incoming year-class. From these analyses it follows that the large peak observed at 15 cm in the summer of 1984 (Figure 12) is probably a combination of the two year-classes.

II) 4Vn, 4Vs, 4W, and 4X Separated.

With the presence of these large year-classes in 4VWX as a whole a more detailed examination of length-frequency distribution in adjacent years may reveal whether this represents localized recruitment or a shelfwide phenomenon. For ease of reference the peak first observed in 1981 will be called the 1981 cohort while the peak first observed in 1982 will be referred to as the 1982 cohort.

Figure 14 shows the results of the fall surveys from 1981 to 1983. The large 1981 cohort was most evident in 4Vs in 1981 with a small peak in adjacent 4W no evidence of it appeared in 4X or 4Vn; however, coverage of the latter was incomplete. The 1982 cohort was again first evident in 4Vs and perhaps 4W. In 1982, the 1981 cohort was still quite evident in 4Vs and to a lesser extent in 4W and 4Vn again, little or no evidence of it was seen in 4X although the incomplete coverage of this division may account for its absence. In the fall of 1983, the 1981 and 1982 cohorts are most evident in 4W. Some evidence of what is probably a combination of both these modal length groups (i.e. Probably 1981 and 1982 year-classes) is now evident in 4X.

Results of the summer surveys 1982-84 are summarized in Figure 15. In 1982 4Vn and 4Vs both show evidence of a relatively large group of fish with a modal length of 8 cm which probably represents the 1982 cohort seen again at 8-9 cm in the fall. No clear indication of the 1981 cohort is in evidence although the long descending tails on the distrubitions may indicate its presence. Some indication of the 1982 cohort can be seen in 4W but none in 4X. In 1983, the 1982 cohort is most evident in 4W and to some extent in 4X. The 1981 cohort can also be seen in 4Vs and 4W. In 1984 the major peak in the summer surveys at 14-16 cm is clearly visible in 4Vs, 4W, and 4X and to a lesser extent in 4Vn. The peak is most evident in 4W. This mode is similar to that observed in the fall surveys and is again probably a combination of the 1981 and 1982 cohorts.

In summary these data indicate that both the 1981 and 1982 year-classes as assumed from the length modes are large relative to others which have been observed since the beginning of regular research vessel surveys.

The 1982 year-class appears to be the larger of the two. In both cases the year-classes were first found in 4Vs and 4W but subsequently appeared in 4X, 4Vn has shown little evidence of this recruitment.

Summary and Conclusions

Summary

4VWX COMBINED

* Estimates of redfish biomass distribution since 1970 indicate three main areas of concentration; 4Vn, 4Vs, and 4X. Division 4W has a high but more widespread distribution of redfish biomass.

* Trends in redfish biomass indicate a general decline throughout the 1970s with an ensuing increase in the early 1980s.

* Total landings have declined steadily since 1970 to a low of just over 10,000 t in 1984.

* Scotia-Fundy based stern trawler (TC 5) catch rates increased between 1976 and 1982 and have decline since. Directed redfish catches by this class of vessel have also declined since 1982.

* Scotia-Fundy based side trawler (TC 4) catch rates have increased since 1980. Directed redfish catches by this class of vessel have been relatively stable over the period of increasing catch rates.

* Analysis of redfish length-frequency distributions reveal that two strong length modes, which probably represent the 1981 and 1982 year-classes, have entered the population. The 1982 year-class may be the largest to have entered the population since 1970.

4Vn

* Redfish biomass estimates for this area declined between 1970 and 1977 since then they have been relatively stable or increasing slightly.

* Total landings have declined since 1981.

* Stern trawler catch rates declined in both 1983 and 1984 after a period of relative stability between 1973 and 1981.

* Side trawler catch rates declined steadily between 1968 and 1980, increased until 1983 but have declined in 1984.

* Length-frequency distributions have given little or no evidence of large incoming year-classes in recent years.

4Vs

* Biomass estimates declined between 1970 and 1977 and have remained

stable or increased slightly since.

* Total landings have declined since 1981.

* Stern trawler catch rates increased between 1978 and 1982 but have declined since.

* Side trawler catch rates declined from 1971 to 1980, increased until 1982 and since then have remained stable.

* Analysis of redfish length-frequency distributions indicate that the two large length modes, probably representing the 1981 and 1982 year-classes, were initially most evident in 4Vs.

4W

* Biomass estimates declined between 1970 and 1983. The increase observed in 1984 is due to several large catches in Stratum 57.

* Total landings declined precepitously in 1982 and have remained low since then.

* Stern trawler catch rates declined between 1970 and 1976, increased until 1981 and have fluctuated since.

* Side trawler catch rates increased between 1977 and the present, the greatest increase occurring beween 1982 and 1984.

* Length-frequency distributions indicate that both the length modes, probably representing the 1981 and 1982 year-classes are well represented in 4W.

4X

* Biomass estimates declined between 1970 and 1980 and have increased rapidly since. The majority of this increased biomass is attributable to increases in Unit Area 4Xm.

* Total landings have been relatively stable since 1977.

* Stern trawler catch rates declined between 1969 and 1973, increased until 1981 and have declined since.

* Side trawler catch rates were stable between 1968 and 1976 and have increased since.

* Length-frequency distributions indicate that the length modes assumed to represent large 1981 and 1982 year-classes did not become evident in 4X until 1983.

Conclusions

The overall assessment of redfish in management unit 4VWX indicates a general decline in biomass throughout the 1970s with a subsequent increase since 1980. Both the decline and the increase are attributable to changes in redfish biomass in Divisions 4W and 4X, since Subdivisions 4Vn and 4Vs have contained relatively stable levels. No single area has shown any conclusive evidence of a continued decline in recent years; however increases in 4X have been consistent since 1980.

Catch rate series for the two major gear types prosecuting this fishery give somewhat contradictory results. Side trawler catch rates for the entire management unit have increased since 1980. This compares well with the increase in redfish biomass observed in 4X because since 1980 this area has accounted for an increasing proportion of the landings by this gear type. Side trawler catch rates in 4W have also increased rapidly since 1982. This may indicate that the increased estimate of redfish biomass observed there in 1984 is not spurious. The relative stability of side trawler catch rates in 4Vn and 4Vs are borne out by the equally stable estimates of biomass in these areas.

Stern trawler catch rates in the management unit as a whole have been more variable than those of the side trawlers. Between 1976 and 1982 they have increased but have decreased since. These declines are most evident in 4X, 4Vn, and 4Vs. Catch rates in 4W have fluctuated since 1980 but show no conclusive evidence of a continued decrease. These declines are somewhat more difficult to reconcile with estimates of redfish biomass since they do not track them as the side trawler catch rates. The explanation may lie in the decreases in directed catches (and therefore directed effort) by this gear type, especially since 1982.

Redfish length-frequency distributions indicate the presence of a large group of small fish with a modal length of 15 cm in July of 1984. Analysis of both fall and summer research vessel length-frequency data indicate that this large group of fish is composed of two relatively strong length modes which probably represent year-classes. The first surveyed in the fall of 1981 while the second and apparently larger group first appeared in 1982. Both of these year-classes are more numerous than any observed since the inception of the surveys in 1970. Analysis of these survey length-frequency data by division and subdivision indicate that both of these large year-classes first appeared in 4Vs and 4W and subsequently in 4X. 4Vn has shown little or no evidence of their presence.

The pattern of appearance of these strong year-classes indicates that they are not confined to any single area. Their initial appearance in 4Vs and 4W and their subsequent occurence in 4X may be interpreted in one of two ways. It may be that these year-classes first arose in 4VsW, and subsequently spread to 4X. However, given the rather sedentary nature of this species this does not seem likely. It may be that, given the contagious distribution of redfish, sampling inensity was not high enough in all areas to pick up these year-classes. Whatever the underlying mechanism, these two strong year-classes are now evident in all portions of the management unit except 4Vn. If pre-recruit mortality is not inordinately high these year-classes should begin recruiting to the commercial fishery early in the 1990s.

Given these results there is no conclusive evidence to indicate either a general or localized decline in redfish abundance in management unit 4VWX. Biomass estimates in all areas are stable or increasing. Catch rates for side trawlers which expends the most consistent amount of effort in this fishery, have increased for the past four to five years. While stern trawler catch rates have declined, with a concomittant decline in directed effort, since 1982.

Analysis of redfish length-frequency distributions indicate the presence of two strong year-classes at a modal length of 15 cm in 1984. These are in evidence in all areas of the management unit except 4Vn and may contribute signficantly to the fishery in the early 1990s.

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Table 1. Total redfish landings from 4VWX.

Year	4Vn	4Vs	4W	4X	Total
1968	7730	2222	1169	1982	13103
1969	6259	9347	3684	2763	22053
1970	4246	6694	16215	4424	31579
1971	6954	23698	19953	11776	62381
1972	4525	14580	22223	8972	50300
1973	7125	11213	14709	7126	40173
1974	6985	8112	11587	6153	32837
1975	7821	6772	9487	3903	27983
1976	5704	4718	3225	4812	18459
1977	5223	7123	2274	3225	17845
1978	3937	7856	1621	2680	16094
1979	4706	4979	1948	1521	13154
1980	3893	5431	2441	2351	14116
1981	6657	6789	3045	2453	18944
1982	6561	4585	598	4347	16091
1983	3707	3758	1491	3921	12877*
1984	1362	1888	1599	3134	10295**

* Provisional data.

** Provisional data (catches by division for Canada, Scotia-Fundy and Newfoundland only -- total includes all countries).

Table 2. TAC's, quotas, allowances, and catches since 1974.

	1974	1975	1976	1977	1978	1979		1980		1981		1982	1983	1984
TAC	40000	30000	20000	20000	20000	20000	20000	30000	30000	30000	30000	30000	30000	30000
Landings	32837	27983	18459	17845	16094		13154		14116		18944	16092	12877*	10295*
Canada:														
Quota	20000	14860	12000	13000	17500	13000	18000	18500	29000	18500	29000	25000	27000	28000**
Landings	15739	17025	12625	14712	13576		12240		13108		17753	14366	11988*	7976*
France:														
Quota	1000	740	250	250	250	500[a]	500[a]	500[a]	500[a]	500[a]	500[a]	500[a]	500[a,b]	500
Landings	420	186	279	63	121		20		21		3	2	5*	85*
Japan														1500
														1329*
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	0	0	0	0	0
Landings	8891	5465	4446	2876	2147				885		762	1611	810*	872*
Others:														
Quota	1100	1100	750	250[b]	750[b]	6500	1500	500	500	11000	500	0	0	0
Landings	288	228	88	19	250		894		102		426	113	74*	33*
Reserve												4500	2500	1000**

[a] St. Pierre vessels only
[b] By-catch only
* Provisional Statistics
** Resource Short Plant Program

Landings to 1982 are from ICNAF and NAFO Statistical Bulletins.
In 1979, 1980 and 1981 quotas were amended during the year; initial and final ones are given.

Table 3. Total redfish landings by Scotia-Fundy OTB1-TC4 and OTB2-TC5 from 4VWX.

	4Vn		4Vs		4W		4X	
Year	OTB1	OTB2	OTB1	OTB2	OTB1	OTB2	OTB1	OTB2
1968	1892	70	985	217	198	103	1007	227
1969	2195	246	801	154	1537	177	1523	447
1970	1176	665	787	374	4087	1410	2222	752
1971	3189	511	4942	1441	4419	942	4515	1696
1972	1472	595	3077	968	5030	1482	1555	617
1973	1848	503	2246	298	3210	405	802	112
1974	2795	691	2924	423	1480	287	812	435
1975	1428	1492	1946	488	2174	487	475	378
1976	807	330	1717	171	1470	280	602	263
1977	1112	1115	2655	1099	635	654	479	307
1978	758	516	1795	2234	474	823	333	264
1979	1405	457	972	2185	546	1150	478	187
1980	1044	196	1286	2927	408	1672	516	586
1981	1795	1048	1640	3703	383	2044	1059	405
1982	743	1277	1756	1784	149	280	1035	1111
1983	1216	1319	1334	1514	308	723	1331	786
1984	319	582	562	1075	989	255	1328	171

Table 4. Redfish landings by Scotia-Fundy OTB1-TC4 for 4VWX by Quarter.

Year	4Vn 1st	4Vn 2nd	4Vn 3rd	4Vn 4th	4Vs 1st	4Vs 2nd	4Vs 3rd	4Vs 4th	4W 1st	4W 2nd	4W 3rd	4W 4th	4X 1st	4X 2nd	4X 3rd	4X 4th
1968	67	971	380	474	199	315	83	388	51	75	51	21	45	200	646	116
1969	191	788	681	535	263	303	108	127	19	267	1199	52	113	456	660	294
1970	345	139	268	424	250	60	59	418	45	839	2819	384	57	156	1465	544
1971	116	1477	1105	491	740	2204	1270	728	708	1085	2466	160	41	1270	2407	797
1972	507	583	278	104	575	1500	788	214	308	1726	2367	629	48	676	724	107
1973	263	443	545	597	354	683	538	671	611	920	1043	636	40	459	203	100
1974	339	185	1422	849	607	809	803	705	202	435	617	226	311	138	256	107
1975	130	255	676	367	174	780	577	415	382	618	503	671	19	232	197	27
1976	168	94	457	88	165	616	915	21	39	614	794	23	42	132	389	39
1977	12	116	712	272	70	880	1301	404	23	153	355	104	9	93	334	43
1978	8	143	540	67	60	840	641	254	4	56	386	28	11	20	185	117
1979	13	115	1061	216	2	263	650	57	17	308	183	38	96	120	106	156
1980	10	243	789	2	23	329	708	226	19	168	203	18	7	62	381	66
1981	7	211	1050	527	32	590	507	511	13	108	42	220	36	1	637	385
1982	1	162	523	57	29	291	762	674	0	53	75	21	0	77	422	536
1983	10	589	611	6	24	47	524	739	0	5	23	280	2	124	735	470
1984	4	35	241	39	3	88	467	4	13	0	447	529	112	334	537	345

Table 5. Redfish landings by Scotia-Fundy OTB2-TC5 for 4VWX by Quarter.

Year	4Vn 1st	4Vn 2nd	4Vn 3rd	4Vn 4th	4Vs 1st	4Vs 2nd	4Vs 3rd	4Vs 4th	4W 1st	4W 2nd	4W 3rd	4W 4th	4X 1st	4X 2nd	4X 3rd	4X 4th
1968	0	70	0	0	60	52	0	105	19	18	0	66	51	6	53	117
1969	0	28	6	212	90	7	10	47	45	1	119	12	100	49	185	113
1970	176	11	327	151	217	14	5	138	56	13	332	1009	20	167	225	340
1971	117	42	309	43	633	528	79	201	108	347	241	246	40	523	801	332
1972	92	289	185	29	466	191	194	117	165	341	744	232	19	266	257	75
1973	420	31	23	29	89	152	34	23	249	97	27	32	50	2	13	47
1974	231	146	58	256	208	116	61	38	7	102	143	35	0	38	322	75
1975	356	85	780	271	110	94	230	54	29	193	12	253	7	94	157	120
1976	194	130	0	6	90	51	23	7	26	218	5	31	24	99	58	82
1977	108	261	718	28	55	111	497	436	37	59	493	65	33	125	52	97
1978	55	39	345	77	197	1089	610	338	32	343	345	103	21	168	64	11
1979	72	132	211	42	155	518	308	1204	2	684	402	62	19	4	1	163
1980	48	6	124	18	149	609	1630	539	32	785	648	207	36	222	80	248
1981	4	363	622	59	95	1809	1685	114	37	1282	594	131	12	252	46	95
1982	0	191	919	167	39	154	1355	236	10	96	97	77	67	106	495	443
1983	8	73	1092	146	146	389	869	110	36	279	210	198	172	158	284	172
1984	6	191	248	137	654	159	183	79	83	64	85	23	14	106	43	8

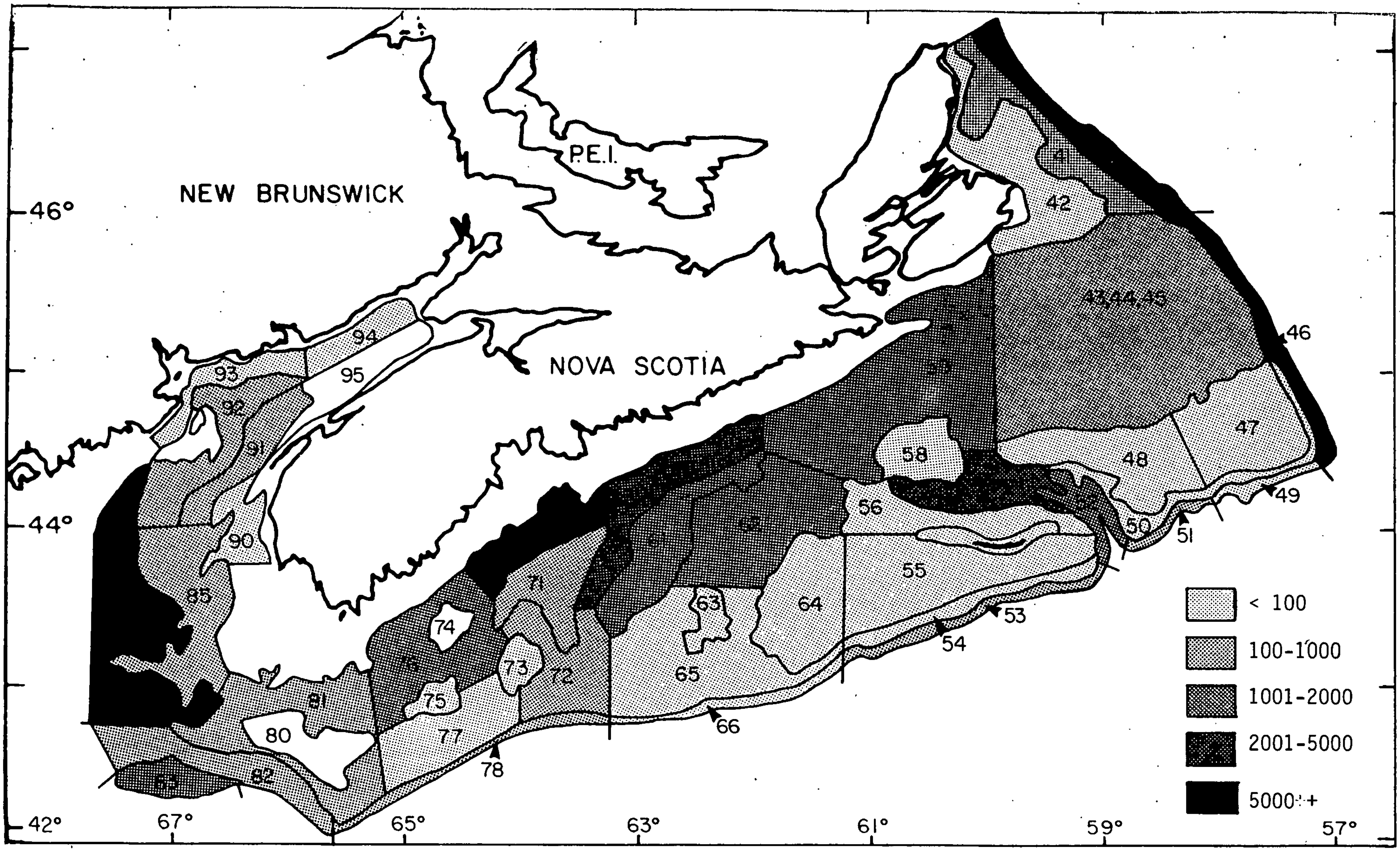


Figure 1. Redfish biomass estimates

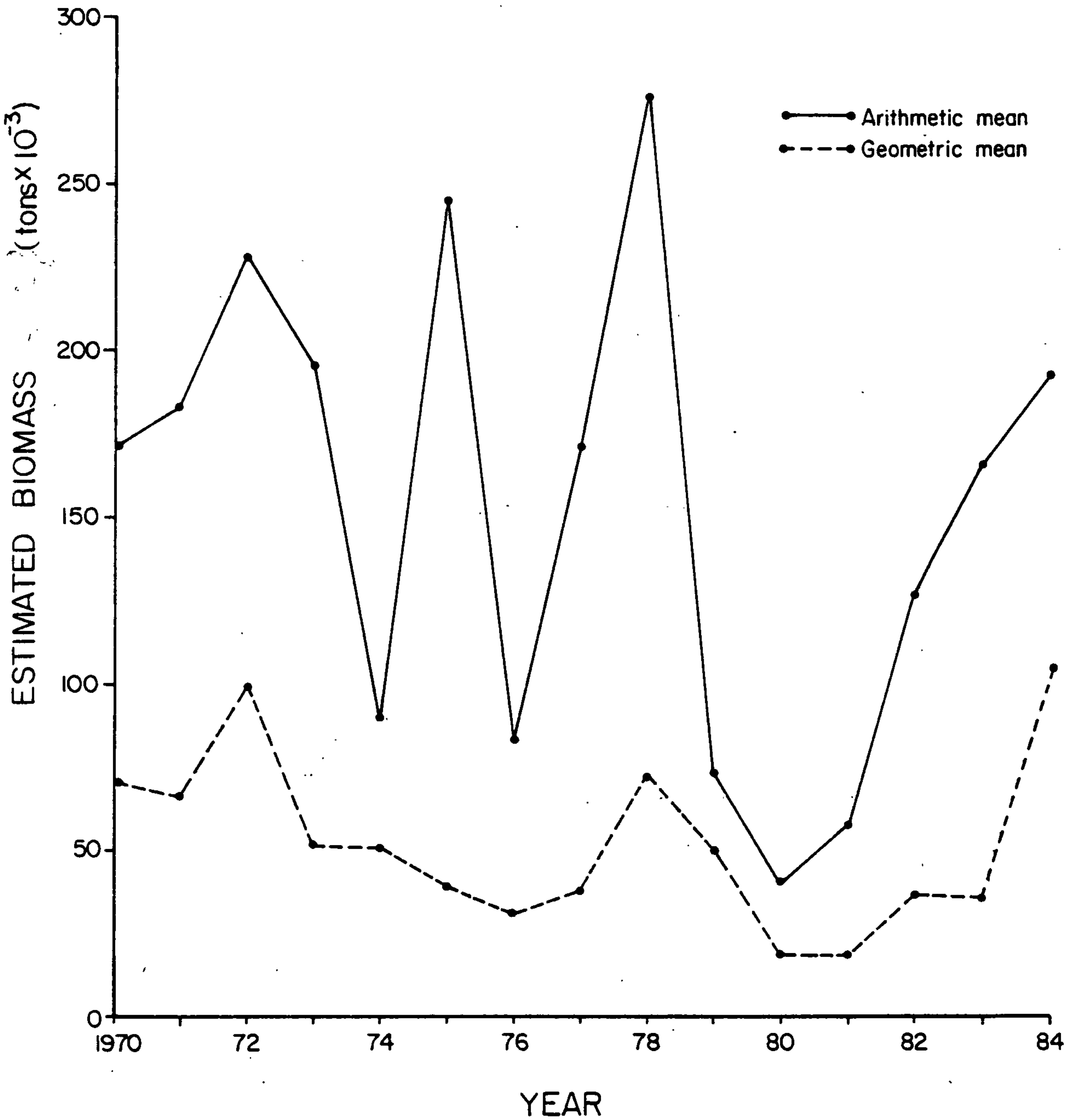


Figure 2. Yearly estimates of total redfish biomass in Division 4VWX. These estimates were calculated from data gathered during July research surveys.

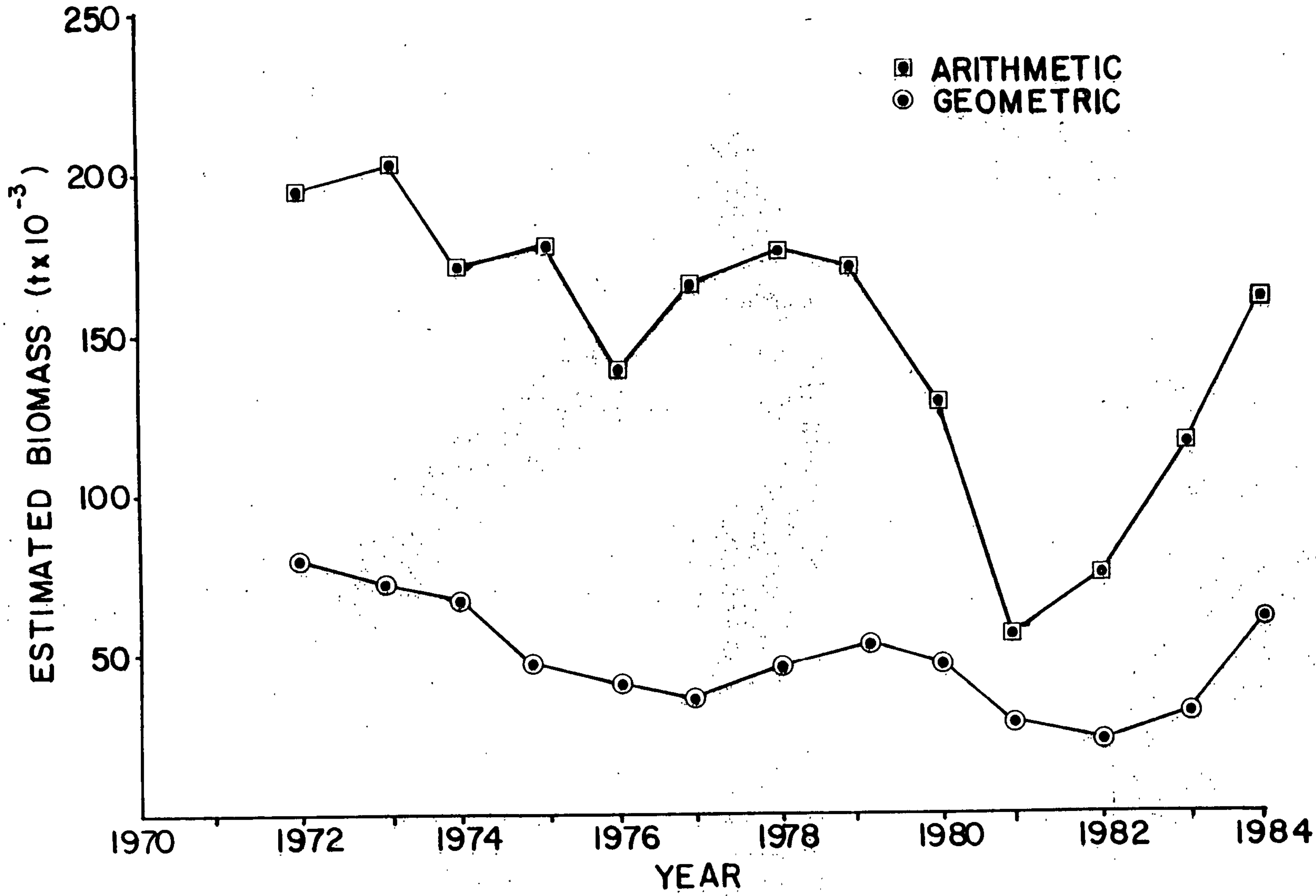


Figure 3. Estimates of total redfish biomass in Division 4VWX. Values shown are three-year running means (ie. 1972 value if the mean of '70 - '72, etc.). These values are estimated from July survey data.

Figure 4. Geometric mean biomass estimates for 4Vn and 4Vs.

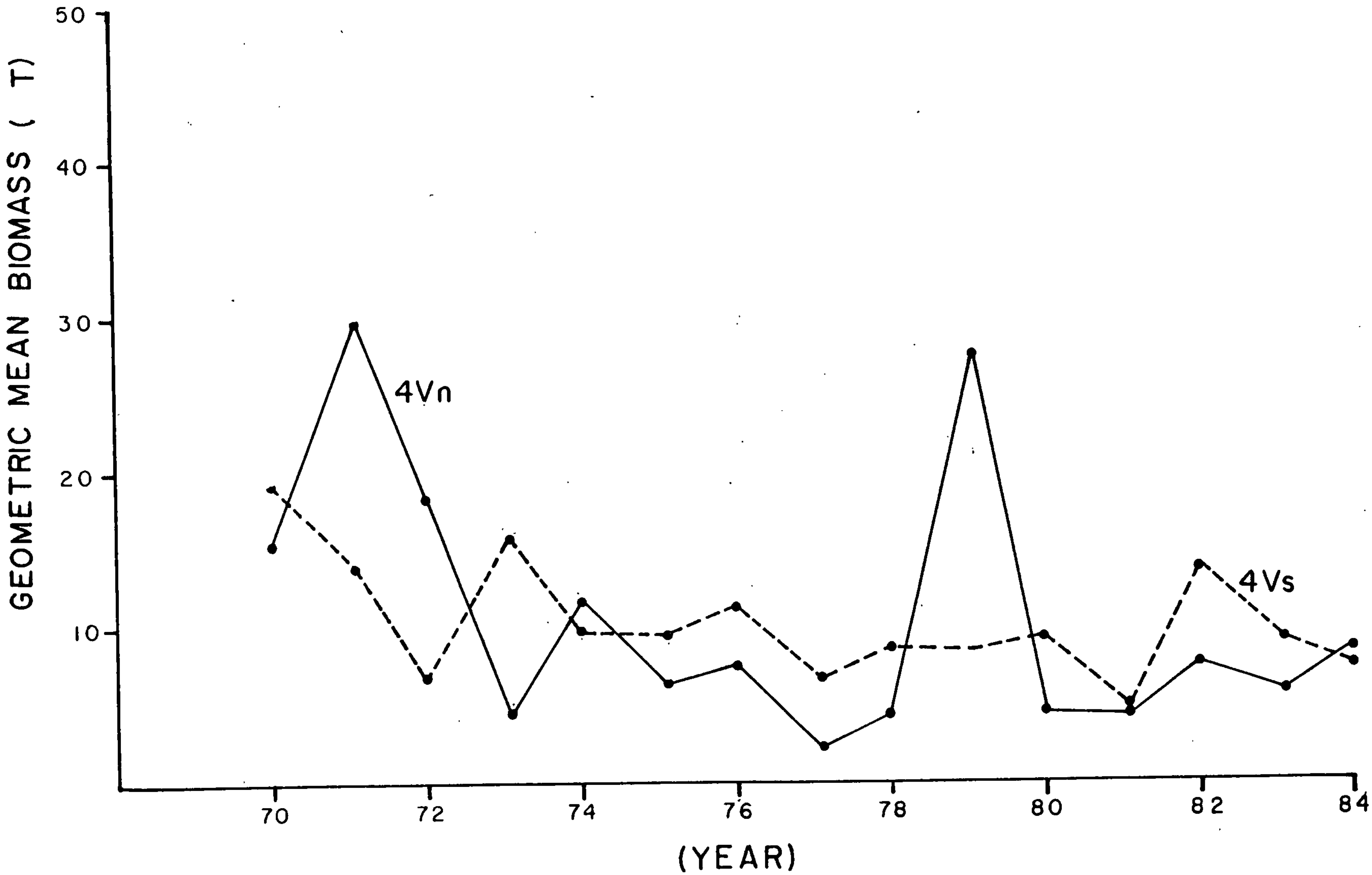
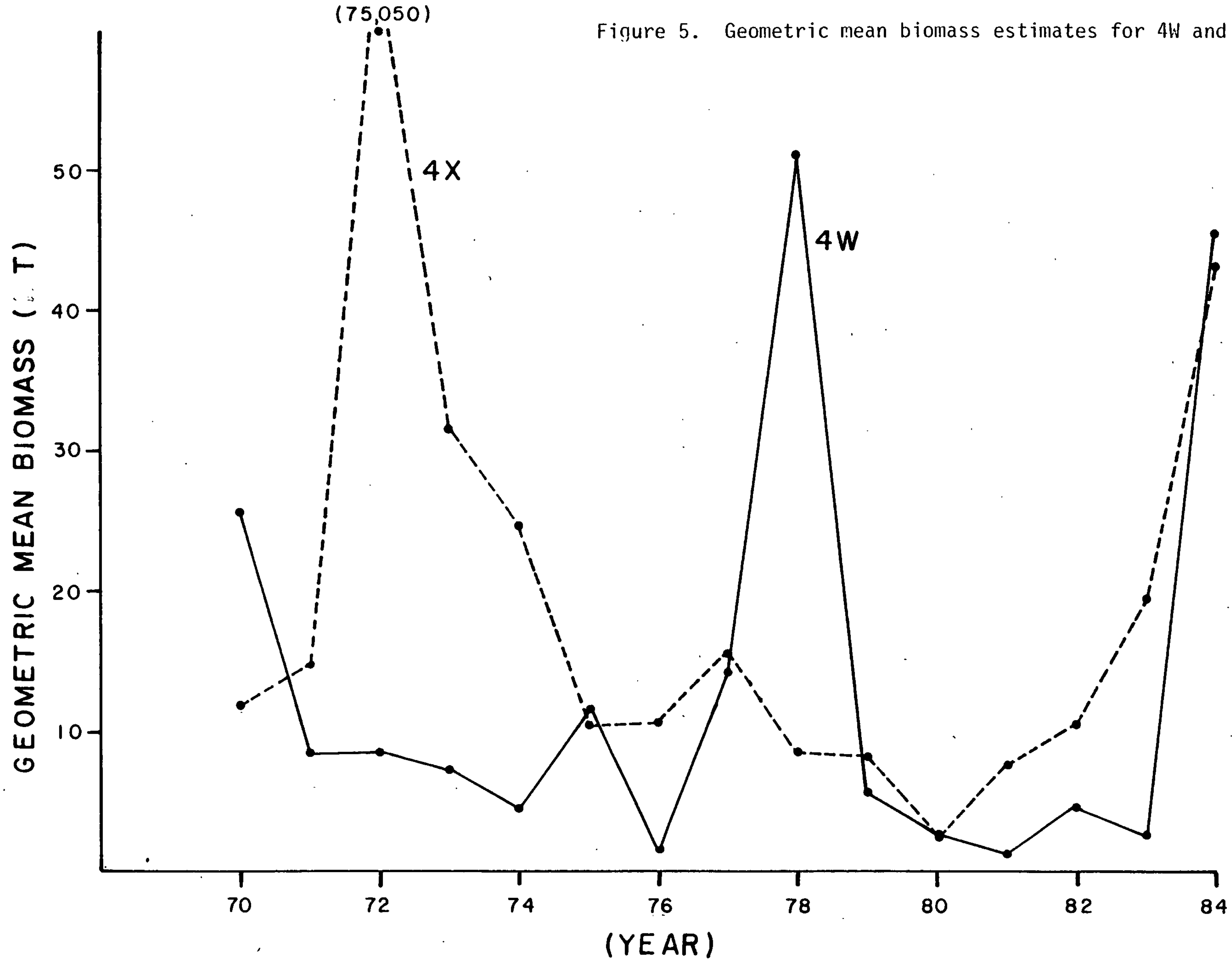


Figure 5. Geometric mean biomass estimates for 4W and 4X.



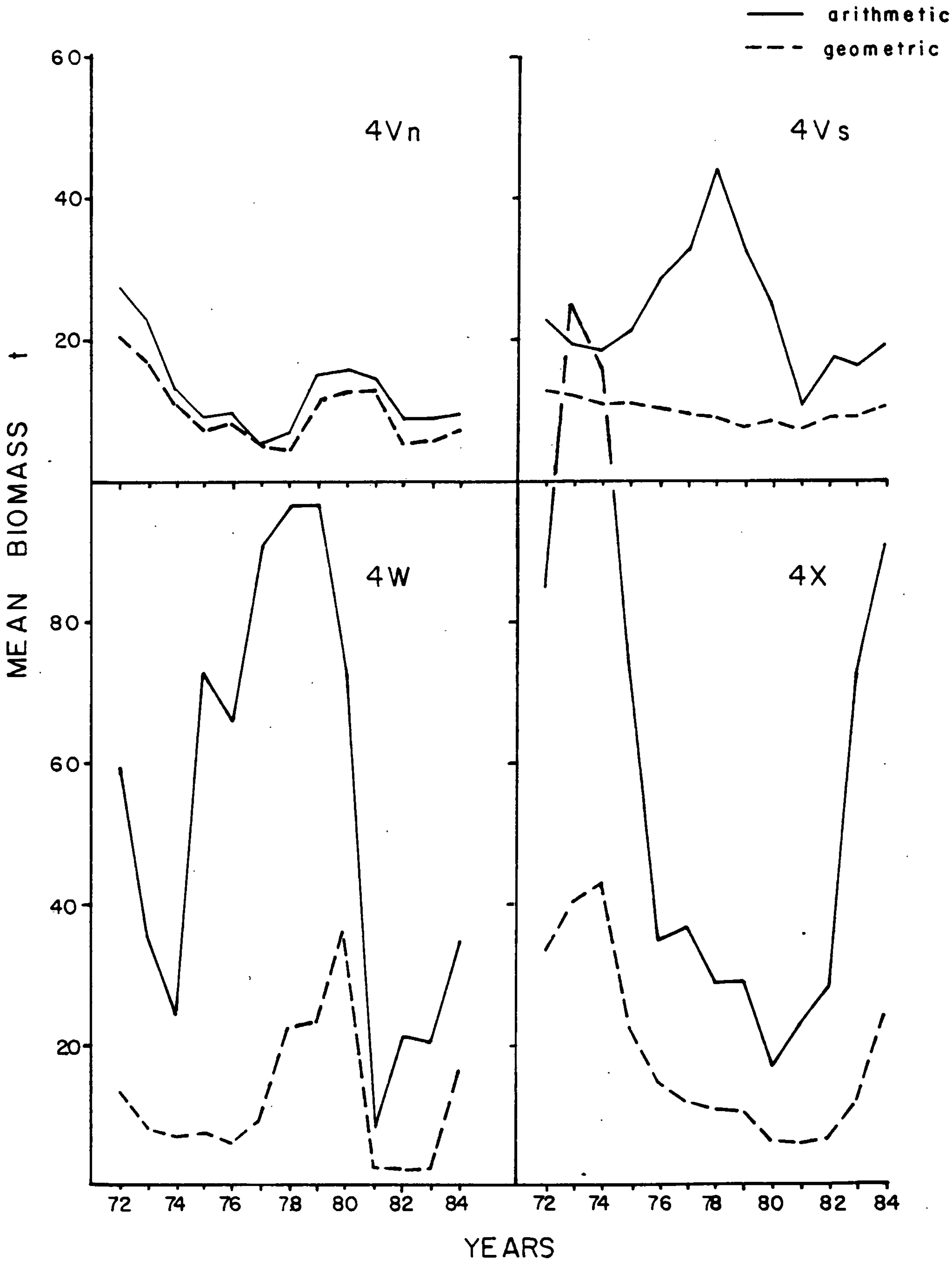
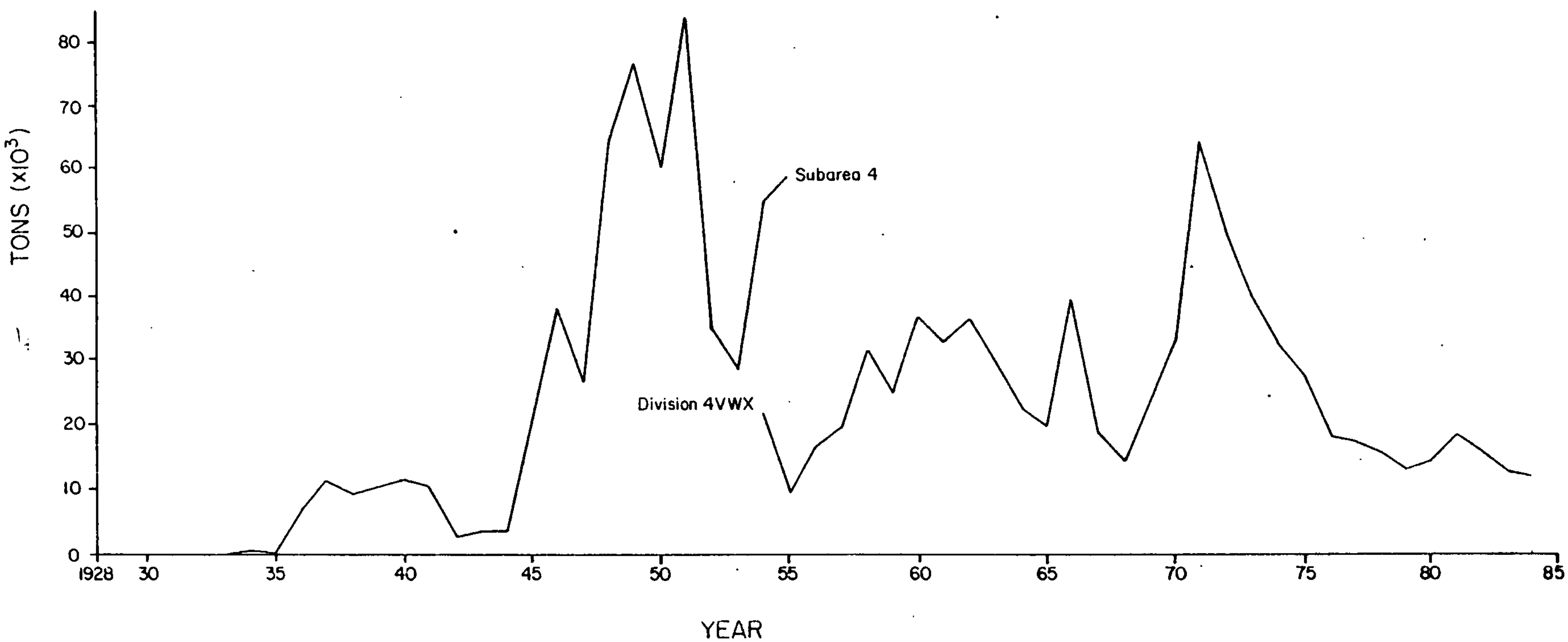


Figure 6. Three-year running mean estimates of redfish biomass in 4Vn, 4Vs, 4W, and 4X.

Figure 7.

Commercial Redfish Landings from Subarea 4 (to 1955) and Division 4VWX (since 1954).



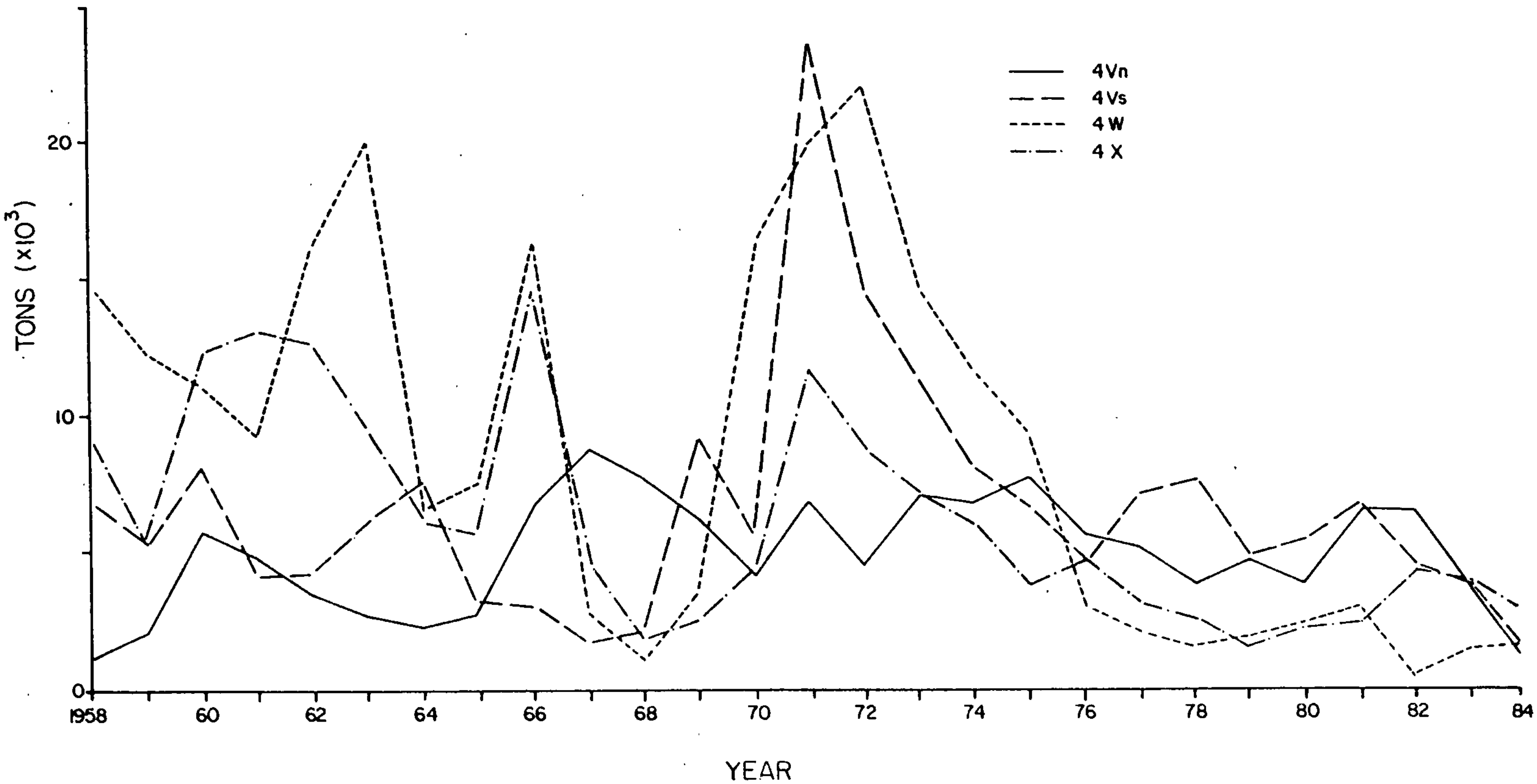


Figure 8. Redfish landings from Divisions 4VWX (1958-1984).

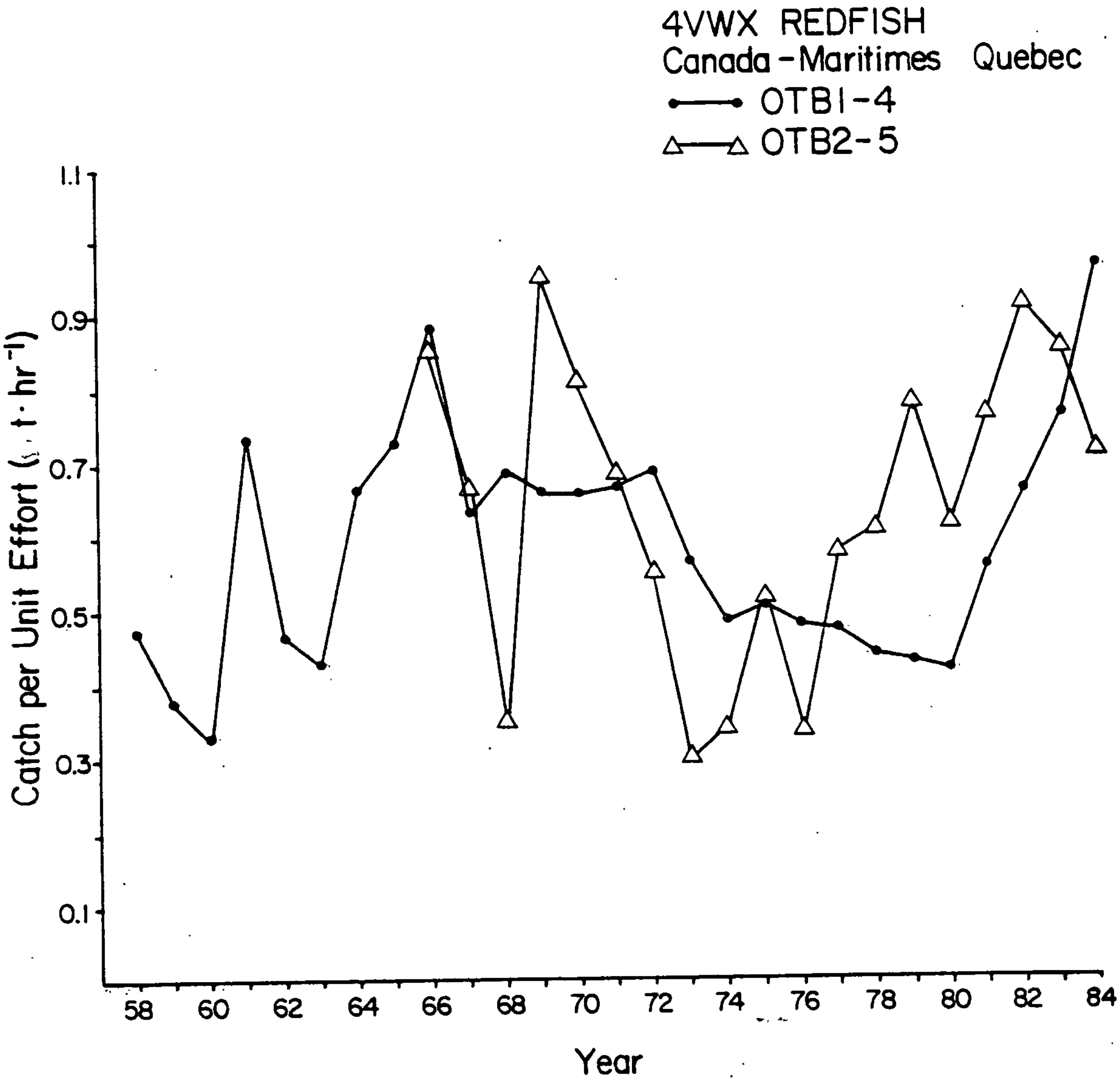


Figure 9. Catch rate series for Maritimes and Quebec based side (tonnage class 4) and stern (tonnage class 5) trawlers. Catch rates were calculated from total yearly values of catch and effort for each category.

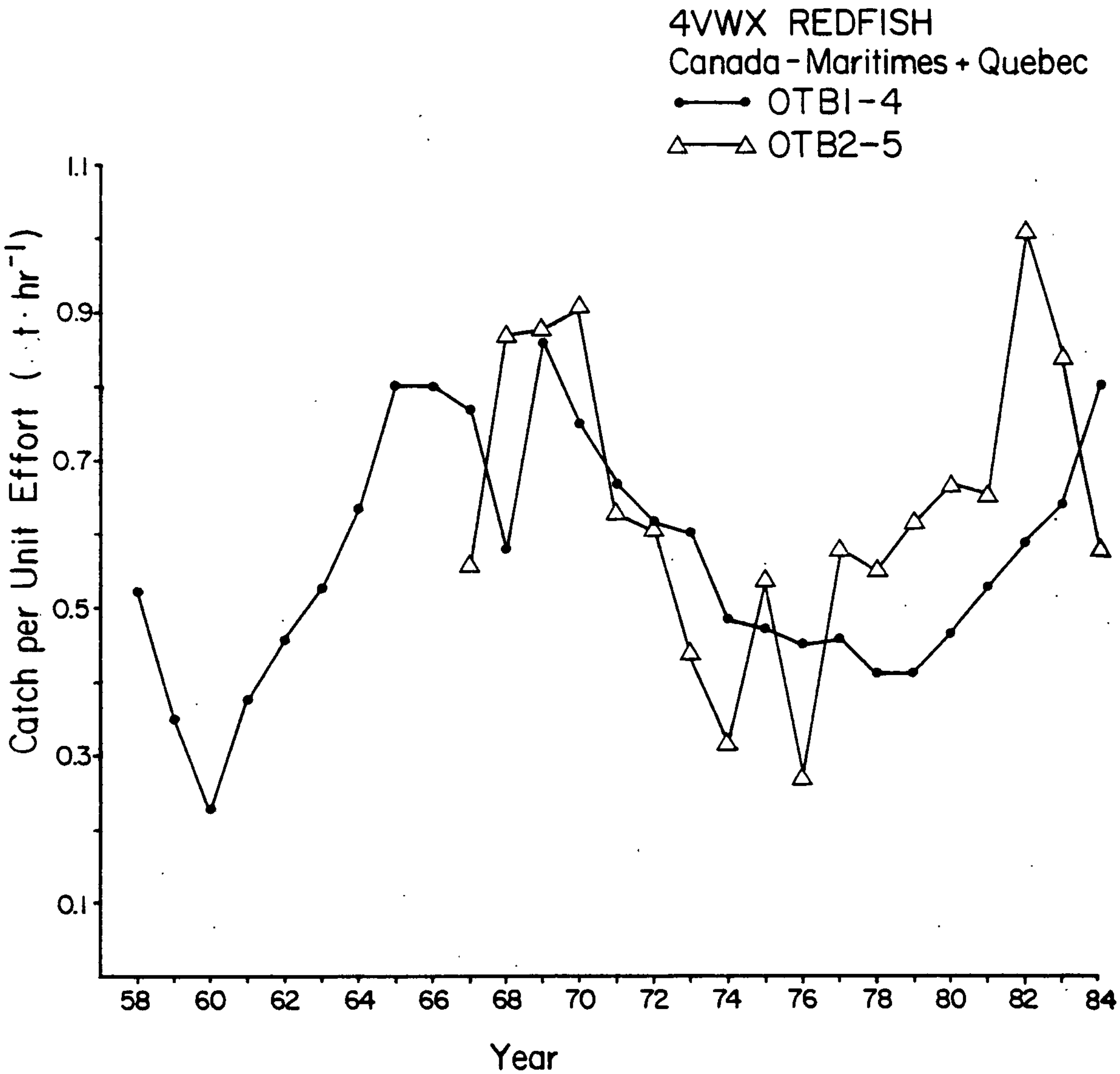


Figure 10. Catch rate series for Maritimes and Quebec based side (tonnage class 4) and stern (tonnage class 5) trawlers. Catch rates were calculated from third quarter values of catch and effort for each category.

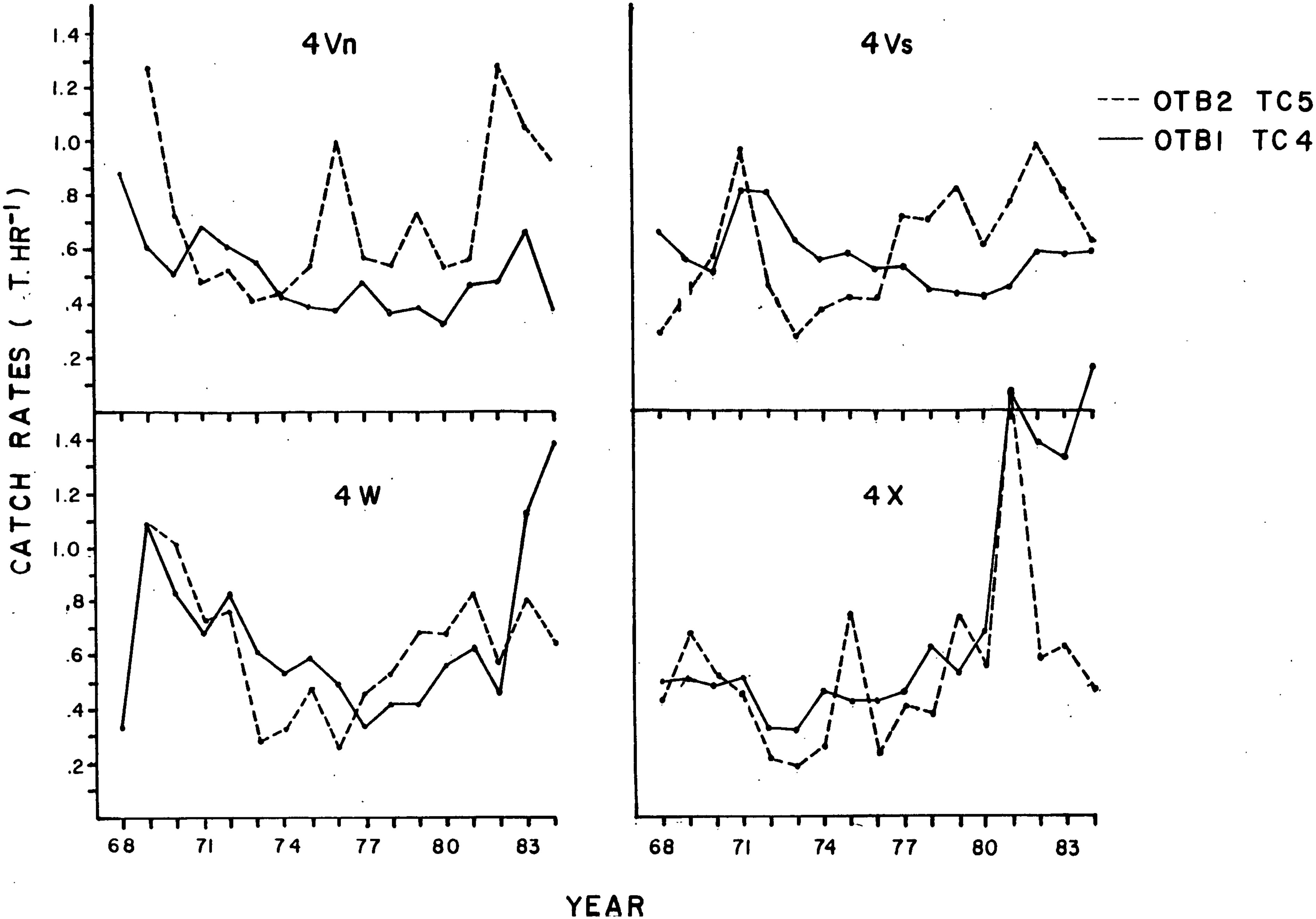
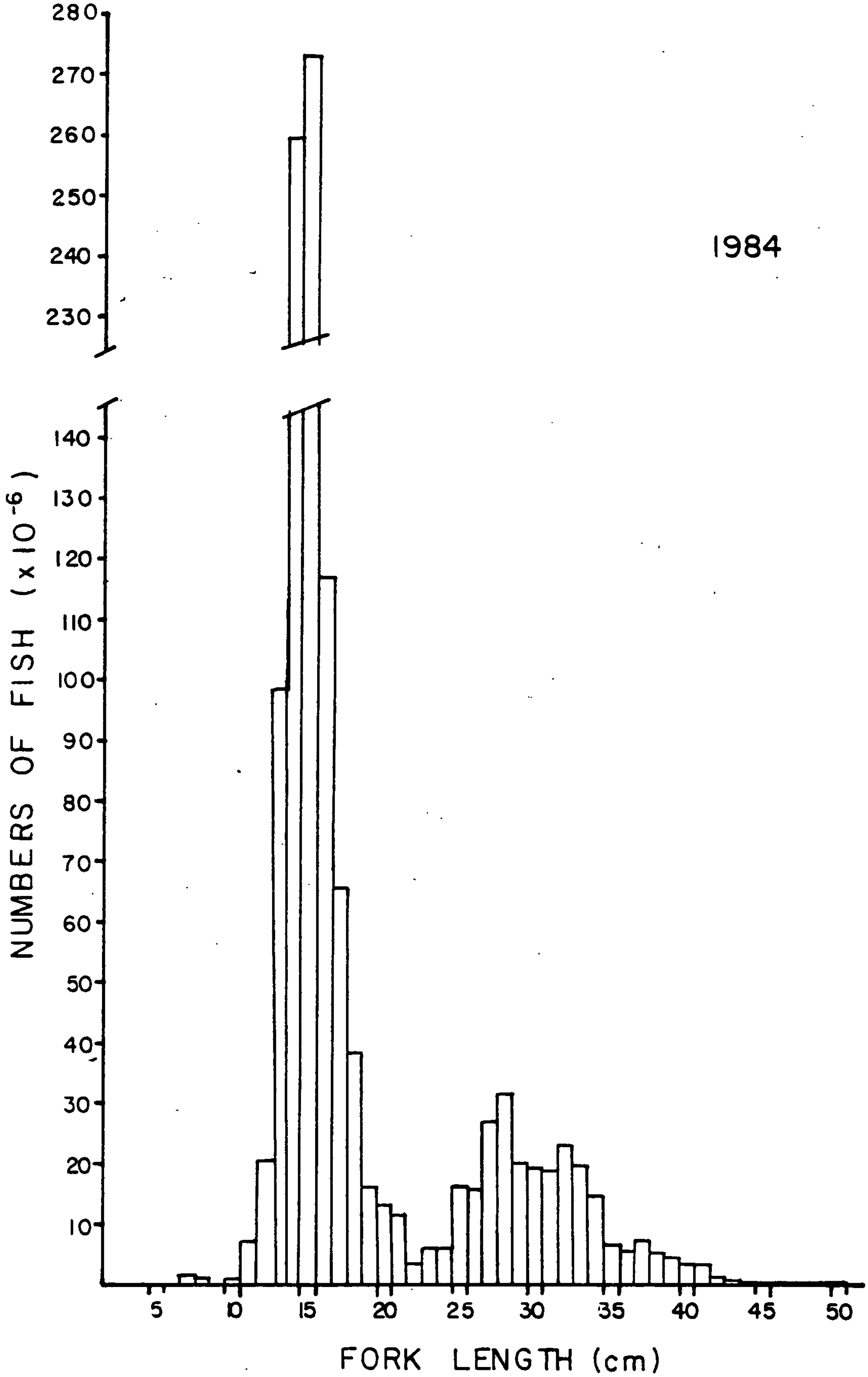
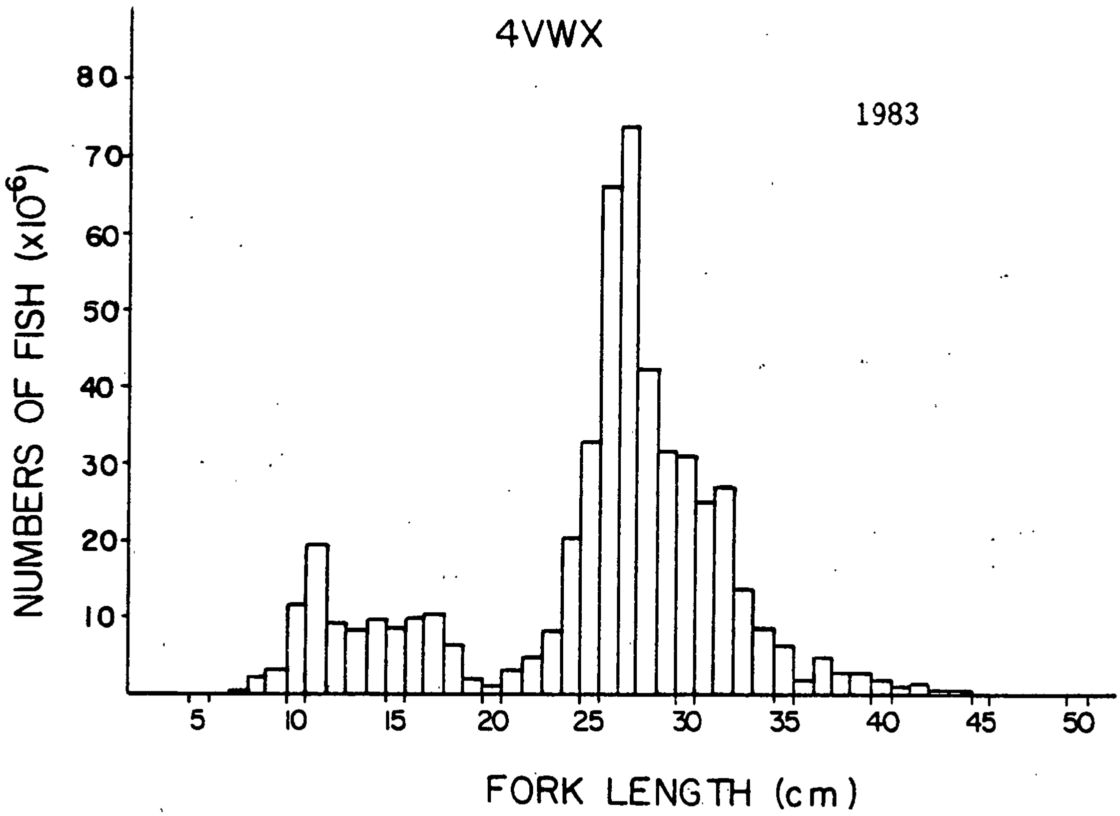
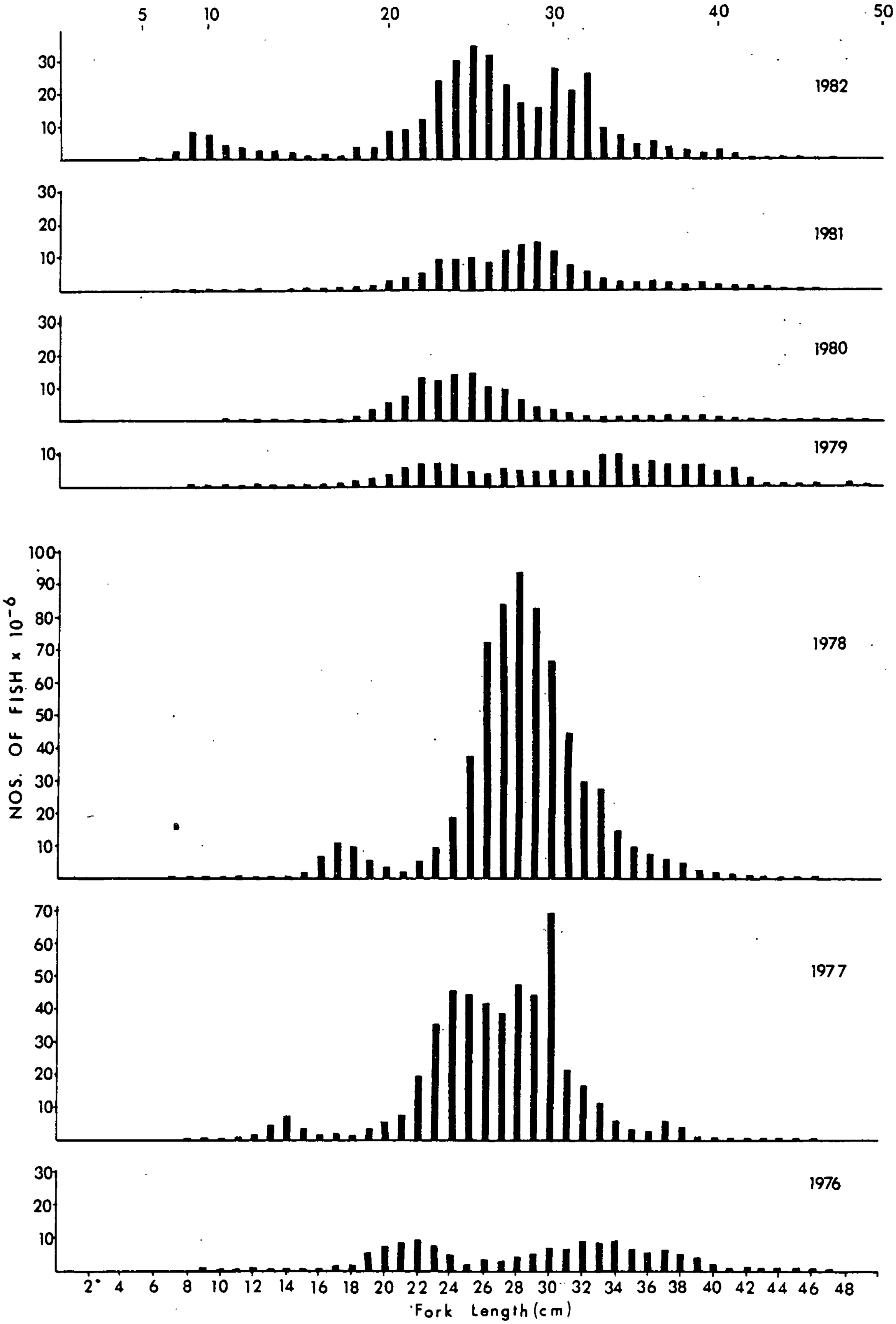


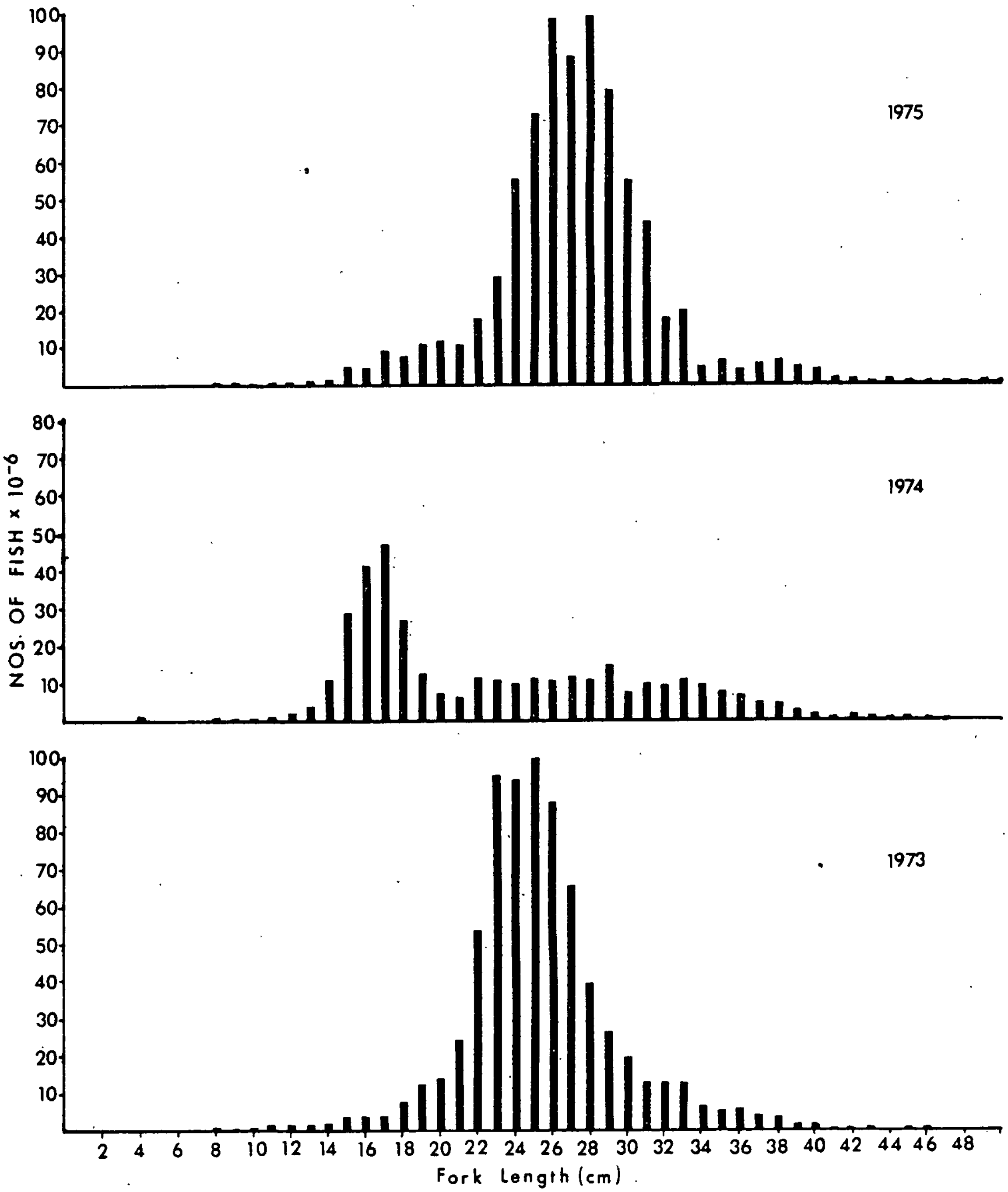
Figure 11. Catch rate series for side and stern trawlers calculated from total annual catch and effort.

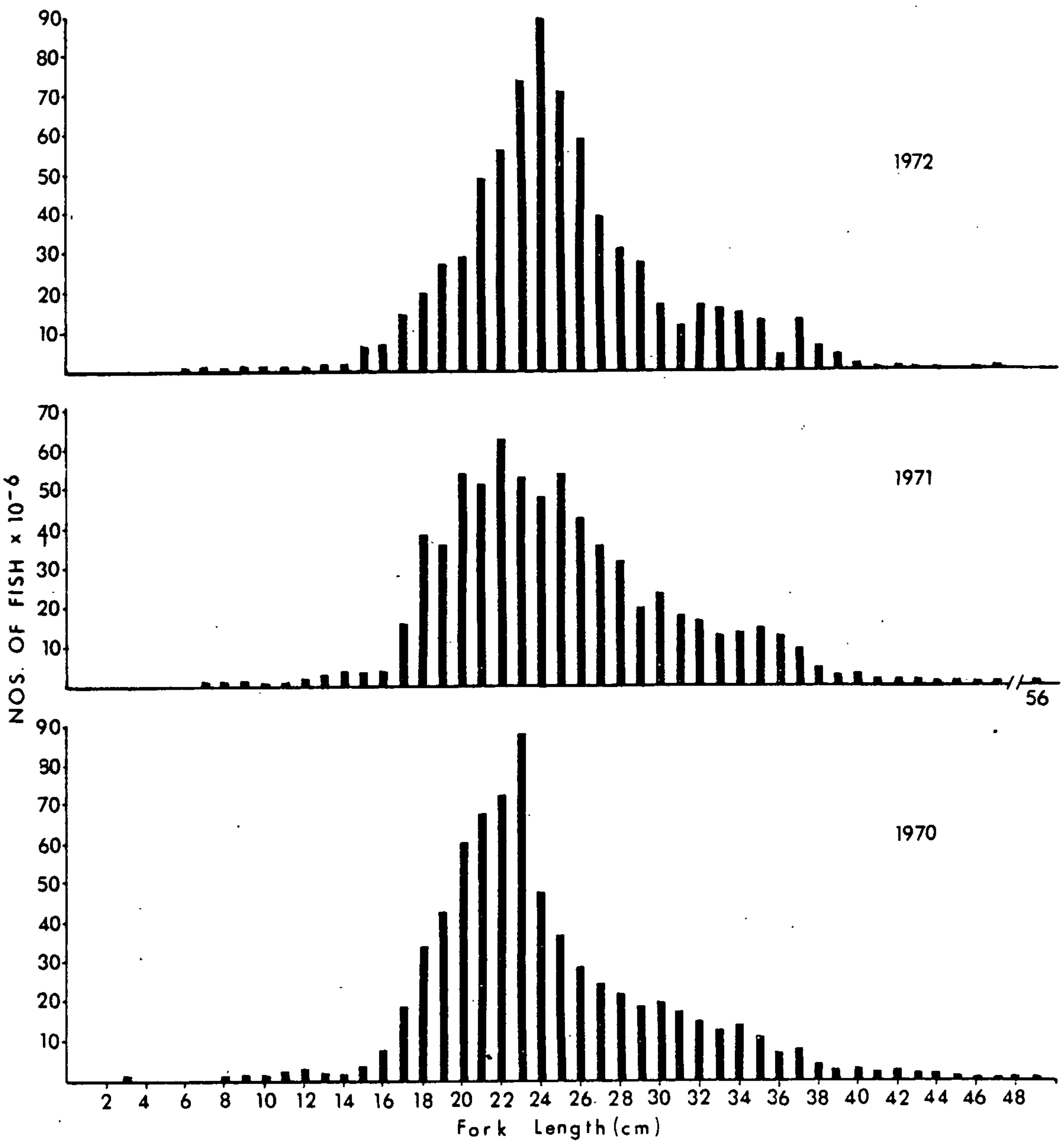
Figure 12. Redfish length-frequencies from summer surveys for 4VWX combined.


1984
NUMBERS OF FISH (x 10^{-6})
280
270
260
250
240
230
140
130
120
110
100
90
80
70
60
50
40
30
20
10
5
10
15
20
25
30
35
40
45
50
FORK LENGTH (cm)


4VWX
1983
NUMBERS OF FISH (x10⁻⁶)
80
70
60
50
40
30
20
10
5
10
15
20
25
30
35
40
45
50
FORK LENGTH (cm)


5
10
20
30
40
50
1982
1981
1980
1979
1978
1977
1976
NOS. OF FISH x 10^-6
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
Fork Length (cm)


1975
1974
1973
NOS. OF FISH x 10⁻⁶
100
90
80
70
60
50
40
30
20
10
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
Fork Length (cm)



NOS. OF FISH x 10⁻⁶
1972
1971
1970
56
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
Fork Length (cm)

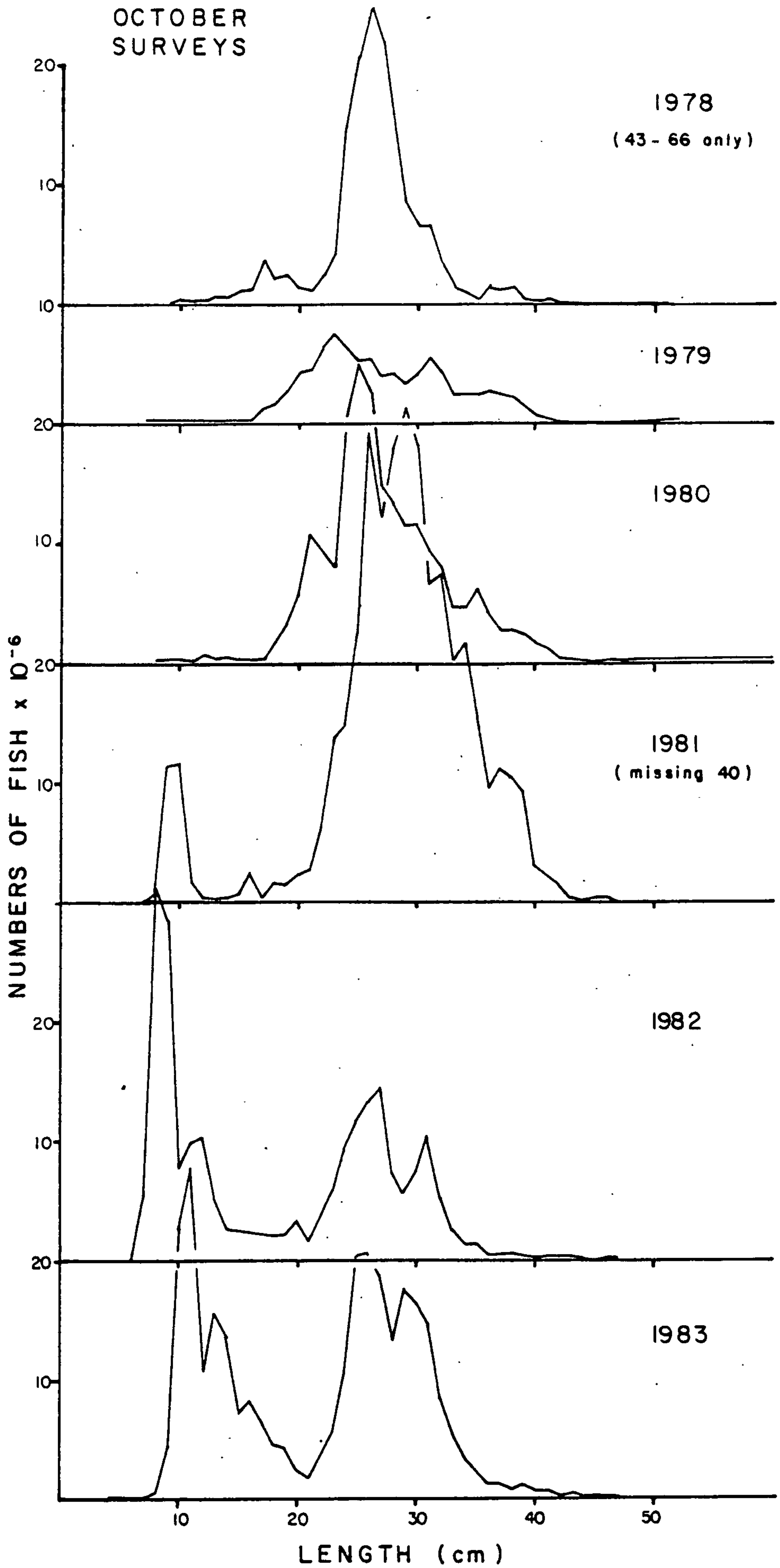
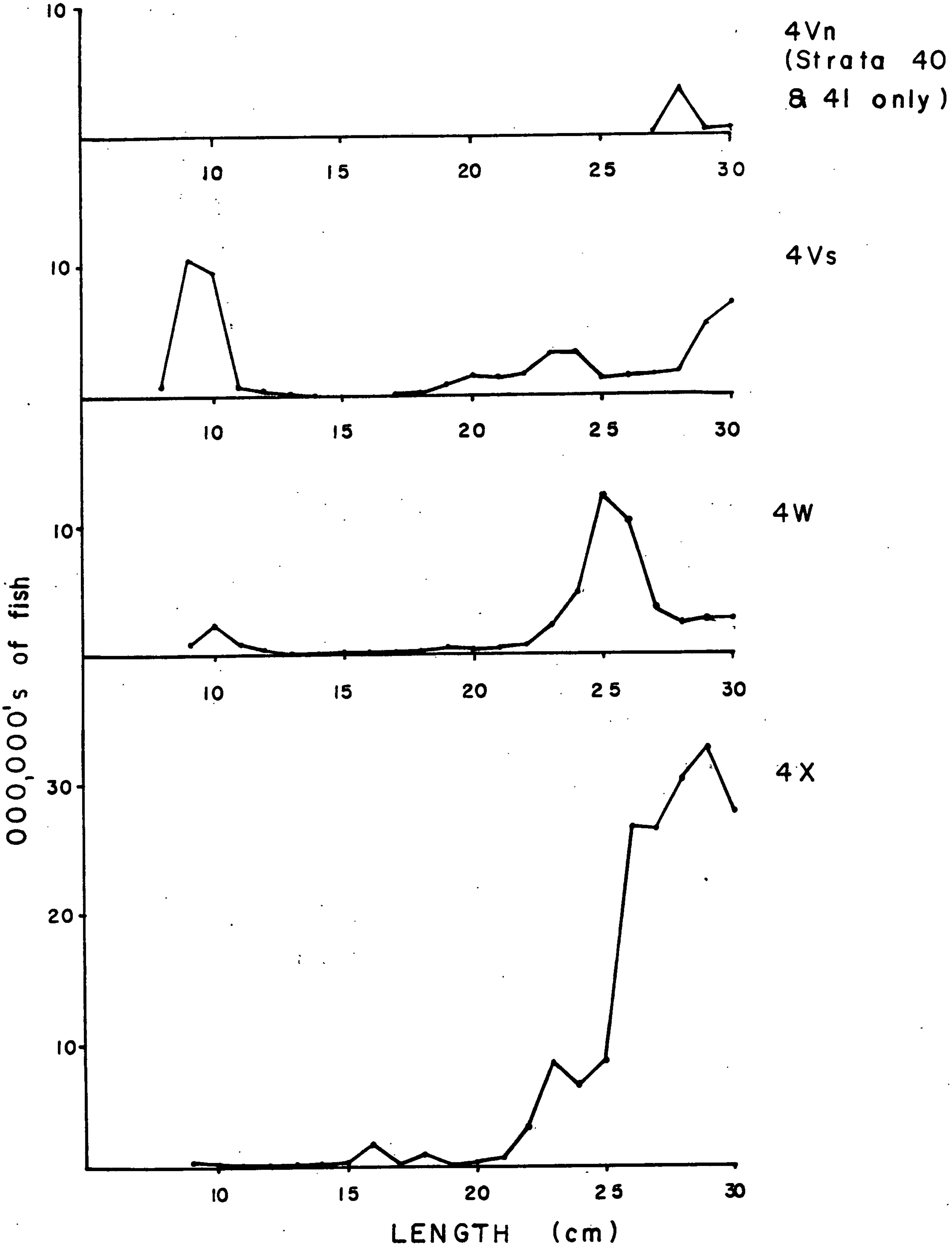
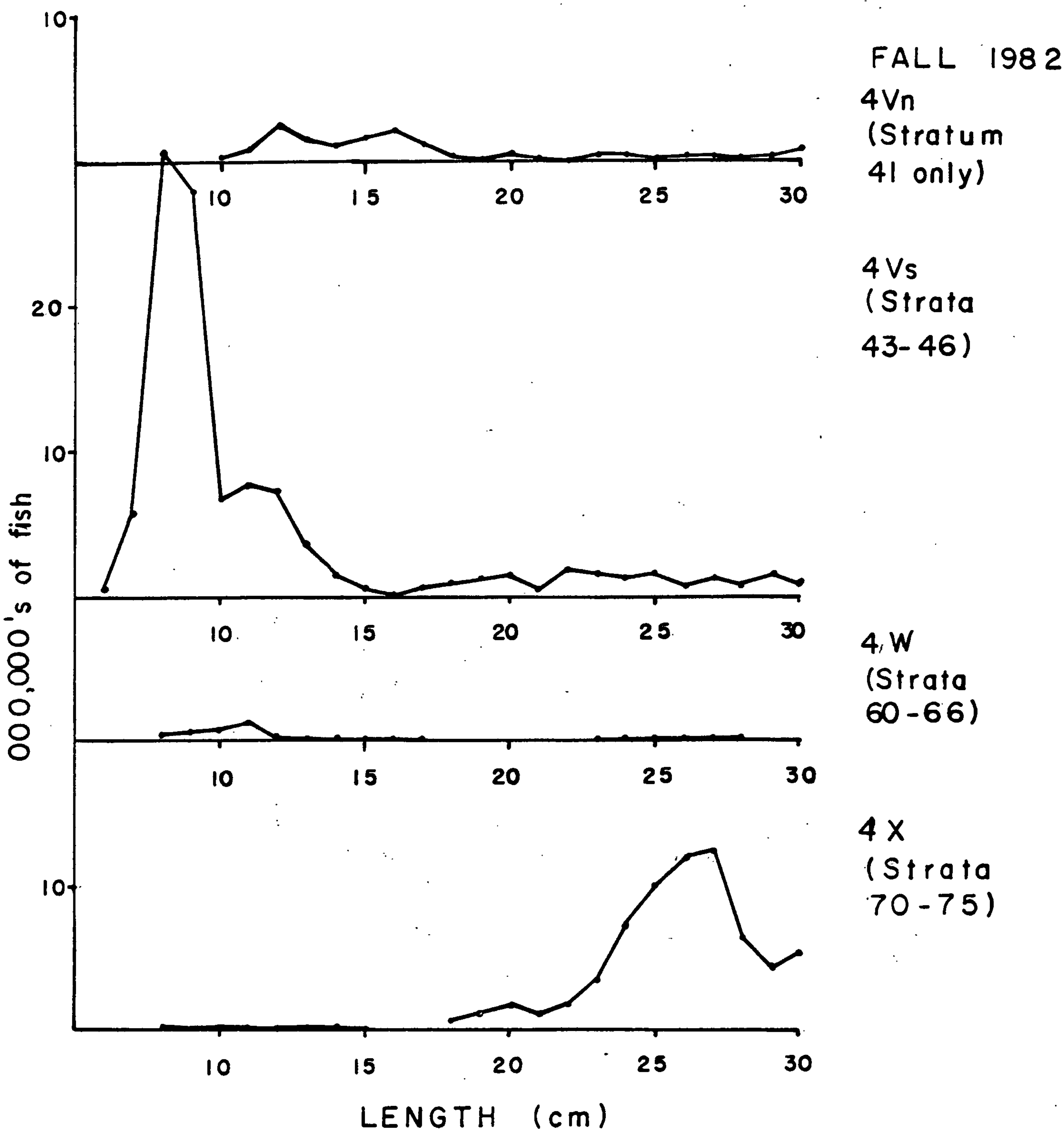


Figure 13. Redfish length-frequency distributions from all surveys for 4VWX combined.

Figure 14. Redfish length-frequency distributions from fall surveys for 4Vn, 4Vs, 4W, and 4X.

FALL 1981


10
4Vn
(Strata 40
& 41 only)
10
15
20
25
30
4Vs
10
10
15
20
25
30
4W
10
10
15
20
25
30
000,000's of fish
4X
30
20
10
10
15
20
25
30
LENGTH (cm)


FALL 1982
4Vn
(Stratum
41 only)
4Vs
(Strata
43-46)
4W
(Strata
60-66)
4X
(Strata
70-75)
000,000's of fish
LENGTH (cm)
10
20
10
10
10
15
20
25
30

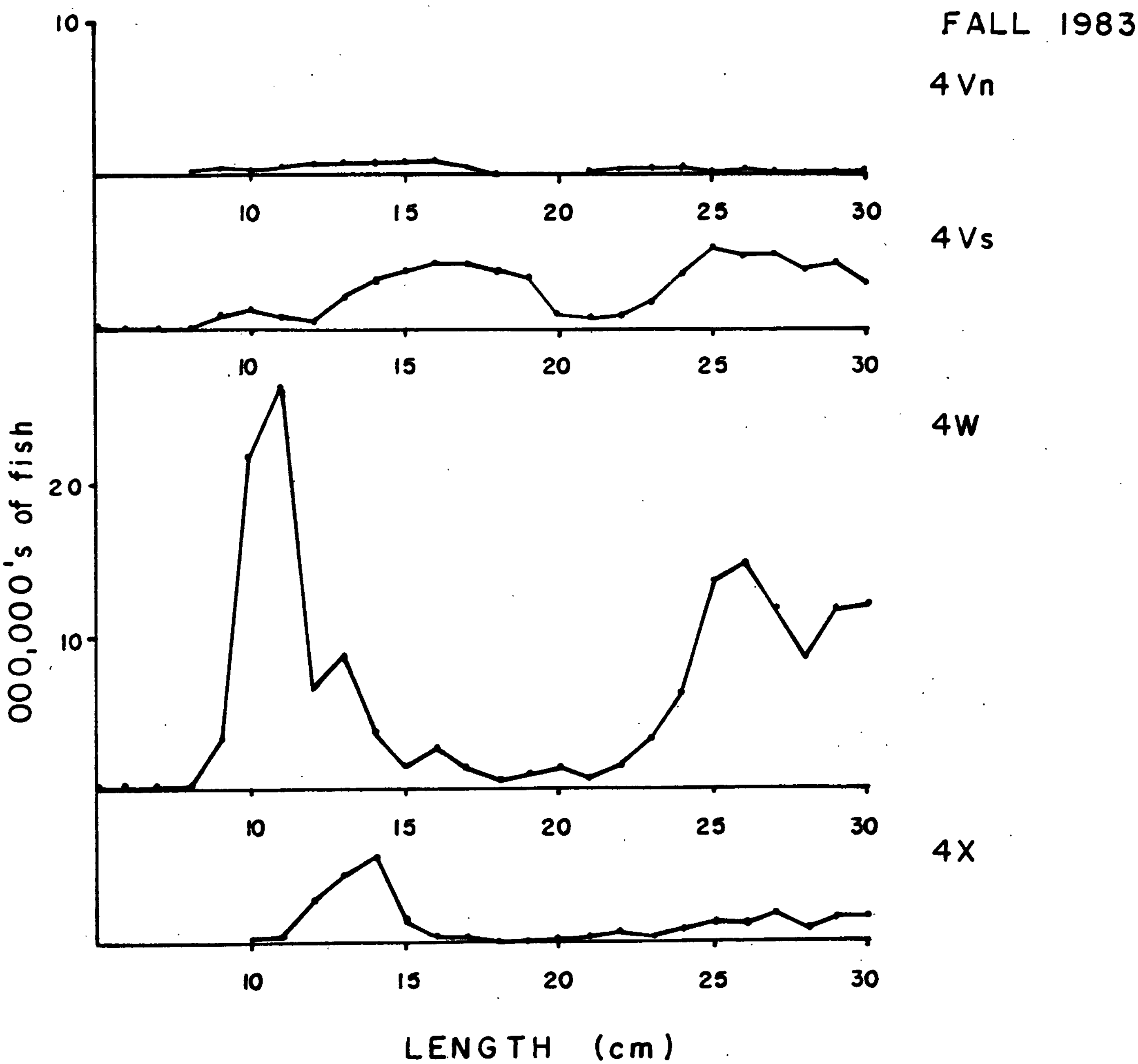
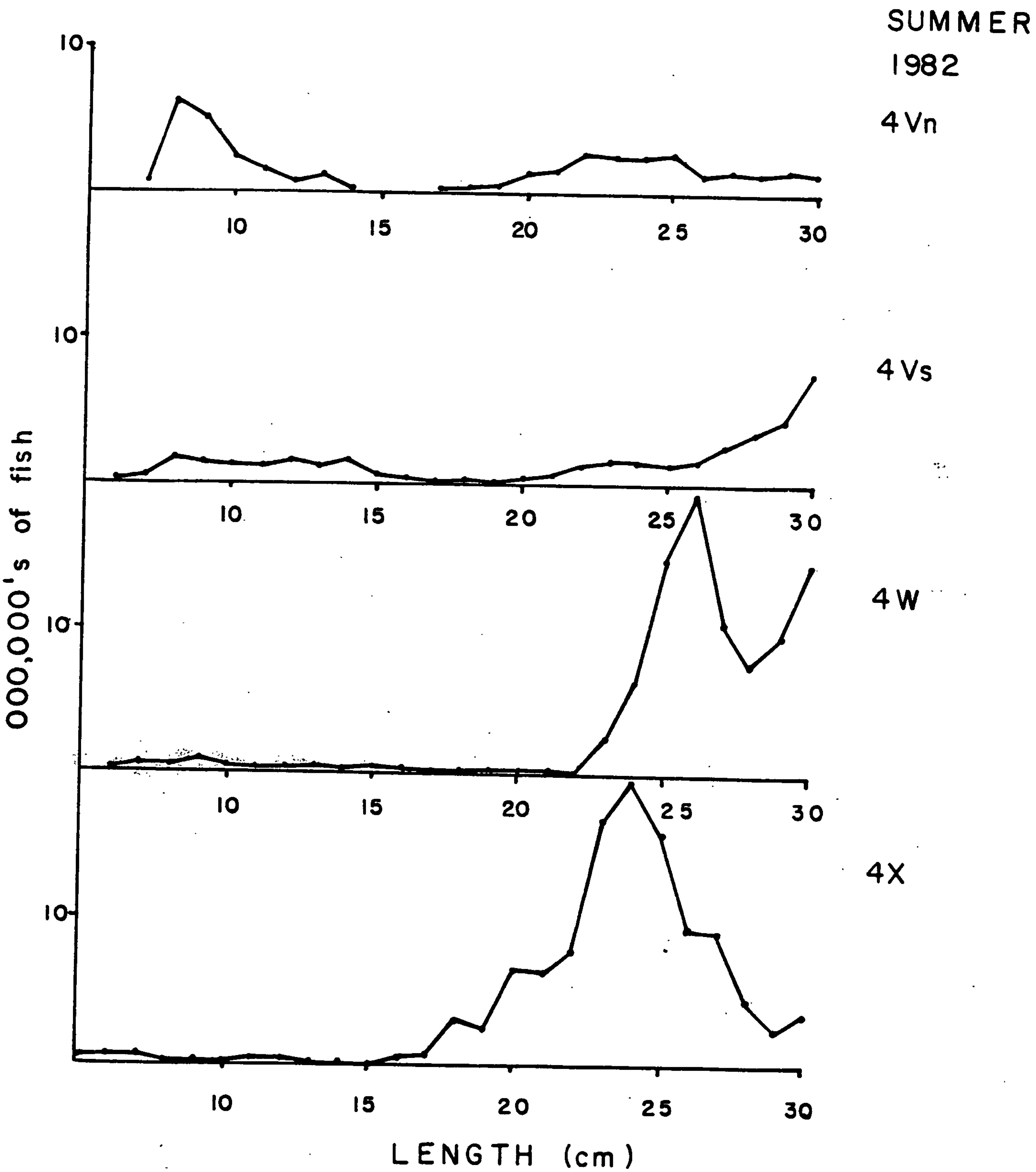
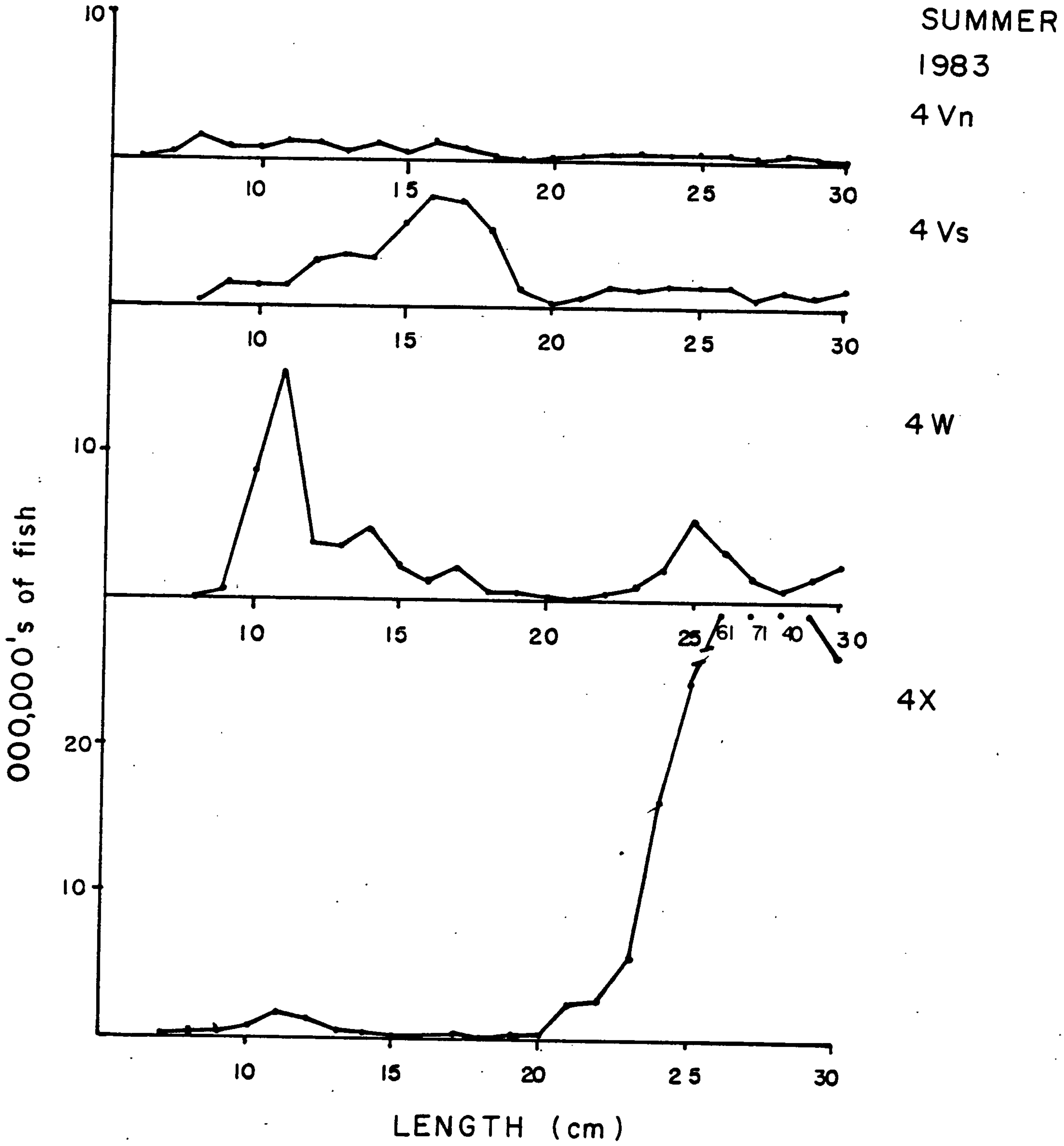
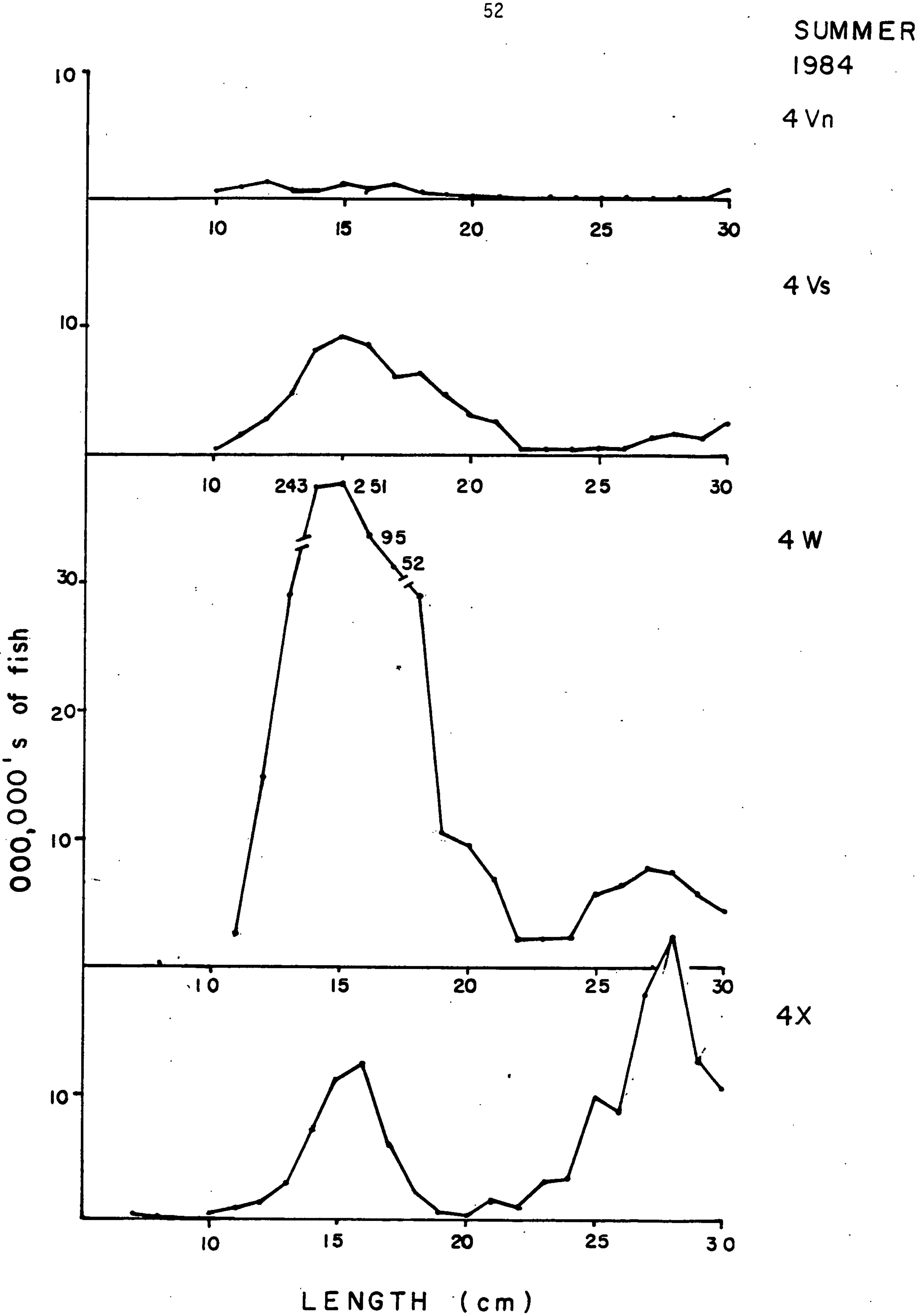

FALL 1983
4Vn
4Vs
4W
4X
10
20
10
10
15
20
25
30
000,000's of fish
LENGTH (cm)

Figure 15. Redfish length-frequency distributions from summer surveys for 4Vn, 4Vs, 4W, and 4X.


SUMMER
1982
4Vn
4Vs
4W
4X
10
10
15
20
25
30
000,000's of fish
LENGTH (cm)


SUMMER
1983
4 Vn
4 Vs
4 W
4X
000,000's of fish
LENGTH (cm)
10
20
10
15
25
30
61
71
40


SUMMER
1984
4 Vn
4 Vs
4 W
4X
243
251
95
52
10
30
20
10
15
20
25
30
000,000's of fish
LENGTH (cm)