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Canadian Atlantic Fisheries Scientific Advisory Committee

CAFSAC Research Document 85/44

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Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 85/44

Atlantic argentine (*Argentina silus* Ascanius): stock status on the Scotian Shelf and a discussion of relationships with Georges Bank argentine.

by

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Abstract

Research vessel biomass estimates of Argentina silus in Div. 4VWX declined in 1984 to about half the level of 1982-83. This 1984 level was similar to that of 1977-81. Increased abundance since extension of jurisdiction resulted from recruitment of several good year-classes to the surveyed population, particularly that of 1980. The abrupt decrease in estimated biomass in 1984 is unlikely to be due to mortality and may reflect changes in availability to surveys with age (size).

Commercial catches from 1977 have averaged less than 1,500 t, provisional 1984 catches being about 600 t taken mainly as by-catch in the silver hake fishery. There is no basis to change previous CAFSAC advice on long-term yield expectations of 10,000 t from Div. 4VWX.

Review of relationships of Subarea 5 argentine with those of Div. 4VWX indicates that Subarea 5 concentrations are likely the southern fringes of populations which also occur in Div. 4VWX and there is no basis for a separate Subarea 5 management unit. The Canada/USA maritime boundary places almost all areas containing fishable concentrations of argentine in Canadian waters. The 10,000 t potential long-term catch calculated for Div. 4VWX argentines may be applicable, in fact, to argentine in Div. 4VWX + Subarea 5.

The proportion of argentine biomass estimated by Canadian surveys to be in the Fundian Channel - Bay of Fundy area was consistently high in 1970-81 (averaging 50-60%) but decreased substantially to 5-21% in 1983-84. This observation is relevent to discussions concerning adequacy of access provisions for foreign nations interested in fishing for argentine. Most of the estimated biomass in 1983-84 was in the area presently open to fishing, in contrast to earlier years.

Résumé

En 1984, la biomasse d'Argentina silus, estimée à partir d'un navire de recherches, avait diminué d'à peu près la moitié dans div. 4VWX, par rapport au niveau de 1982-1983. Le niveau de 1984 était le même qu'en 1977-1981. Depuis l'extension de juridiction, l'abondance avait augmenté en raison du recrutement d'abondantes classes d'âge au sein de la population dénombrée, en particulier celle de 1980. Il est peu probable que la baisse soudaine de la biomasse estimée pour 1984 soit due à la mortalité du poisson. Cette réduction pourrait refléter des changements d'accessibilité du poisson, selon l'âge (taille), au moment des dénombrements.

Depuis 1977, les prises commerciales totalisaient en moyenne moins de 1 500 t, alors qu'en 1984, elles étaient provisoirement estimées à environ 600 t, constituées principalement de prises fortuites de la pêche de merlu argenté. Il n'y a pas lieu de changer les conseils du CSCPCA en ce qui concerne les prises prévues à long terme, évaluées à 10 000 t dans la div. 4VWX.

Les rapports qui existent entre les argentines de la sous-zone 5 et celles de la div. 4VWX indiquent que les concentrations de la sous-zone 5 représentent probablement des poissons formant les limites méridionales de populations qui se trouvent aussi dans la div. 4VWX. Il n'y a donc aucune raison de faire de la sous-zone 5 une unité de gestion séparée. Si l'on considère la frontière maritime Canada/Etats-Unis, on voit que presque toutes les zones qui contiennent des concentrations exploitables d'argentines se trouvent en eaux canadiennes. La prise potentielle à long terme de 10 000 t prévue pour les argentines de la div. 4VWX pourrait en fait s'appliquer aux argentines de la div. 4VWX + sous-zone 5.

Dans la région du chenal Fundian/baie de Fundy, la proportion de la biomasse des argentines estimée par des dénombrements canadiennes est restée élevée de 1970 à 1981, mais elle a beaucoup diminué (jusqu'à 5-21 %) en 1983-1984. Cette observation n'est pas sans intérêt pour ce qui est des discussions concernant le caractère adéquat des clauses d'accès touchant les pays étrangers qui s'intéressent à la pêche des argentines. Contrairement aux années précédentes la plus grande partie de la biomasse estimée pour 1983-1984 se trouvait dans la région actuellement ouverte à la pêche.

Introduction

The Atlantic argentine (Argentina silus Ascanius) occurs in the western Atlantic from West Greenland to Georges Bank, but has been of sufficient abundance to attract persistent fishing interest only in the southern part of its range on the Scotian Shelf (Div. 4VWX) and Georges Bank (Subdiv. 5Ze). Stock abundance and fishery trends have previously been described by Halliday (1974, 1984), Sinclair (1980, 1981), and Koeller (1982, 1983). The present paper updates the recent series of stock status reports by reviewing research vessel survey and commercial fishery data.

The International Court of Justice (ICJ) rendered its decision on the Gulf of Maine maritime boundary between Canada and the USA on 12 October 1984. The decision placed the Fundian Channel and the northeastern part of Georges Bank in Canadian waters. The implications for argentine management, of boundary settlement, and the location of the line, are discussed.

Commercial Fishery

Catches and TACs

Argentine fishing began in the early 1960s and peak catches of 49,000 t occurred in 1966. A further period of high catches occurred in the early 1970s (Table 1), but recent catches have been low. Historically most catches have been made by the USSR and Japan in Subareas 4 and 5.

TACs on argentine in Div. 4VWX, introduced at a level of 25,000 t in 1974, were reduced in 1977 to 20,000 t. Recent stock status reviews have resulted in an advised catch limit of 10,000 t for 1983 and subsequent years. No TAC was set for 1983 but those for 1984 and 1985 were set at 10,000 t. Recent catch and TAC history is as follows ($t \times 10^{-3}$):

	1978	1979	1980	1981	1982	1983	1984	1985
TAC	20	20	20	20	20	-[1]	10	10
Nominal Catch	2	3	2	+	+	1	1*	...

[1] No TAC set but Japan allocated 3100 t.
* Provisional Statistics

The argentine fishery in Div. 4VWX was limited to seaward of the small mesh gear line during the season 15 April to 15 November, as of 1977, and this corresponded with reduction of annual catch to about 2,000 t. The further reduction in catch in 1981 and later years corresponded to the failure of the Scotian Shelf squid fishery. The provisional 1984 catch of 623 t is comparable to the level of the previous three years. This catch was taken mainly by the USSR and Cuba as by-catch in their silver hake fishery.

Size Composition of Removals

National sampling has been inadequate to allow estimation of size composition of the international catch. The Scotia-Fundy International Observer Programme (IOP) has collected sufficient data, however, to allow such estimates to be made. Sinclair (1980) and Halliday (1984) provided length-frequencies for the international catch in 1977-79 and 1982-83 respectively, based on these data. Sinclair's results are reproduced as Fig. 1. Halliday's estimates for 1982 and 1983 have been revised, and estimates for 1981 and 1984 are now available (Fig. 2). Revision to the 1982 estimate involved weighting of samples by national catches, whereas revision to that for 1983 involved taking final catch statistics into account. An inventory of samples for 1981-84 is given in Table 2. The IOP argentine length-frequency data for 1980 are presently undergoing editing and are not yet available for analysis.

Sinclair's size compositions for 1977 and 1979 are quite similar with modes at 23 cm and about 30 cm, whereas that for 1978 is almost uni-modal at 26 cm. In the 1981-84 series, the size composition in 1981 is uni-modal at 29 cm, whereas that for 1982 is bi-modal at 21 cm and 31 cm. Both 1983 and 1984 size compositions are uni-modal at 24 cm and 27 cm respectively. These data are consistent with research survey length-frequency data (see below) and support the interpretation that good year-classes entered the fishery in the 20-25 cm length range in 1977, 1979, and 1982 and to a large extent supported the fishery during 1978-84 period.

Research Vessel Surveys

Biomass Estimates

Stratified-random bottom trawl surveys in July (from 1970) and in March and October (from 1979) provide time series of biomass estimates for Div. 4VWX (Table 3). On some occassions in 1980-83 comparative fishing experiments resulted in two surveys being conducted in the same season and year, and these cruises provide additional estimates (Table 3). The results of these comparative fishing experiments were reviewed by Halliday (1984) who concluded that, for the purpose of describing general abundance trends, it is satisfactory to use the survey biomass data without inter-vessel adjustments. This procedure is followed here.

High variation among estimates masks trends when biomass estimates are plotted individually (Fig. 3), but trends become clearer when the data are combined and smoothed. In addition, the 1978 point has been adjusted by removing one very large set which gives what appears to be an anomalous estimate (Koeller, 1983). The resultant series (Fig. 3) suggests that biomass declined from 1970 to about 1975, increased and remained stable in 1976 to 1980, then increased again until 1982-83. Biomass decreased in 1984 to about the 1976-80 level. The estimates doubled between 1973-75 and 1976-80, and doubled again between 1976-80 and 1981-83, halving in 1984.

Only a small proportion of the biomass estimates has been associated with the eastern shelf area (Table 3). About 60% of the estimated biomass, in total from 1970, has been accounted for by the Fundian Channel - Bay of Fundy strata (or 50% if the 1978 survey is again discounted as anomalous). In the last two years, 1983 and 1984, the percentage has been substantially lower however (about 12%). The proportions from each cruise plotted individually illustrate that 6 of the 7 observations in 1982-84 lie outside the range of earlier points with proportions of biomass in the Fundian Channel - Bay of Fundy in the range of 5-21% (Fig. 4). (Only surveys in Table 3 with complete coverage of all important strata are used in these comparisons.)

Biomass estimates for the Central and Eastern Shelf, and the Fundian Channel-Bay of Fundy, plotted separately, show peaks in both areas in early 1983 and substantial declines since (Fig. 5). The increase represented by the 1983 peak was relatively much greater in the Central and Eastern Shelf area, however, and 1984 levels were still higher than those prior to 1982 despite the declining trend. In contrast, 1984 biomass levels in the Fundian Channel-Bay of Fundy were the lowest in the time series from 1970. Mean bottom temperature in the strata in which argentine occur in greatest abundance (66+78 in the Central Shelf, and 82-84 in the Fundian Channel) did not change greatly in 1984 in comparison to earlier periods (Fig. 6). Temperature observations used were made at survey trawling stations, and it is the catches from these same stations which were used to generate biomass estimates. The number of observations is not large ($\bar{n}$=5.3 per survey in strata 66+78 and 6.9 in strata 82-84) and the temperature means will be influenced by variation from survey to survey in mean depth fished. Thus, these data alone are not sufficient to allow change in environmental conditions to be discounted as an explanation of the changes in biomass estimates observed. Nonetheless, reduced catches in 1984, and the reduced proportion of the estimated biomass which occurred in the Fundian Channel-Bay of Fundy area in 1983-84 cannot be ascribed readily to anomalies in temperature conditions.

Size Composition Estimates

Seasonal surveys conducted from the spring of 1979 illustrate in detail the size composition changes in the population (Fig. 7). Earlier survey size composition data are given in Halliday (1984). These earlier data suggest that the increase in biomass in 1977 resulted from recruitment of a strong year-class which showed up in the 20-25 cm length range in July 1977. This biomass increase was sustained by another strong year-class which appeared in 1979 (Fig. 7a). The further increase in biomass in 1982-83 resulted from recruitment of a year-class stronger again than the earlier two strong year-classes, and which has been interpreted by Halliday (1984) as the 1980 year-class. This year-class was first picked up in the March 1981 survey at about 10 cm and can be followed through the length-frequency histograms with some confidence to a modal length of 26 cm in October 1983 (Fig. 7b). The estimated population size compositions from 1984 surveys, with modes in the 26-30 cm range suggest that the 1980 year-class continues to dominate and that subsequent year-classes of 1981-83 are likely poor.

Argentine in Subarea 5

Management units for argentine in the northwestern Atlantic were established as Div. 4VWX and as Subarea 5 at the January 1974 special meeting of ICNAF and became applicable in 1974 (ICNAF 1974a). There have been no changes in management areas since their establishment but separate management of argentine in Subarea 5 was discontinued after 1974 when they were included in the "Other Finfish" category and managed along with several other species under a single TAC applying to Subareas 5 and 6 (ICNAF, 1974a).

Biological aspects of argentine management were first considered by STACRES of ICNAF at its meeting of January 1974 (ICNAF 1974b). STACRES concluded that "As there is no precise separation of stocks between SA5 and Div. 4X and it is possible that some argentine catches in SA5 are from Div. 4X stocks, it is not possible at this time to define the potential yield from SA4 distinct from that of SA5. Thus, it may be desirable to manage argentine, as for pollock, and combine SA4 and 5 for management purposes." The report of STACRES went on to provide a single TAC recommendation for the combined Subareas but also to state "To prevent local over-exploitation, it would be appropriate to divide this TAC equally between Div. 4VWX and SA5".

The Fisheries Commission of ICNAF chose to partition the TAC set for 1974 equally between Div. 4VWX and Subarea 5. (Essentially, it set separate TACs for these two areas.) This decision was based on administrative convenience. The Fisheries Commission was in the process of establishing a second tier TAC system for Subarea 5. Pollock, which was managed on the basis of Div. 4VWX + Subarea 5, was already causing problems because it did not fit neatly under the second tier TAC for Subarea 5. There was a strong motivation to make management areas for single species TAC managment coincide with that for the multi-species (2nd tier) TAC; the 2nd tier system would otherwise be prejudiced. While STACRES preferred that argentines be dealt with in the same way as pollock with a single TAC for Div. 4VWX + Subarea 5, it recognized the Commission's problem by advising on how to partition the TAC between Subareas (i.e. equally).

Distribution of argentine based on Canadian research vessel survey data and equivalent data from USA surveys in 1965-78 (Almeida et al. 1984) is interpreted in Fig. 8. These data indicate that, in the Fundian Channel - Gulf of Maine Basin area, argentine catches are largely restricted to the Div. 4X portion, and almost exclusively to within the Canadian zone. Concentrations do extend along the eastern edge of Georges Bank, and occassional large catches have been made there (McKenzie, MS 1966), but USA surveys indicate argentine are usually scarce in this area. The Canadian zone encompasses all locations in which large catches have been made.

No argentine have been reported as caught in Subarea 5 fisheries since extensions of jurisdiction in 1977. Prior to that date, more argentine were reported caught in Subarea 5 than in Subarea 4 (9,000 t versus 7,000 t annually in 1963-76 -- Table 1). Although most Subarea 5 catches were reported from Subdiv. 5Ze, significant amounts were recorded from Subdiv.

5Zw and some even from Subarea 6. A. silus does not occur in these latter areas except as isolated specimens, thus such catch records are judged to be in error. Assignment of catches between Subdiv. 5Ze and Div. 4X is also likely to have an element of arbitrariness to it, in addition to the more general level of error in assignment to area of capture implied by the reports of more southern catches. Descriptions of fisheries in annual USSR Research Reports to ICNAF provide no comment on their Subarea 5 argentine fisheries with the exception of the large 1972 fishery. Konstantinov and Noskov (1973) reported that the 1972 fishery was based on dense pre-spawning accumulations of argentine located in Georges Basin which is the deepest part of the Fundian Channel and which is divided by the Subarea 4/5 line. Although caught in Subarea 5, these authors conclude that "Because the Georges Basin concentrations belong properly to the Browns Bank stock, it is not surprising to see the composition of catches in both areas essentially the same". The basis for their claim is not given.

In summary, the creation in 1984 of separate management units in Subarea 5 and Div. 4VWX was an administrative convenience. Biological advice at the time was that the Subarea 4/5 line did not provide a clear separation among stocks and that argentine in Subareas 4 and 5 would best be considered together for management purposes. Research vessel surveys indicate that most of the population is usually distributed on the Div. 4X side of the Subarea boundary line. The only report on the location of Subarea 5 fisheries is that for the large USSR fishery of 1972 and, in that year, the fishery was conducted very close to the boundary with Div. 4X. Commercial statistics indicate more catch from Subarea 5 than Subarea 4 historically, but it seems likely that Subarea 5 catches were taken in areas immediately adjacent to Div. 4X, and there is indeed no basis for managing argentine separately on either side of the Subarea 4/5 line. In contrast, the ICJ line circumscribes the distribution of fishable concentrations of argentine satisfactorily, placing them almost exclusively in the Canadian zone.

Conclusions

The recently advised reference catch level of 10,000 t for Div. 4VWX was developed in 1982 by CAFSAC (1983) based on an average trawlable biomass estimate from research vessel surveys of 62,000 t in 1958-68, and on a yield-per-recuit calculation which gave $F_{0.1} = 0.15$. Neither the biomass estimate or the input parameters for the yield-per-recruit calculation were considered reliable, but the calculation was taken as guidance on what might be a reasonable expectation for long-term average sustainable yield.

Catches which averaged about 7,000 t from Div. 4VWX (about 16,000 t from Div. 4VWX + Subarea 5) in 1963-76 corresponded to a decline in stock biomass, as estimated by research vessel surveys, at least between 1970 and the mid-1970s, just prior to extensions of jurisdiction. Catches at these levels may, therefore, not have been sustainable. In contrast, reduced catches from 1977 (averaging about 1,500 t) corresponded with increases in stock size from 1973-75 to 1981-83 of about four times. However, stock

size halved in 1984 from the 1981-83 level despite the absence of a significant fishery. Much of the increase in survey estimated biomass in 1982-83 was accounted for by small fish, probably of the 1980 year-class at ages 2 and 3. Argentine are a long-lived species (see e.g. Emery and McCracken, 1966), thus the rapid decrease in biomass is unlikely to have arisen from natural mortality. More likely a distributional change is involved, such as a movement to deeper water with age, which would reduce availability to surveys. In any case, these considerations do not give a basis for a change in reference catch from that of 10,000 t for Div. 4VWX provided by CAFSAC in 1982.

Settlement of the USA-Canada boundary claims in the Gulf of Maine area places almost all of the area of significant distribution of argentine in Canadian waters. There is no conclusive indication, however, that Subarea 5 has contained persistent argentine concentrations incremental to those in Subarea 4. There is, therefore, no basis on which to retain a management unit division corresponding to the Subarea 4/5 line, and it may prove that the calculations on which CAFSAC's 1982 advice was based give guidance as to long-term catches from Div. 4VWX + Subarea 5, rather than from the Scotian Shelf alone.

Canadian surveys have consistently indicated that 50-60% of the biomass in Div. 4VWX was in the Fundian Channel area, and this is consistent with complaints by the USSR in particular in the early 1970s that this was a prime fishing area, access to which was being reduced by imposition of the haddock closed areas. Complete exclusion from this area since extension of jurisdiction has led to continuing complaint by both USSR and Japan that allocations cannot be taken. Estimates of the proportion of biomass in the Fundian Channel area in 1983-84 surveys are much lower (5-21%), however. Estimates of biomass in the Fundian Channel-Bay of Fundy area in 1984 were the lowest obtained since the data series began in 1970. This suggests that a change in distribution may have occurred which would make the Fundian Channel less important as a potential fishing area.

Acknowledgements

We wish to thank A.F. Sinclair for making IOP data available to us, and P.A. Koeller who reviewed the manuscript and made helpful suggestions for its improvement.

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Table 1. Nominal catches (t) of Argentina silus by NAFO Subarea and country, 1963-84.

	NAFO SUBAREA							COUNTRY					
Year	1	2	3	4	5	6	Total	USSR	FRG	Japan	Cuba	Misc.	Unknown
1963	-	-	-	8,127	4,210	-	12,337	12,337	-	-	-	-	-
1964	13	-	-	4,943	12,830	952	18,738	18,725	13	-	-	-	-
1965	-	-	-	5,611	9,453	166	15,230	15,230	-	-	-	-	-
1966	-	-	119	14,983	33,938	-	49,040	49,040	-	-	-	-	-
1967	-	-	825	4,271	2,026	-	7,122	7,015	-	42	-	65	-
1968	-	-	449	2,675	1,481	853	5,458	4,184	-	1,274	-	-	-
1969	-	5	106	5,354	2,608	5	8,078	5,707	-	2,338	-	28	5
1970	-	-	793	4,553	1,369	10	6,725	2,614	-	4,100	-	1	10
1971	-	-	532	6,715	7,293	-	14,540	5,535	-	9,003	-	2	-
1972	-	-	262	5,868	32,707	-	38,837	38,127	-	710	-	-	-
1973	-	-	138	1,444	2,512	-	4,094	3,691	-	403	-	-	-
1974	-	-	545	17,496	19,695	-	37,736	37,172	-	557	-	7	-
1975	-	-	16	14,691	1,398	68	16,173	16,052	-	56	-	65	-
1976	-	-	163	7,010	322	-	7,495	6,895	-	384	112	104	-
1977	-	-	-	2,489	-	-	2,489	219	136	2,115	15	4	-
1978	100	-	-	1,897	-	-	1,997	330	101	1,545	21	-	-
1979	228	-	-	2,640	-	-	2,868	232	228	2,407	1	-	-
1980	-	-	-	2,053	-	-	2,053	528	-	1,521	4	-	-
1981	19	-	-	369	-	-	388	71	19	298	-	-	-
1982	17	-	12	417	-	-	446	201	17	174	54	-	-
1983	-	-	-	863	-	-	863	364	-	148	351	-	-
1984*	-	-	-	623	-	-	623	450	-	18	150	5	-

*Provisional statistics obtained from FLASH.

Table 2. Estimation of argentine removals from Div. 4VWX in 1981 to 1984; IOP sample summary. Sample weighting was by month and unit area within country where sampling level permitted. Distribution of catch among unit areas (and months in 1984) was based on ratios of observed catches in IOP. This assumes that distribution of observed catches by month and unit area was representative of distribution of total catch.

YEAR: 1981

Country	Division	Month	No. of Samples	Number Measured	Associated Catch
Japan	4WX	Aug-Sept	16	4090	298
Portugal	4W	Apr-May	2	344	4[2]
USSR	4WX	Apr-June	10	1662	71
Total	4WX	Apr-Sept	28	6096	373

YEAR: 1982

Country	Division	Month	No. of Samples	Number Measured	Associated Catch
Cuba	4W	May-July	15	2835	53
Japan	4WX	Aug-Sept	5	1136	163
USSR	4WX	Apr-July	31	5728	201
Total	4WX	Apr-Sept	51	9699	417

YEAR: 1983

Country	Division	Month	No. of Samples	Number Measured	Associated Catch
Cuba	4WX	Apr-July	17	2741	351
Japan	4WX	Aug-Sept	7	1487	148
USSR	4WX	Apr-July	31	6283	364
Total	4WX	Apr-Sept	55	10511	863

YEAR: 1984[1]

Country	Division	Month	No. of Samples	Number Measured	Associated Catch
Cuba	4WX	Apr-June	21	3052	150
Japan	4V, 4X	Aug-Dec	8	664	18
Portugal	4W	June-July	2	435	5
USSR	4WX	May-Sept	44	7233	450
Total	4VWX	Apr-Dec	75	11384	623

[1] Provisional statistics from FLASH.
[2] IOP catch, NAFO catch is nil.

Table 3. Biomass estimates of Argentina silus on the Scotian Shelf from stratified-random bottom trawl surveys in a) summer, b) spring, and c) fall. (Biomass in metric tons. A = A.T. Cameron, H = Lady Hammond, N = Alfred Needler.)

Cruise	Year	AREA[1] Fundian Channel-Bay of Fundy	Central Shelf	Banquereau-Sable Island	Total
a) SUMMER					
A175/6	1970	4637	768	78	5483
A188/9	1971	3236	1705	623	5564
A200/1	1972	618	170	183	971
A212/3	1973	1081	1318	127	2526
A225/6	1974	1085	1591	104	2780
A236/7	1975	242	135	188	565
A250/1	1976	1806	244	0	2050
A265/6	1977	5622	2288	5	7915
A279/80	1978	24900	1603	11	26514
A292/3	1979	4047	3264	108	7419
A306/7 (H37/8)	1980	3065 (1056)	556 (2704)[3]	71 (173)	3692 (3933)
A321/2 (H59/60)	1981	4202 (18324)	1735 (523)[3]	83 (88)	6020 (18935)
- (H80/1)	1982	- (395)	- (3312)[3]	- (392)	- (4099)
N12/3 (H101/2)	1983	2678 (3395)	9785 (9004)[3]	63[3] (71)	12526 (12470)
N31/2	1984	766	3734	191[3]	4691
b) SPRING					
H13/4	1979	271[3]	209	0	480
H33/4	1980	1598[3]	1286	20	2904
H48/9	1981	327[3]	2293	372	2991
H71/2	1982	111[3]	2988	1707	4806
H94/5	1983	991	15087	762	16840
N24/5	1984	528	4146	413	5087
c) FALL					
H26/7	1979	3135	565	22[3]	3722
H42/3	1980	3407	917	24	4348
H64/5	1981	1449	1358	206	3013
H84/5[2] (NO2/3)	1982	10353 (-)[3]	4134 (8009)[3]	68 (31)[3]	14555 (8040)
N17/8	1983	115	2255	58	2428
N36/7[2]	1984	386	1886	83	2355

[1] Fundian Channel-Bay of Fundy = Strata 80-95; Central Shelf = Strata 60-78; Banquereau-Sable Island = Strata 46-59.
[2] Preliminary analysis - data editing not completed.
[3] Important strata not sampled. (H13/4:72. H26/7:46,49-52. H48/9:83-84. H59/60:60-61,65-66,72,77. H71/2:83. H101/2:61,65-66,72. NO2/3:49-54,77-78,80-91; N31/2:46.)

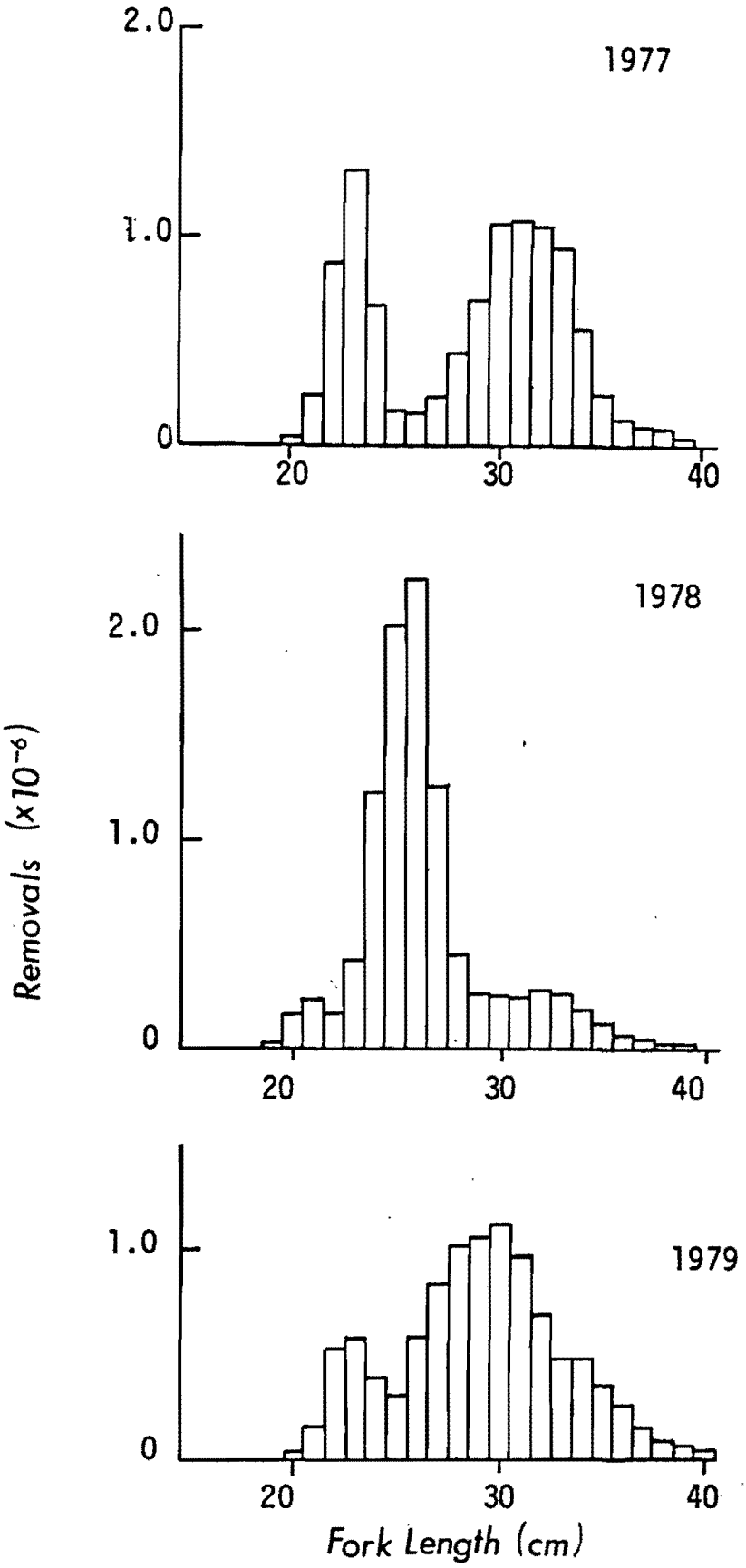

Figure 1. Estimated size composition of removals by the commercial fishery for A. silus 1977-1979 as given by Sinclair (1980).

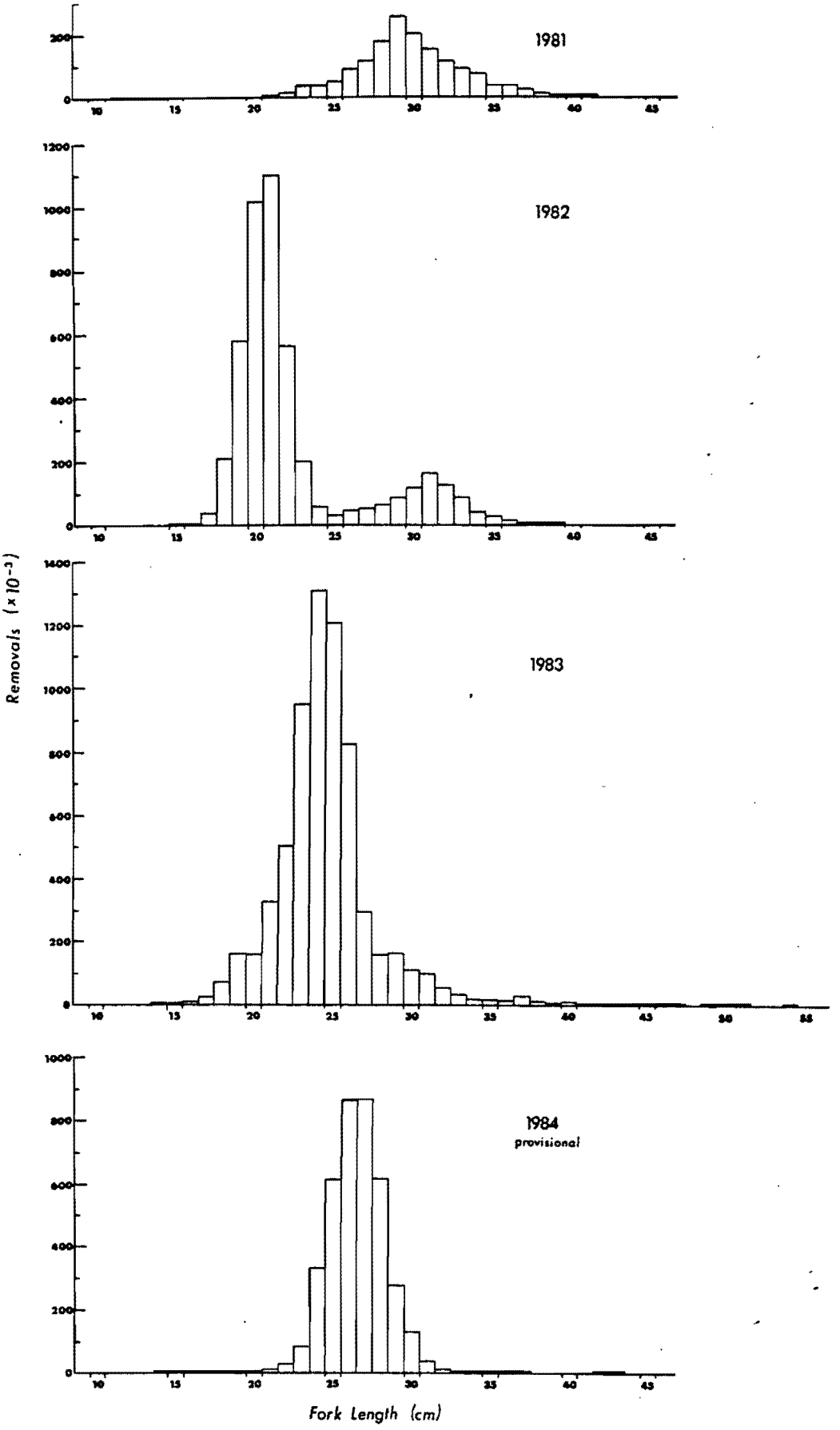

Figure 2. Estimated number of removals at length of A. silus by the international fishery in Division 4VWX in 1981-1984, based on IOP sampling.

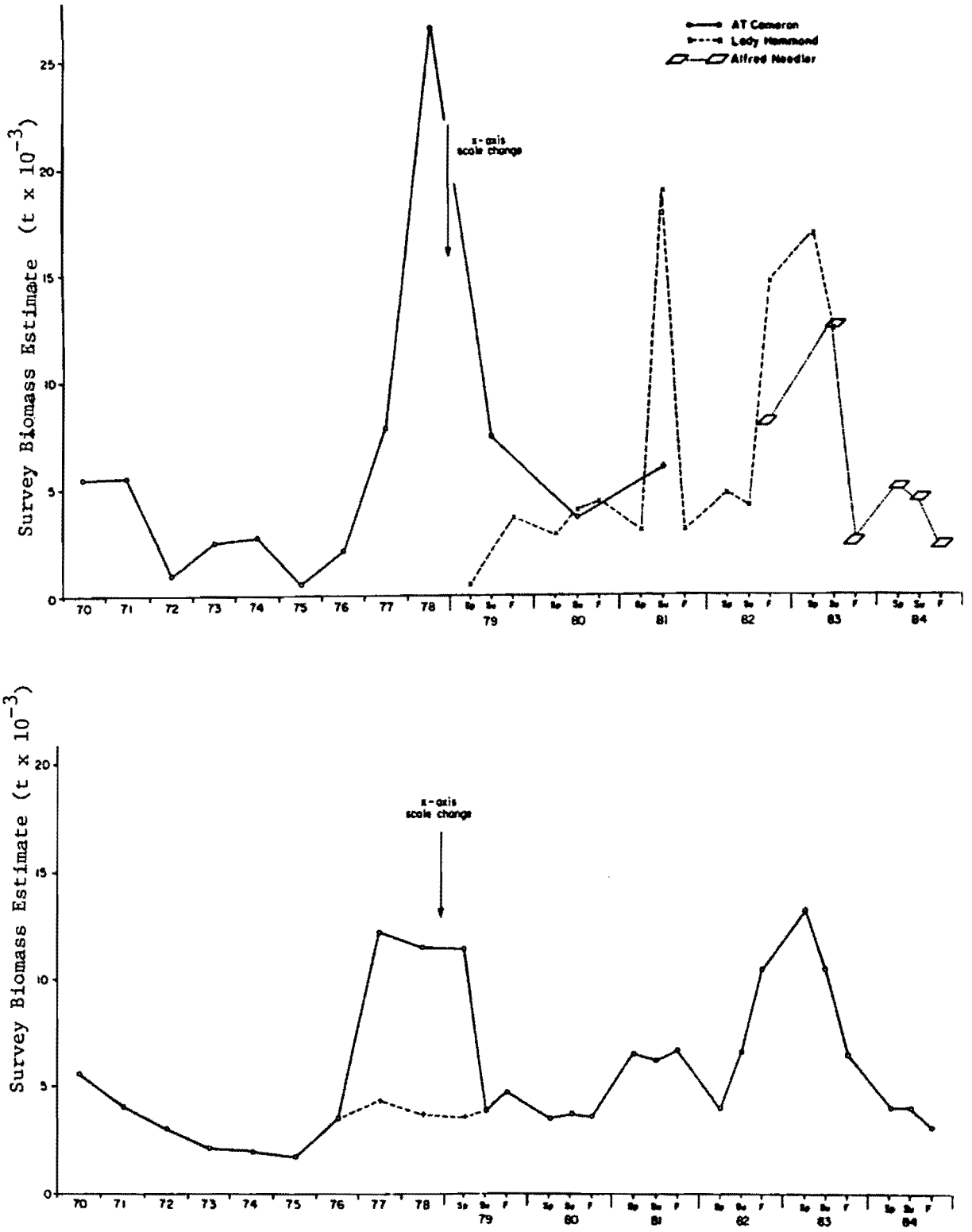

Figure 3. Population biomass estimates of A. silus in Division 4VWX, 1970-84, from stratified-random bottom trawl surveys. Upper: unadjusted estimates by vessel. Lower: smoothed estimates using 3-point running means (first and last points given double weight in calculating 2-point mean); estimates unadjusted for vessel or season but estimates for the same season and year averaged before smoothing. Dashed line connects mean recalculated after exclusion of one large set in 1978.

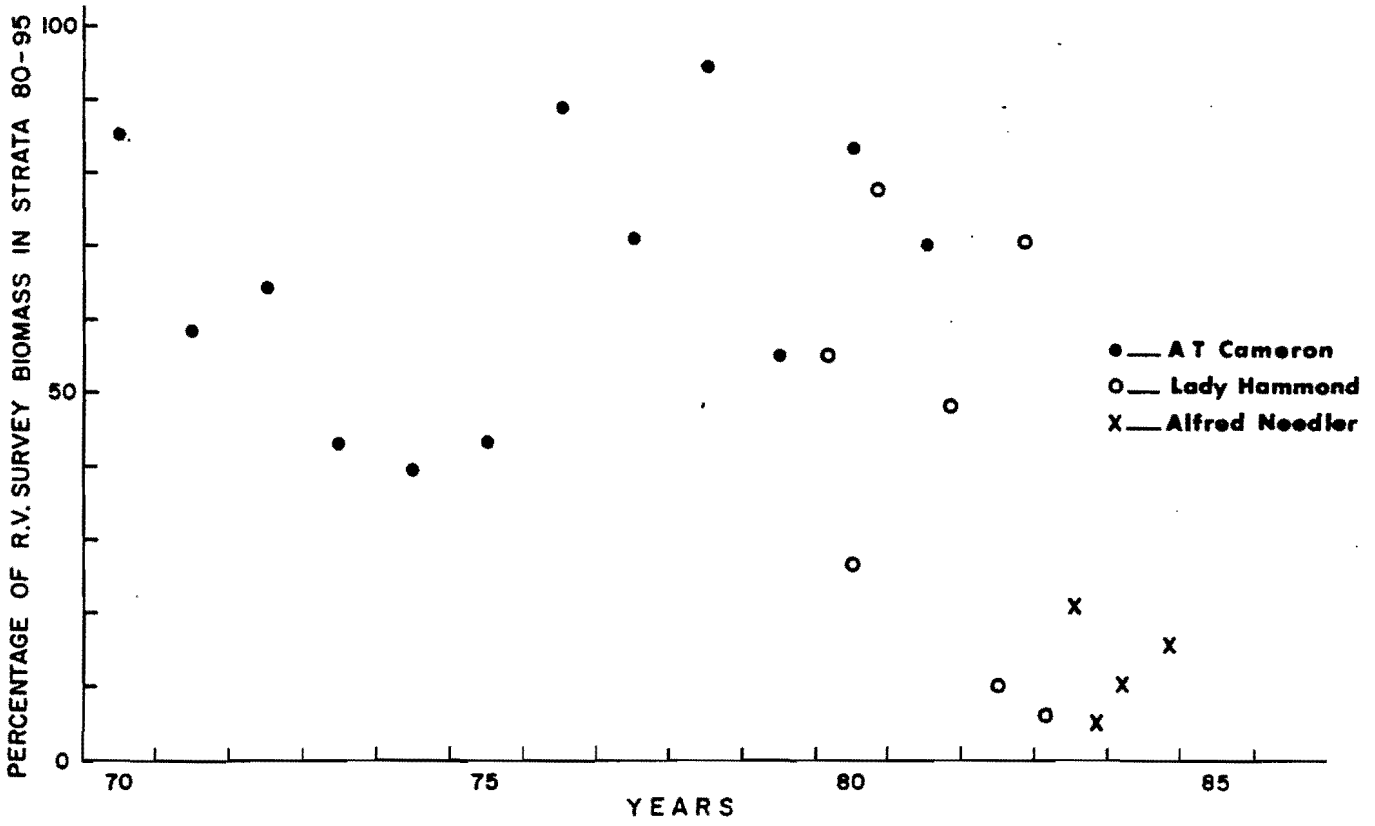

Figure 4. Percentage of A. silus biomass occurring in the Fundian Channel-Bay of Fundy area (Strata 80-95) as estimated by stratified-random bottom trawl surveys.

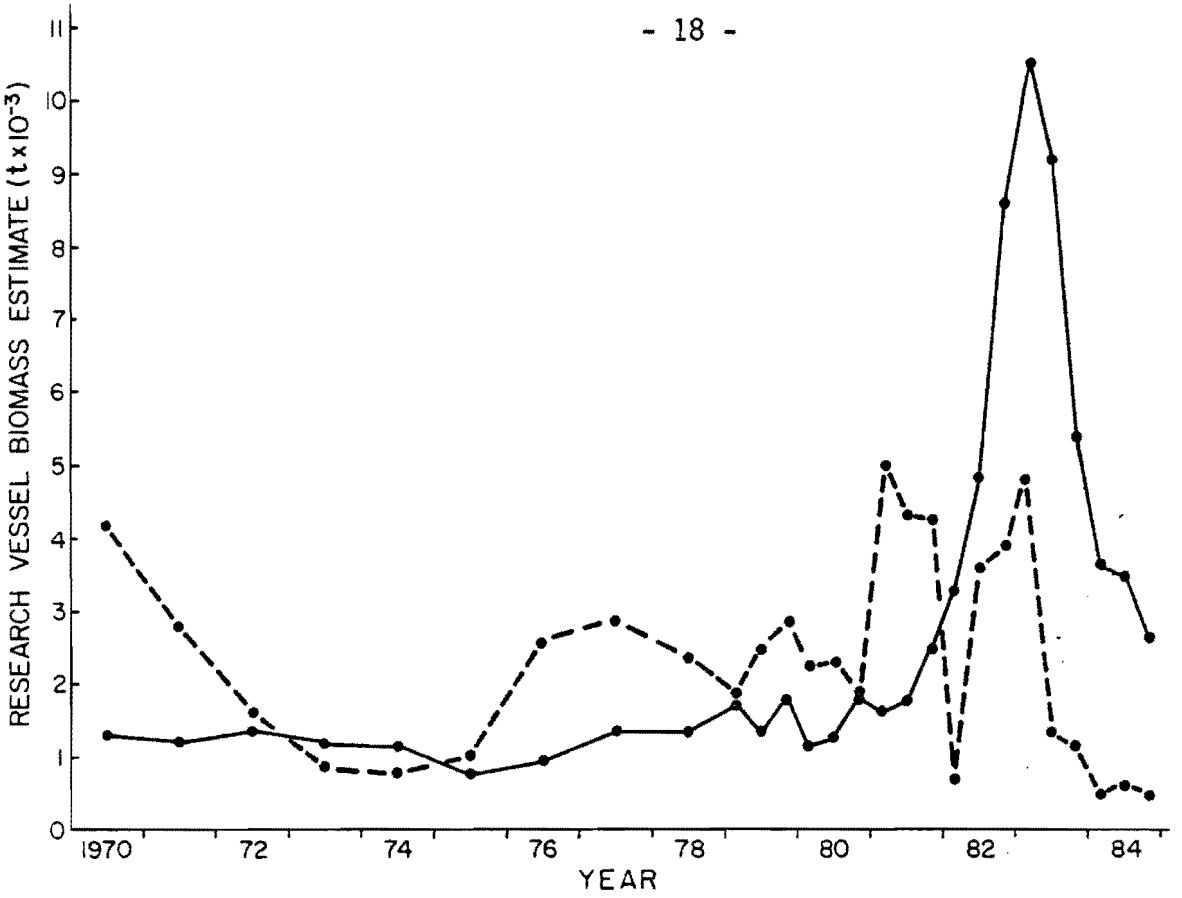

Figure 5. Population biomass estimates of A. silus, 1970-84, from stratified-random bottom trawl surveys for the Fundian Channel-Bay of Fundy area (dashed line) and the Central and Eastern Shelf area (solid line), smoothed using 3-point running means. Unusually large 1978 set excluded.

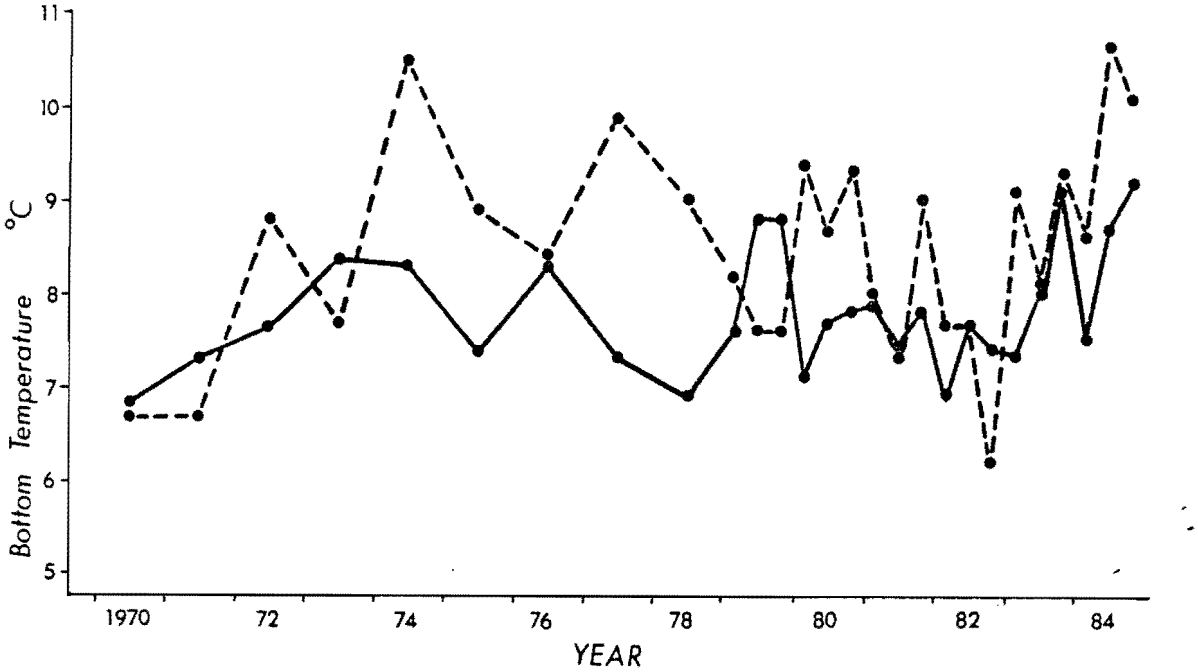

Figure 6. Mean bottom temperature (^{o}C) at fishing stations in deep strata (greater than 100 fm) on the Central Shelf (Strata 66 and 78 - dashed line) and in the Fundian Channel (Strata 82, 83, and 84 - solid line) in 1970-84 stratified-random bottom trawl surveys.

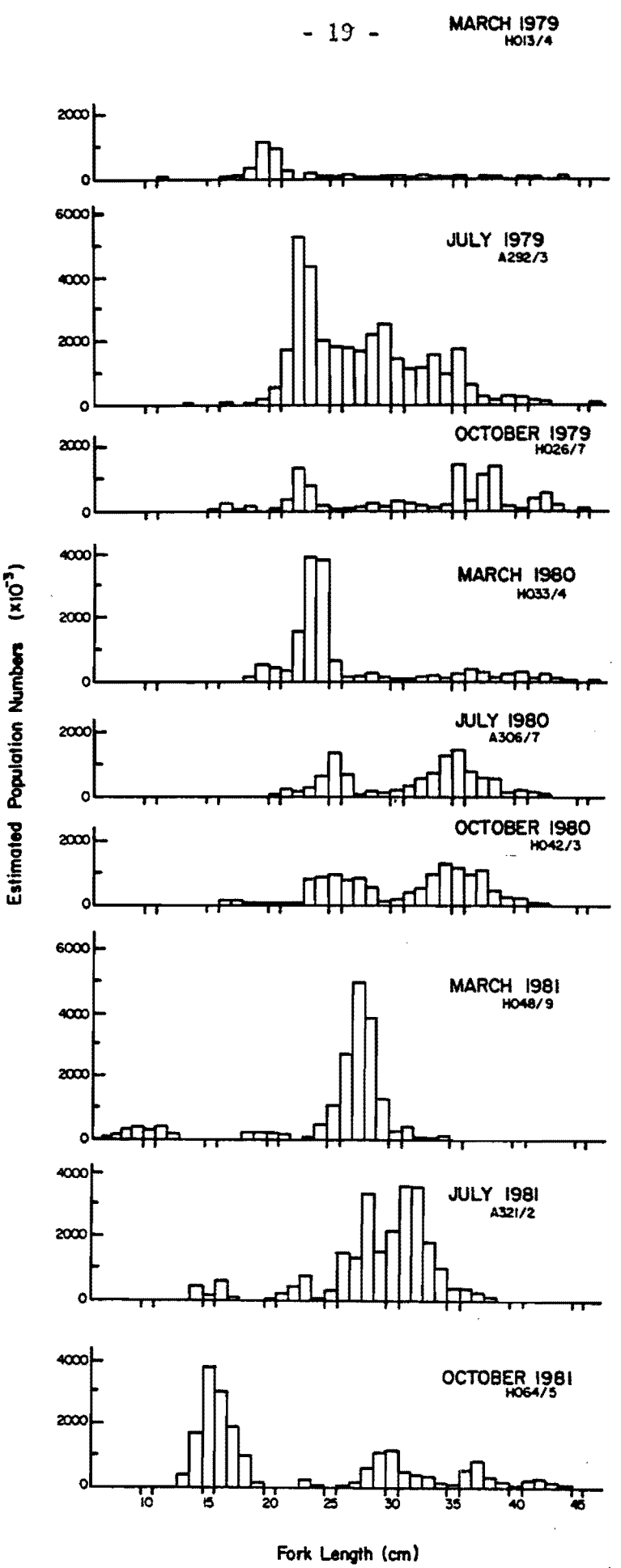

Figure 7a. Estimated population numbers at length of A. silus in Division 4VWX from stratified-random bottom trawl surveys conducted seasonally (spring, summer, and fall) from March 1979 to October 1981.

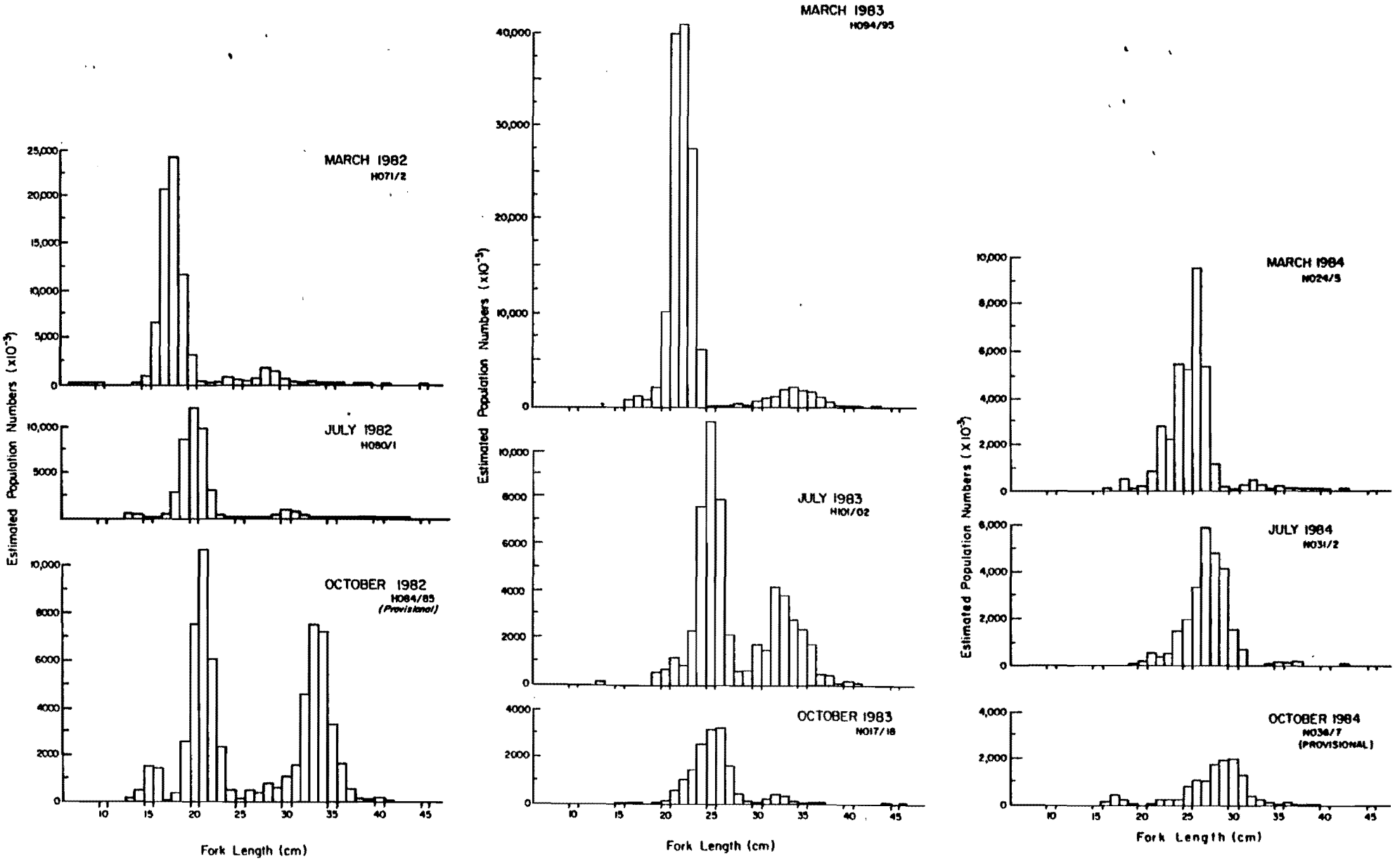

Figure 7b. Estimated population numbers at length of A. silus in Division 4VWX from stratified-random bottom trawl surveys conducted seasonally (spring, summer, and fall) from March 1982 to October 1984. (Note change of vertical scale by x2.5 for large estimates.)

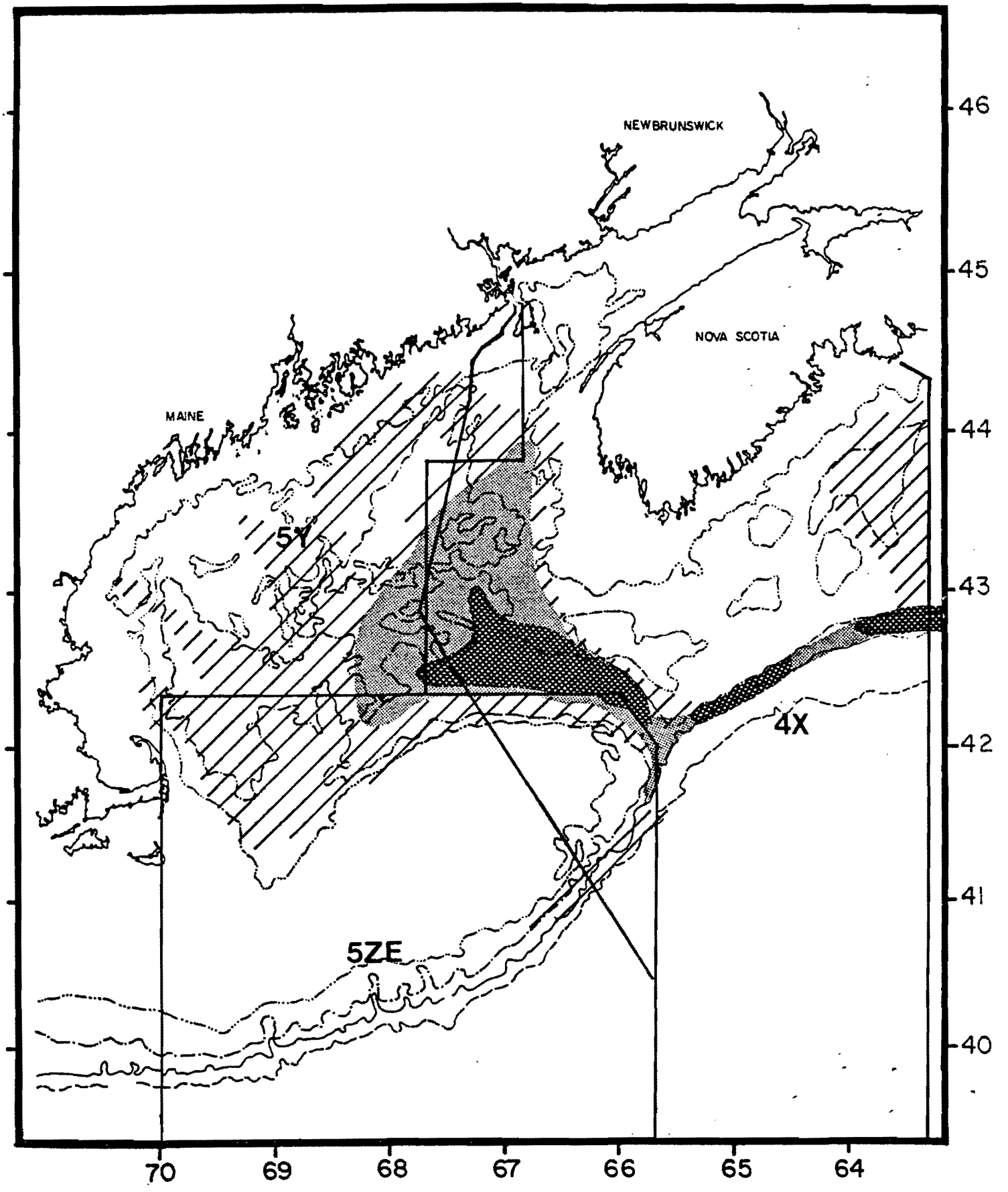

Figure 8. Distribution of A. silus based on Canadian and USA research vessel bottom-trawl surveys.